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А.В. Гаврилова

ENGLISH FOR STUDENTS MAJORING IN PLASMA PHYSICS

Учебное пособие по английскому языку

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Автор

Гаврилова А.В.

«English for Students Majoring in Plasma Physics»: учебное пособие по английскому языку для магистрантов направления обучения «Физика» (физика плазменных процессов) //А.В.Гаврилова - СПб., Изд-во Политехн.ун-та, 2021. 185 с.

Учебное пособие предназначено для магистрантов, обучающихся по направлению «Физика» (физика плазменных процессов). Пособие содержит неадаптированные научные и научно-популярные тексты на английском языке. Основная цель учебного пособия – познакомить обучающихся с лексикой и грамматическими структурами научных текстов. Тексты сопровождаются переводом сложных терминов, лексико-грамматическими упражнениями, видео материалом, а также заданиями по совершенствованию письменной речи и проведению презентаций.

В пособии представлены научные тексты для перевода с русского языка на английский, тексты на английском языке для просмотрового чтения и пересказа, а также задания с использованием Интернет-ресурсов.

Печатается по решению редакционно-издательского совета Санкт-Петербургского государственного политехнического университета.

Введение

Пособие «English for Students Majoring in Plasma Physics» имеет целью совершенствование языковых компетенций магистрантов, обучающихся по направлению «Физика», выработку устойчивых навыков работы со специальной литературой на английском языке. Эффективная обработка и оперативный анализ научной англоязычной информации, а также ее использование составляют важный элемент повседневной работы физика-исследователя. Подготовка к такой деятельности интегрирует получаемые студентами языковые и профессиональные компетенции. Методической основой интеграции призвано стать настоящее пособие.

Сформулированная выше цель требует чтобы студенты на базе изученной лексики и грамматики решили следующие задачи: 1) произвести оперативный анализ предложенного текста и освоить его содержание; 2) сформировать умение вести диалог и диспут на профессиональную тему; 3) приобрести навык просмотрового чтения и краткой передачи содержания прочитанного, а также, 4) приобрести навыки публичного выступления. Пособие служит комплексному обучению всем перечисленным видам языковой деятельности.

Пособие предназначено для студентов, прошедших обучение по стандарту программы подготовки бакалавров и продолжающих изучение языка в университете по программе магистратуры. Настоящее пособие является обобщением многолетнего опыта автора преподавания языка студентам физических направлений, может, в то же время, быть рекомендовано более широкому кругу читателей.

Учебное пособие состоит из восьми разделов. Каждый раздел содержит фрагменты аутентичного научного текста и сопровождается списком ключевых терминов и словосочетаний, содержит упражнения, цель которых - развитие и совершенствование лексических и грамматических навыков, а также отработка языковых и речевых умений. Упражнения направлены на изучение терминологии, ее закрепление и активизацию. В приложении к пособию приведены правила пунктуации, используемые в письменной речи. В разделах есть задания на использование этих правил. Пособие рекомендовано в качестве основного курса иностранного (английского) языка и рассчитано на использование во время аудиторных занятий, а также для самостоятельной работы студентов.

Лексический состав текстов пособия представляет собой словарный минимум, подлежащий активному усвоению по тематике «физика плазмы». Тексты пособия представляют собой фрагменты оригинальных статей из научных изданий и являются примерами современного научного стиля. К каждому тексту придается краткий словарь.

Задания и упражнения, сопровождающие основной материал разделов, способствуют усвоению лексики и грамматики английского языка и обеспечивают последовательность и глубину освоения характерных особенностей физических текстов. В конце пособия приведены ответы к наиболее сложным заданиям и упражнениям. Авторы убедительно рекомендуют пользоваться ими как средством итогового контроля усвоения учебного материала.

В конце каждого их тематических уроков приводятся факультативные задания для тренировки навыков письменной речи и проведения презентаций с привлечением Интернет-ресурсов. Это является наиболее творческим заданием учебного пособия. Аудиторную работу можно завершить студенческой Интернет-конференцией по научным проблемам. Это позволяет обучающимся развивать навыки публичного выступления. Для подготовки к презентации студентам рекомендуется пользоваться сайтом http://www.academicearth.org/, на котором представлены аудио и видеоматериалы по лекциям, проводимым в лучших университетах США. Подготовка презентаций по предложенным темам будет способствовать развитию поисковой и информационной компетенции студентов, т.к. предполагает использование современных инструментов (ментальных карт, интерактивных плакатов и презентаций, облака ключевых слов) для их создания.

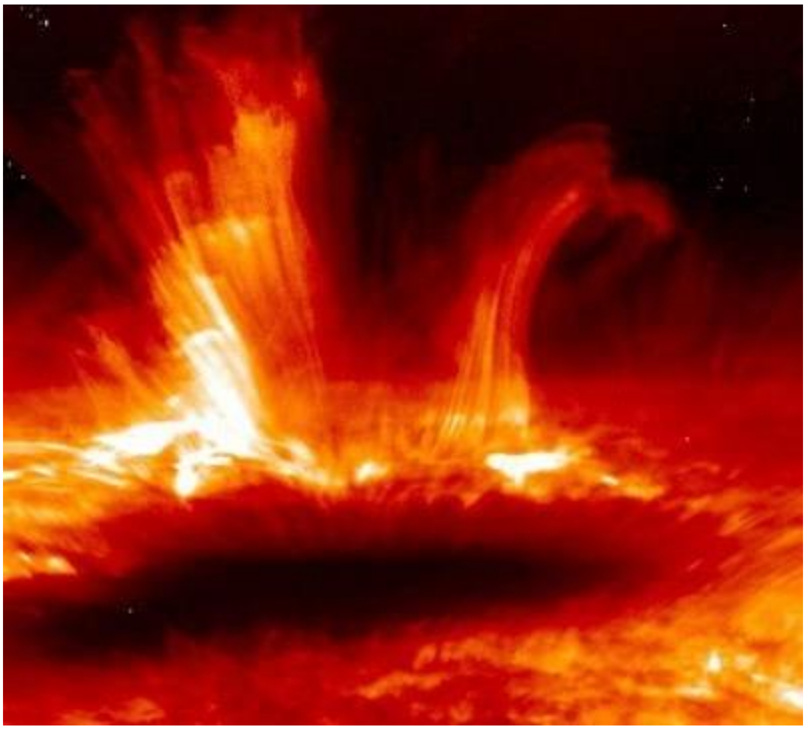
Автор рекомендует регулярно использовать материалы для аудирования, размещенные также на других сайтах и подкастах, представленных в приложении по организации самостоятельной работы студентов в компьютерной обучающей среде.

Работа с пособием в целом и выполнение заданий на перевод в частности предполагает умение пользоваться электронными словарями и поисковыми системами. Данное пособие может быть использовано как самостоятельно, так и в дополнение к основному учебнику курса, рекомендованному рабочей программой при изучении соответствующей дисциплины.

CONTENTS

UNIT 1

TEXT 1. The Ablation Process



The ablation process of hydrogen fuel pellets in hot magnetized plasmas is investigated using a newly developed two dimensional time dependent hydrodynamics code, P2D. Surface evaporation and ablated fluid flow are evolved, coupled with a kinetic calculation of the non-local heating due to slowing down of hot Maxwellian background electrons in the cold ablated plasma. Results of the neutral gas shielding model of pellet ablation are extended to include effects due to no-spherical ablation flows, proper treatment of scattering in the kinetic calculation of the hot electron heat deposition, and atomic physics processes in the ablation cloud and at the pellet surface. These effects have been considered previously, though never as a comprehensive whole. The non-spherical nature of the ablation flow reduces the ablation rate by about a factor of two, while the use of a full Maxwellian distribution for the hot electrons increases ablation by a factor of about four. With Maxwellian hot electrons, atomic physics effects (principally due to dissociation and sublimation) can reduce the ablation rate by up to a factor of two. These effects are systematically quantified using simple physical arguments and code results. For comparison with experiment, we give a simple fit to the code ablation rate results for spherical deuterium pellets: $G_{2DGS} \approx 1.65$ x $10^{15} R_p [cm]^{1.26} n_e [cm^{-3}]^{0.35} T_e [eV]^{1.87}$ atoms/s, where R_p is the pellet radius and n_e (T_e) is the plasma density (temperature). This fit is compared with measured local ablation rates in Ohmic discharges on TFTR and JET. Predicted ablation rate profiles agree well with those on TFTR, but poorly with those on JET; pellet penetration depths agree well on both machines. Probable causes of the observed discrepancies (both experimental and theoretical) are discussed; in particular, transport processes in the post injection plasmas are shown to be able to account for some of the differences.

Pellet injection in magnetic fusion reactors allows fuel to be deposited deep within the plasma, and has allowed access to plasma operating regimes with better confinement properties. The ablation process, which involves complex interactions between the pellet's partially conducting ablation cloud, the background plasma, the ambient magnetic field and the pellet's motion is poorly understood and diagnosed. While the basic self-shielding mechanism that allows pellet lifetimes in hot plasmas to be interesting has been appreciated for some time, most theoretical approaches to the problem have been oversimplified, neglecting much of the important physics. The difficulties inherent in diagnosing the rapid and highly perturbing ablation process have, until recently, made for a dearth of direct measurements with which to compare theoretical predictions. Also contributing to the sow advancement of understanding of pellet ablation was the apparent success of the early neutral gas shielding (NGS) model of the ablation process in matching measurements of the day; I fact, many more complete models of ablation seemed to yield poorer agreement with experiment.

In particular, inclusion of a full Maxwellian distribution function for the hot background plasma electrons in calculations of the driving heat flux seem to indicate excessive ablation rates. Atomic physics effects incorporated into the NGS model seem to have little effect on the ablation rate. Non-spherically symmetric pellet ablation has been investigated, but such geometrical effects are not generally accepted in the field. So-called 'plasma shielding', in which the cold conducting ablatant streams along the lines of force providing additional shielding for the pellet, has also been investigated, though principally in zero and one dimensional models. Owing to their low dimensionality these models cannot properly treat the interaction between the (presumed) spherical ablation flow near the pellet and the channel flow along the lines of force.

Topic vocabulary:

Ablation process – процесс абляции (абляция – уноса вещества с поверхности), pellet ablation – абляция пеллет (пеллеты – твердые микрочастицы, содержащие одно или несколько активных действующих веществ, в физике плазмы – топливные частицы), ablation flow – абляционный поток, ablation cloud – абляционное облако, comprehensive whole – единое целое, Maxwellian hot electrons – горячие электроны с максвелловским распределением скоростей, dissociation and sublimation – диссоциация и сублимация, Ohmic discharges – омические разряды, observed discrepancies – наблюдаемые несоответствия, pellet injection – инжекция пеллет, background plasma – фоновая плазма, ambient magnetic field – внешнее магнитное поле, pellet's motion – движение пеллет, perturbing (adj) - возмущающий, dearth of direct measurement – отсутствие прямых измерений, neutral gas shielding –экранирование нейтрального газа, to yield an agreement with smth/smb – достичь согласия с чем-то

Task 1.1. Answer the questions

1. What is the use of pellet injection?
2. Why is it necessary to study pellet ablation?
3. Why was earlier advancement of understanding of pellet ablation slow?
4. How is the NGS model extended in this paper?
5. Is the solution analytical or computational?
6. How does the inclusion of Maxwellian distribution function into the NGS model affect the calculated ablation rate?

7. What is the influence of the geometrical effects?
8. How does the inclusion of atomic physics processes change the ablation rate?
9. Is there good agreement between the model and the experimental results?
10. What is ‘plasma shielding’?

Task 1.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

The ablation process of hydrogen fuel pellets in hot magnetized plasmas is investigated using a newly developed two dimensional time dependent hydrodynamics code, P2D. Surface evaporation and ablated fluid flow are evolved, coupled with a kinetic calculation of the non-local heating due to slowing down of hot Maxwellian background electrons in the cold ablated plasma. Results of the neutral gas shielding model of pellet ablation are extended to include effects due to no-spherical ablation flows, proper treatment of scattering in the kinetic calculation of the hot electron heat deposition, and atomic physics processes in the ablation cloud and at the pellet surface. These effects have been considered previously, though never as a comprehensive whole. The non-spherical nature of the ablation flow reduces the ablation rate by about a factor of two, while the use of a full Maxwellian distribution for the hot electrons increases ablation by a factor of about four. With Maxwellian hot electrons, atomic physics effects (principally due to dissociation and sublimation) can reduce the ablation rate by up to a factor of two. These effects are systematically quantified using simple physical arguments and code results. For comparison with experiment, we give a simple fit to the code ablation rate results for spherical deuterium pellets: $G_{2DGS} \approx 1.65 \text{ x } 10^{15} R_p[\text{cm}]^{1.26} n_e[\text{cm}^{-3}]^{0.35} T_e[\text{eV}]^{1.87}$ atoms/s, where R_p is the pellet radius and n_e (T_e) is the plasma density (temperature). This fit is compared with measured local ablation rates in Ohmic discharges on TFTR and JET. Predicted ablation rate profiles agree well with those on TFTR, but poorly with those on JET; pellet penetration depths agree well on both machines. Probable causes of the observed discrepancies (both experimental and theoretical) are discussed; in particular, transport processes in the post injection plasmas are shown to be able to account for some of the differences.

Google translation

Процесс абляции водородных топливных таблеток в горячей намагниченной плазме исследуется с использованием недавно разработанного двумерного кода гидродинамики, зависящего от времени, P2D. Поверхностное испарение и поток аблированной жидкости развиваются в сочетании с кинетическим расчетом нелокального нагрева вследствие замедления горячих максвелловских фоновых электронов в холодной абляционной плазме. Результаты модели абляции окатышей нейтральным газом расширены и включают в себя эффекты, связанные с несферическими абляционными потоками, надлежащую обработку рассеяния при кинетическом расчете теплового осаждения горячих электронов и процессы атомной физики в облаке абляции и в грануле. поверхность. Эти эффекты были рассмотрены ранее, хотя никогда не были единым целым. Несферическая природа потока абляции уменьшает скорость абляции примерно в два раза, в то время как использование полного максвелловского распределения для горячих электронов увеличивает абляцию примерно в четыре раза. В случае максвелловских горячих электронов эффекты атомной физики (главным образом из-за диссоциации и сублимации) могут снизить скорость абляции почти в два раза. Эти эффекты систематически оцениваются с использованием простых физических аргументов и результатов кода. Для сравнения с экспериментом приведем простое соответствие результатов кодовой скорости абляции для сферических дейтериевых шариков: G 1,65 x 10 R [см] n [см] T [эВ] атомов / с, где R - радиус шарика, а n (T) - плотность плазмы (температура). Это соответствие сравнивается с измеренными локальными показателями абляции в омических разрядах на TFTR и JET. Предсказанные профили скорости абляции хорошо согласуются с данными по TFTR, но плохо с данными по JET; Глубина проникновения гранул хорошо согласуется на обеих машинах. Обсуждаются возможные причины наблюдаемых расхождений (как экспериментальных, так и теоретических); в частности, показано, что транспортные процессы в плазме после инъекции способны объяснить некоторые различия.

PROMT translation

Процесс удаления водородных топливных шариков в горячем намагниченном plasmas исследован, используя недавно разработанные два размерных кодекса гидродинамики с временной зависимостью, P2D. Поверхностное испарение и удаленный поток жидкости развиты, вместе с кинетическим вычислением нелокального нагревания из-за замедления горячих электронов истории Maxwellian в удаленной плазме холода. Результаты нейтральной модели ограждения газа удаления окатыша расширены, чтобы включать эффекты из-за несферических потоков удаления, надлежащей обработки рассеивания в кинетическом вычислении горячего электронного теплового смещения и атомных процессов физики в облаке удаления и в поверхности окатыша. Эти эффекты рассмотрели ранее, хотя никогда как всестороннее целое. Несферическая природа потока удаления уменьшает темп удаления приблизительно на фактор два, в то время как использование полного распределения Maxwellian для горячих электронов увеличивает удаление фактором приблизительно четырех. С горячими электронами Maxwellian атомные эффекты физики (преимущественно из-за разобщения и возвышения) могут уменьшить темп удаления до фактора два. Эти эффекты систематически определяются количественно, используя простые физические аргументы и кодируют результаты. Для сравнения с экспериментом мы даем простую подгонку к кодовым результатам темпа удаления для сферических шариков дейтерия: G

1.65 x 10 R [cm] n [cm] T [eV] atoms/s, где R - радиус окатыша и n (T), является плазменной плотностью (температура). Эта подгонка по сравнению с измеренными местными темпами удаления в омических выбросах на TFTR и САМОЛЕТЕ. Предсказанные профили темпа удаления соглашаются хорошо с теми на TFTR, но плохо с теми на САМОЛЕТЕ; глубины проникновения окатыша соглашаются хорошо на обеих машинах. Вероятные причины наблюдаемых несоответствий (и экспериментальный и теоретический) обсуждены; в частности, транспортные процессы в почтовой инъекции plasmas, как показывают, в состоянии составлять некоторые различия.

Task 1.3. Match words or phrases in column A with their synonyms in column B. Find sentences in the text with the words from column A and translate them. Make your own sentences with the words from column B.

	A		B
a	discrepancy	**1**	upload
b	dearth	**2**	difference
c	account for	**3**	produce
d	yield	**4**	explain
e	discharge	**5**	lack
f	inherent	**6**	characteristic

Task 1.4. Choose the correct word for the context:

Both living and inanimate microscopic objects are (1) *subject to/owing to* thermal (2) *fluctuations/vacillations* that cause them to (3) *jiggle/jigzag* about incessantly when viewed under an optical microscope. Many biological organisms (4) *modify/rectify* thermal (5) *hesitations/fluctuations* to facilitate transport of molecules and to move through their (6) *medium/environment*. (7) *Motility/motion* in biological systems is crucially important in a wide range of biological processes including the (8) *script/transportation* of DNA in viruses, the (9) *propulsion/effort* of bacteria as they search for food and the exercise of striated muscle (when a dumb bell is lifted). Initially, an understanding of the driven process of passive (10) *diffusion/dissolution* due to thermal energy is developed, and this is then extended to the analysis of the (11) *motions/movements* produced by molecular motors. (12) *Thanks for/owing to* the importance of this ability in determining biological process, a series of non-invasive methods have been developed to measure molecular spectroscopy, pulsed laser (13) *mechanics/techniques*, dynamic light (14) *scattering/scanning*, neutron/X-ray inelastic (15) *scattering/dissipating*, video particle (16) *pacing/tracking* and nuclear magnetic resonance spectroscopy. Due to this impressive range of dynamic experimental techniques, the field of biological (17) *locomotion/motility* has been proved with firm (18) *foundations/backgrounds*.

Task 1.5. Translate the text into English:

Значение воды и водных растворов солей и кислот трудно переоценить. Они не только составляют основу жизни, вследствие чего понятен интерес к этим объектам биологов, но и находят чрезвычайно широкое применение в технике, где именно на их использовании базируется множество технологических процессов. Все эти обстоятельства вызывают неослабевающий интерес к изучению физических свойств воды и водных растворов электролитов (ВРЭ). Большое внимание уделяется определению их диэлектрических характеристик – диэлектрической проницаемости и тангенса угла диэлектрических потерь. Этому вопросу посвящено множество статей, обзоров и ряд монографий. Однако до сих пор данные об указанных величинах, а также из зависимости от частоты нельзя засматривать как полные. В последние десятилетия в литературе появились сведения о формировании в воде гигантских гетерофазных кластеров размерами вплоть до долей миллиметра и временем релаксации более 10с. Эти результаты дают основание предположить возможность возникновения особенностей в спектре диэлектрических потерь воды в низко- и инфранизкочастотной областях. Между тем, наибольшую сложность вызывают измерения и интерпретация данных о диэлектрических характеристиках воды и ВРЭ именно в этой области частот, что связано с возникающими в приэлектронной области двойными электрическими слоями.

В литературе практически отсутствуют данные о диэлектрических характеристиках воды и ВРЭ для частот менее 100Гц. Нам известна лишь одна работа, в которой измерения электрического импеданса дистиллированной воды проводились на частотах 0,01 Гц – 100 кГц, а при анализе экспериментальных данных учитывались влияние и сложная структура двойного слоя. Следует отметить, что в двойных электрических слоях, возникающих на границе раздела ‘металлический электрод – проводящая жидкость’, можно выделить плотную и размытую (диффузионную) часть. Плотная часть (слой Гельмгольца) образуется либо в результате перехода ионов металла в жидкость (вследствие чего его электронейтральность нарушается и к поверхности металла притягиваются положительные ионы из раствора), либо путем адсорбции поверхностью металла полярных молекул жидкости. В слое Гельмгольца сосредоточены частицы, прочно связанные с поверхностью металлических электродов. Протяженность данного слоя незначительна, но именно в этой области наблюдается резкое и наибольшее падение потенциала.

Образование размытой части двойного слоя связано с процессами диффузии ионов и полярных молекул из плотной части в объем жидкости. Падение потенциала в диффузионной области – не столь резкое, как в слое Гельмгольца и, как полагают, происходит по экспоненциальному закону. Диффузионный слой – это менее стабильное образование, чем слой Гельмгольца. Даже при слабом движении жидкости в перемещение вовлекаются ионы диффузионной части, что может привести к изменению его толщины, выносимого заряда и даже знака заряда. В наибольшей степени этот слой подвержен влиянию температуры.

Words and expressions to help:

Водные растворы солей и кислот – aqueous solutions of salt and acids

Диэлектрические характеристики – dielectric characteristics of water

Диэлектрическая проницаемость – dielectric permeability

Тангенс угла диэлектрических потерь – loss angle

Гетерофазный кластер – heterophase clusters

Время релаксации – relaxation time

Диэлектрические потери виды – dielectric loss of water

GRAMMAR POINT

Некоторые способы перевода слова **'due'**:

Due – должный, нужный, подходящий, обязательный.

Example – They paid due attention to the problem. – Они уделили должное внимание данной проблеме.

Due to – 1) - благодаря (благоприятная ситуация, явление);

- из-за (неблагоприятная ситуация, явление);

Example: The experiment was stopped due to the lack of proper equipment. – Эксперимент был остановлен из-за недостатка необходимого оборудования.

- вследствие (нейтральная ситуация, явление).

2) разработанный, составленный, представленный, предложенный (если используется перед одушевленным существительным)

Example: The theory due to Stephen hawking is of great interest. – Теория, разработанная Стивом Хоукином, представляет огромный интерес.

To be due to – происходить из-за (благодаря, вследствие), обусловливается.

Example: This was due to the development of new non-invasive methods. – Это произошло благодаря развитию новых, бескровных методов.

Exercise 1.1. Translate into Russian:

1. The error is due to the latter values.
2. Due to this impressive range of dynamic experimental techniques, the field of biological motility has been provided with firm foundations.
3. Doe to the importance of motility in determination biological processes, a series of non-invasive methods have been developed to measure molecular mobility.
4. He is due to speak at the conference.
5. The disagreement was due to misunderstanding among the members of the group.
6. In this regime, efficiency chargers only slightly due to changes in Te.
7. After due consideration of the paper we passed over to other items on the agenda.

Exercise 1.2. Write your own sentences with the words and expressions:
due, due to, to be due to

Relative Clauses:

The relative pronoun: A relative clause is used to form one sentence from two separate sentences. The relative pronoun replaces one or two identical noun phrases and relates the clauses to each other. The relative pronouns and their uses are listed below.

Pronoun	**Use in formal English**
That	Whose
Which	things
Who	people
Whom	people

Whose	people/things

The relative pronoun completely replaces a duplicate noun phrase. There can be no regular pronoun along with the relative pronoun.

Examples:

Incorrect: This is the problem I studied it at the university.

Correct: This is the problem that I studied at the University.

Who/Whom – **‘**who’ is used when the noun phrase being replaced is in the subject position of the sentence. ‘Whom’ is used when it is in the complement position.

NB: In speech, whom is rarely used, but it should be used when appropriate in formal written English. If you have difficulty deciding whether ‘who’ or ‘whom’ should be used, remember the following rule:

… ‘who’ + verb

…’whom’ + noun

Examples: He was the first who referred to this article.

Dr. Jones is the only doctor whom I have seen about this problem.

‘Whom’ is also used after a preposition. In this case, the preposition should also be moved to the position before ‘whom’ in formal written English.

Example: Mr. Harrison, for whom the room had been reserved in advance, arrived at the hotel one day late.

‘Whose” – This relative pronoun indicates possession.

Example: The president, whose advisors have quit, is giving a press conference.

NB: Remember that a sentence with a relative clause can always be presented as two separate sentences, so clause must contain a verb.

Examples: I read books, which I borrowed from the library. – I read books. I borrowed them from the library.

We know professor N., whose articles were published in Scientific Observer. – We know professor N. His articles were published in Scientific Observer.

Exercise 1.3. Present the following sentences with a relative clause as two separate sentences:

1. John's wife, who is a professor, has written several papers on the subject.
2. The number of students who have bee counted is quite high.
3. The book that is on the shelf is the one that I need.
4. All money that was accepted has already been released.
5. Mr. Parker is the man who was chosen to represent the committee at the convention.
6. Most labs have small machines which are used for demonstration purposes.
7. These particles were named quarks by the Caltech physicist Murray Gell-Mann, who won the Nobel Prize in 1969.
8. It was thought that protons and neutrons were 'elementary' particles, but experiments in which protons were collided with other protons or electrons at high speeds indicated that they were made up of smaller particles.
9. The ablation process, which involves complex interactions between the pellet's partially conducting ablation cloud, the background plasma, the ambient magnetic field and the pellet's motion is poorly understood and diagnosed.
10. The difficulties inherent in diagnosing the rapid and highly perturbing ablation process have, until recently, made for a dearth of direct measurements with which to compare theoretical predictions.

Task 1.6. ***RENDERING PRACTICE***

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

Tools for Plasma Control in Tokamak

This is not nuclear fission that is currently in use, but nuclear fusion, which many regard as the main energy source of the future. Among others, the ITER project, the third most expensive in history, is seeking to turn this venture into reality and is making use of the Tokamak reactor for this purpose. Reactors of this type and the plasma used in them to carry out fusion have a number of control problems, and to solve them the electronics engineer Goretti Sevillano has come up with some tools in her thesis defended at the University of the Basque Country. Her thesis is entitled “Tools for plasma control in Tokamak nuclear fusion reactors: Astra-Matlab integration and control in real time”.

What happens in fission is that the nucleus of an atom is split; this is in stark contrast to fusion in which two lightweight atoms join together. Sevillano explains that the latter could generate more energy than fission, on which nuclear power stations are currently based. But that is not all. "In fission reactions there is a risk of explosion, but not in fusion, so nothing like what took place in Chernobyl or Fukushima would ever happen. What is more, the waste generated in fission has a very long life and is radioactive; but this is not the case in fusion. Likewise, the fuels are more accessible. Uranium or plutonium is used in fission, and its access is not so widespread; but in fusion, helium or tritium, which can be obtained from water or earth, are used," she explains. So her PhD thesis is another step along the path to fusion.

Among all the reactors it is the Tokamaks studied by this researcher which are best placed in the race to obtain efficient energy from nuclear fusion. Sevillano has detailed how they function: "The materials used in fusion must have certain specific features, and these materials have to be turned into plasma. At the same time, the plasma has to be restricted to a limited space to enable the reaction to be generated and the energy to be used. To achieve this, magnetic confinement is applied in the case of the Tokamaks." In other words, the magnetic field creates lines that act as a wall to keep the plasma in the space where it is meant to remain. But the plasma and the device itself have several problems that have yet to be solved, and Sevillano has worked on some of them.

"To develop Tokamaks, many of the plasma's parameters must be controlled, as well as the whole device itself; the currents that are going to be used, the voltage, the intensity, etc. Until all these things are controlled, it will not be possible to use these machines to produce marketable energy," the researcher points out. In connection with this, Sevillano has embedded a code known as ASTRA into the Matlab software; ASTRA is frequently used to simulate the behaviour of Tokamak reactors, and the embedding of this code into Matlab will facilitate the development of controllers suited to these devices. The control problems are of several kinds, but in this case some very specific parameters relating to the plasma have been explored in depth. "Control of the parameters is necessary to obtain the maximum energy possible from the plasma, and the amount of this energy that can be extracted is calculated on the basis of the current: the greatest amount of current possible has to be maintained during the longest time possible. That is why these parameters have to be controlled by means of the control, in turn, of the numerous coils and voltages within the structure," she adds. Sevillano points out that this PhD thesis has produced only a single branch of what would be a complete tree. "All I have achieved is no more than a step towards doing more things. The aim of all these tasks is to design a machine capable of generating marketable energy within the ITER project," she explains. It is a long-term task: they have been working on nuclear fusion for the last 50 years and they calculate they will obtain some results around the year 2050.

Task 1.7. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 1.8. Discuss the text with your partner.

Task 1.9. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 1.10 Watch the video and in your own words report the main idea of it.

https://www.youtube.com/watch?v=WavEMOp9Ed0

Task 1.11 Academic Writing

Study the information on academic writing and do the exercises.

THE PURPOSES OF ACADEMIC WRITING

1.11.1.The most common reasons for writing:

- to report on a piece of research the writer has conducted
- to answer a question the writer has been given or chosen
- to discuss a subject of common interest and give the writer's view to synthesize research done by others on a topic

1.11.2.Common types of academic writing

- Notes
- Reports
- Projects
- Essays
- Dissertations/Thesis
- Papers

1.11.3.The most common written sources

- Textbooks
- Websites
- Journal articles
- Official reports (e.g. from government)
- Newspaper or magazine articles
- e-books

1.11.4.The most common requirements to your academic text

- your should give reasons for your initial hypothesis
- you should obtain more well-rounded data
- you should show the logic of your experiments
- you should present clear, consistent logical argument to somebody else involved in the research of this field.

Exercise 1.11.4. Read the introduction and answer the questions.

1 Introduction

Understanding and controlling instabilities in a magnetically confined plasma is of major importance on the road to the production of electricity through nuclear fusion. One major difficulty lies in the computational cost associated to the kinetic study of the micro-turbulence (in microseconds and millimeters) at the global confinement time (in seconds and meters), which exceeds the capabilities of current top-Tier computers. Solutions based on multiscale modelling or using a set of reduced models (using fluid, MHD description) can be used in order to alleviate the computational load. This comes nonetheless at the cost of more complex software development and maintenance. To build such multiscale or multi-models application, an interesting approach [1] consists in coupling single scale components (where a scale can be either spatial, temporal or refer to a different physics or numeric model), where each single component is easier to develop, validate and maintain. Such coupling can rely on the usage of a data structure common to allcomponents, and possibly using a dedicated I/O library to access the data, as proposed by the EFDA ITM-TF task force [2, 3]. The coupled application is then described using a script based approach or controlled by a scientific workflow manager. In such workflows, coupled components can be legacy codes, possibly running in parallel, at different core count and runtime, making its optimal execution on the targeted environment more complex. A solution to simplify the execution of such workflow consists in running the simulation platform within a regular parallel allocation in a single computer. The Integrated Plasma Simulator

[4] is based on such principle: it runs in a single (possibly very large) computing allocation and handles internally the scheduling of load balancing of the tasks associated with each component, considering several layers of abstraction for the parallelism. We have implemented within the IPS platform two fusion workflows with different computational needs: an acyclic (loose-coupling) chain composed of a high-resolution equilibrium reconstruction and its stability study, and a cyclic (tight-coupling) turbulence transport time evolution. The acyclic case involves a parameter scan for which the runtime of each run can differ a lot, whereas the cyclic case is composed of codes which have to be executed in sequence with different level of parallelism and computational cost. This contribution presents briefly the characteristics of the IPS platform and compares them to other platforms used by the fusion community in Europe. The layered implementation required to embed legacy codes coming from the ITM community into the IPS platform is presented for generic components. Finally, targeted cyclic and acyclic workflows are presented and their characteristics are discussed to highlight the benefits of using one or another platform in the different configurations.

1.What is a piece of research the writer has conducted?

2. Did the writer give an answer to the question that he/she has been given or chosen?

3. Was it the subject of the common interest?

4. Did the writer manage to synthesize research done by others on a topic?

5. What is the difference between textbooks, websites, journal articles, official reports, newspaper or magazine articles, e-books?

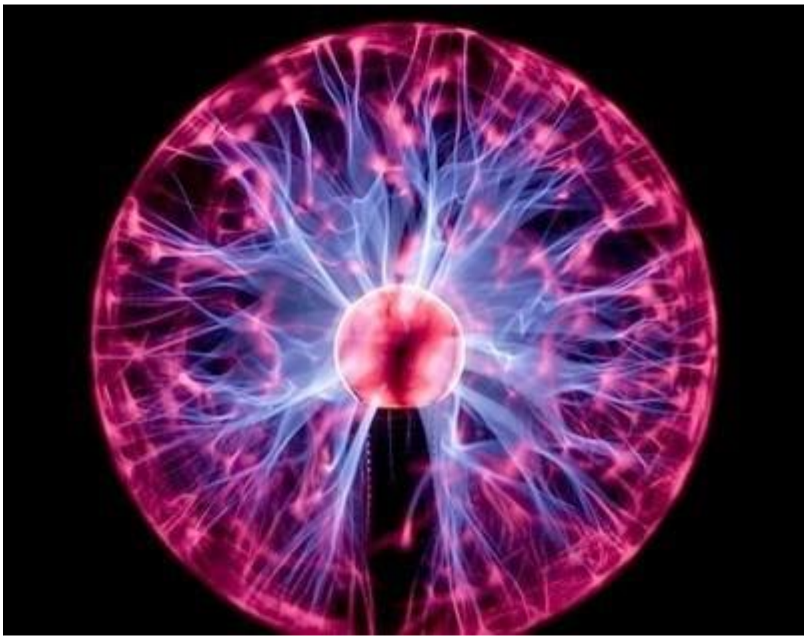
6. Find examples of the mentioned above writing formats in the Internet.

7. What are the most common requirements to an academic text?

1.11.5 Look at Punctuation rules in the Appendix and find examples of some rules in the Text 1.11.4

UNIT 2

TEXT 2. Wave field Calculation and the Ray Tracing Method.



Radio frequency heating and current drive are important features of many tokamaks. In order to predict the efficiency of the current drive and where it takes place in the tokamak profile, computational techniques which couple calculations of the wave field to Fokker–Planck solutions of the electron distribution function have been developed. In the electron cyclotron and lower hybrid (LH) frequency ranges the wave field is often calculated using ray tracing techniques, though more recently some full wave calculations have been done. Ray tracing provides a simpler way of proceeding, but the problem arises of dealing with the situation in which there is not a single well defined beam and diffraction and beam divergence are important. Since an LH antenna produces a complicated spectrum, launching waves in a range of directions, the problem is particularly acute there. In this paper we suggest a way of calculating the wave field from tracing of multiple rays using a technique based on the stationary phase approximation. We demonstrate how it can be used and its effectiveness through a number of simple examples.

Heating and current drive by radiofrequency waves are important features of most large tokamaks and a number of numerical codes have been written to predict their effectiveness. We shall be particularly concerned with the electron cyclotron (EC) and lower hybrid (LH) frequency ranges, in both of which the wavelengths are sufficiently short compared with the size of the system for ray tracing techniques to be useful. The EC range is the simpler of the two since the waves can be launched from a simple waveguide and propagates from the vacuum into the plasma in a straightforward way. LH is more complicated in that it requires waves to be launched with parallel wavelengths which are evanescent in vacuum and needs a more complex waveguide structure to achieve this. In both cases ray tracing is widely used to calculate the radiation pattern within the plasma and the region where wave absorption takes place. In the EC case there is quite a well collimated beam, but in the LH case the antenna launches a range of wave numbers. Especially in a small tokamak like the Compass machine in Prague, in which we have a particular interest, the launch spectrum is broad. In both cases ray tracing has a number of problems such as the neglect of diffraction and the need for a large number of rays in some cases.

Recently full wave calculations have been carried out in the LH regime but this is very computationally demanding and it would still be useful to find a simpler approach which takes account of diffraction while retaining the simplicity of ray tracing. One method which has been developed, particularly by Pereverzev and collaborators, is paraxial beam tracing. This is based on methods initiated by Maslov and basically involves following the path of a beam, but expanding the parameters around the axis of the beam so that it has a Gaussian envelope whose width reflects the effects of diffraction on the beam. If an LH antenna is large enough then it might be a reasonable approximation to consider just a single ray at the peak of the spectrum and approximate its width in this way. The radiation from a smaller antenna is not well approximated by a single beam, even if it has a finite width. A number of rays might be launched to try to cover the spectrum, but then the problem arises of just how the wave amplitude at any point in the tokamak is related to these rays. The problem is less acute in the EC regime, but even there the approximation of a Gaussian beam may not give a very exact representation of the diffraction pattern produced by the antenna. In this paper we suggest a different method based on the use of the asymptotic method of stationary phase.

Topic vocabulary:

Current drive – генерация тока, computational techniques – методы вычисления, ray tracing techniques – методы определения траектории луча, full wave calculations – расчеты полной волны, way of proceeding – способ обработки данных, beam of divergence – отклонение луча, acute problem – острая проблема, stationary phase approximation – приближение стационарных фаз, propagate - распространяться, evanescent – ничтожно малый, complex waveguide structure – сложная структура волновода, well collimated beam – хорошо коллимированный пучок, paraxial beam tracing – отслеживание траектории осевого луча, finite width – конечная ширина, wave amplitude – волновая амплитуда, axis – ось.

Task 2.1. Answer the questions

1) What is the general goal of wave field calculations?
2) Which methods of a wave field calculation are discussed?
3) What are the features of the EC and the LH frequency ranges?
4) Which restrictions does the ray tracing method have?
5) Why aren't full field calculations always possible?
6) What is the basis of the paraxial beam tracing method?
7) Which approach might be used if an LH antenna is large?
8) What is the problem of beam tracing in case of a small antenna?
9) Does the paraxial beam tracing method allow of correct treating the diffraction in case of a small EC antenna?
10) Which method of wave field calculations is suggested in this article?

Task 2.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

Radio frequency heating and current drive are important features of many tokamaks. In order to predict the efficiency of the current drive and where it takes place in the tokamak profile, computational techniques which couple calculations of the wave field to Fokker–Planck solutions of the electron distribution function have been developed. In the electron cyclotron and lower hybrid (LH) frequency ranges the wave field is often calculated using ray tracing techniques, though more recently some full wave calculations have been done. Ray tracing provides a simpler way of proceeding, but the problem arises of dealing with the situation in which there is not a single well defined beam and diffraction and beam divergence are important. Since an LH antenna produces a complicated spectrum, launching waves in a range of directions, the problem is particularly acute there. In this paper we suggest a way of calculating the wave field from tracing of multiple rays using a technique based on the stationary phase approximation. We demonstrate how it can be used and its effectiveness through a number of simple examples.

Google translation

Радиочастотный нагрев и токовая передача являются важными характеристиками многих токамаков. Чтобы предсказать эффективность привода тока и место его возникновения в профиле токамака, были разработаны вычислительные методы, которые связывают расчеты волнового поля с решениями Фоккера – Планка функции распределения электронов. В диапазонах частот электронного циклотрона и нижнего гибрида (LH) волновое поле часто вычисляется с использованием методов трассировки лучей, хотя в последнее время были сделаны некоторые полноволновые вычисления. Трассировка лучей обеспечивает более простой способ продолжения, но возникает проблема, связанная с ситуацией, в которой нет ни одного четко определенного луча, и важны дифракция и расходимость луча. Поскольку LH-антенна создает сложный спектр, запускающий волны в разных направлениях, проблема здесь особенно остра. В этой статье мы предлагаем способ расчета волнового поля по трассировке нескольких лучей с использованием метода, основанного на приближении стационарной фазы. Мы демонстрируем, как его можно использовать и его эффективность, на нескольких простых примерах.

PROMT translation

Нагревание радиочастоты и текущий двигатель - важные особенности многих токамаков. Чтобы предсказать эффективность текущего двигателя и где это происходит в токамаке profile, вычислительные методы, какие вычисления пары области волны к решениям Fokker–Planck электронной функции распределения были развиты. В электронном циклотроне и частотных диапазонах более низкого гибрида (LH) область волны часто вычисляется, используя поисковые методы луча, хотя позже некоторые полные вычисления волны были сделаны. Отслеживание луча обеспечивает более простой способ продолжиться, но проблема возникает справления с ситуацией, в которой нет ни одного хорошо определенного луча, и дифракция и расхождение луча важны. Так как антенна ЛЮФТГАНЗЫ производит сложный спектр, начиная волны в диапазоне направлений, проблема особенно острая там. В данной статье мы предлагаем способ вычислить область волны от отслеживания нескольких лучей, используя технику на основе постоянного приближения фазы. Мы демонстрируем, как это может использоваться и его эффективность через многие простые примеры.

Task 2.3. Match words or phrases in column A with their synonyms in column B. Find sentences in the text with the words from column A and translate them. Make your own sentences with the words from column B.

	A		B
a	propagate	**1**	Sharp
b	trace	**2**	Spread
c	divergence	**3**	Deviation
d	carry out	**4**	very small
e	pattern	**5**	Way
f	acute	**6**	make complete
g	approach	**7**	Detect
h	evanescent	**8**	Model

Task 2.4. Words often confused. Put the words into the sentences:

Track step progress pace

1.I followed the………………of the scientific research in the report.

2.We must keep in……………with modern development in our scientific brand.

3.The professor spoke so quickly that I couldn't keep……………with him.

4.With the help of modern telescopes it is not difficult to…………….of asteroid's position on the orbit.

NB: ***track*** – (след), отслеживать, прослеживать (обычно с предлогами of, out, up, down)

step – (шаг) to keep in step with… идти в ногу с ….

pace – (темп) to keep pace with …. Не отставать…

progress - развитие

Task 2.5. Write your own sentences with the words

track, track out, track down, track up, step, to keep in step with, pace, to keep pace with, progress

Task 2.6. Read the text and fill in the gaps with the correct words A, B or C from the box:

The scattering phenomenon which we have just discussed was observed experimentally by A.H. Compton in 1922. It seems that he was ……(1) to his experiment by a previous observation by Barkla that when hard X-rays are scattered at large ……(2) by a solid materials, the scattered rays seemed to consist of two components: one component having properties identical ……(3) the incident radiation but the other component ……(4) different, which difference manifested itself through a difference in the rate at which this radiation was ……(5) by intervening media. On the basis of the wave picture we can readily understand the ……(6) of the first component. The incident electromagnetic waves, i.e., the incident X-rays, set the electrons ……(7) in the atoms in oscillation at the same frequency w as the frequency of the wave, and these oscillating electrons will then ……(8) .electromagnetic radiation in all directions at the frequency w.. In this process, the ……(9) of the atom is only temporarily disturbed, and the electrons are not ejected. We may expect that it is mostly the tightly bound electrons which will give ……(10) to this kind of scattering.

1	A led	B resulted	C directed
2	A corner	B angle	C curve
3	A to	B by	C with
4	A being	B been	C be
5	A skimmed	B absorbed	C detected
6	A incidence	B recurrence	C occurrence
7	A link	B bound	C connection
8	A emit	B issue	C get off
9	A state	B condition	C structure
10	A arise	B increase	C rise

Task 2.7. Translate the text into English:

Кварк-глюонная плазма (КГП) представляет собой состояние сильно взаимодействующей материи, в которой освобожденные цветные кварки и глюоны образуют непрерывную среду (хромоплазму) и могут распространяться в ней как квазисвободные частицы. Возникает «цветопроводимость», аналогичная электропроводимости, возникающей в обычной электронно-ионой плазме.

По современным представлениям, КГП может образовываться при высоких температурах и/или больших плотностях адронной материи. Предполагается, что в естественных условиях такая плазма существовала в первые 10^{-5} секунд после Большого взрыва. Условия для ее образования могут существовать в центре нейтронных звезд. Экспериментальное наблюдение КГП – одна из приоритетных задач современной ядерной физики. Наиболее перспективным методом получения КГП считается соударение релятивистских тяжелых ионов. Поэтому исследование ядерно-ядерных (A + A) взаимодействий – одно из важнейших научных направлений в физике высоких энергий.

Расчеты, выполненные на основе квантовой хромодинамики на решетке, предсказывают, что при повышении температуры ядерной материи до значения примерно 170МэВ должен происходить переход из обычной ядерной материи с состояние КГП. В таком состоянии нарушается принцип конфайнмента (пленение кварков в аднонах) и происходит частичное восстановление киральной симметрии. Ожидается, что исследование подобного состояния вещества поможет дать ответ на фундаментальный вопрос физики сильных взаимодействий о природе сил, связывающих кварки и бесцветные адроны.

В течение последних нескольких лет основным ускорителем для изучения взаимодействий тяжелых ядер ионов (RHIC) в Брукхейвенской национальной лаборатории, США. Один из двух больших экспериментов на данном ускорителе – спектрометр ФЕНИКС, который представляет собой сложный экспериментальный комплекс, предназначенный для детектирования и идентификации заряженных и нейтральных частиц, а также для определения их импульсов и энергий. Для измерения характеристик заряженных частиц в эксперименте ФЕНИКС реализована уникальная трековая система, основными элементами которой являются дрейфовые и падовые камеры. Уникальность системы заключается в высокой эффективности (75 – 100%) восстановления треков заряженных частиц в условиях большой множественности, высоком быстродействии (время измерения примерно 500 нс), малой радиационной длине, а также высоком импульсном разрешении. Треки, восстановленные в дрейфовых камерах, экстраполируются до пересечения с другими детекторными подсистемами, предназначенными для идентификации частиц, измерения их энергий, времени пролета и т.д. Для подтверждения треков используется несколько слоев падовых камер, которые измеряют координаты точек пересечения треков заряженных частиц с их плоскостями.

Words and expressions to help:

кварк-глюонная плазма – quark-gluon plasma

цветные кварки – colourful quarks

непрерывная среда – uniform medium

цветопроводимость – colourconductivity

электронно-ионная плазма – electron-ion plasma

адронная материя – hadronic matter

Большой взрыв – Big Bang

приоритетные задачи – crucial questions

ядерно-ядерные взаимодействия – nucleon-nucleon interactions

принцип конфайнмента – principle of confinement

киральная симметрия – kiral symmetry

бесцветные адроны – colourless hadron

GRAMMAR POINT

Singular and Plural forms of the nouns of Greek and Latin origin

singular	Plural
Phenomenon Gr. (явление)	Phenomena (явления)
Datum Lat. (данное)	Data (данные)
Thesis Gr. (тезис)	Theses (тезисы)
Radius Lat. (радиус)	Radii (радиусы)
Formula Lat. (формула)	Formulae/formula (формулы)
Analysis Gr. (анализ)	Analyses (анализы)
Axis Gr. (ось)	Axes (оси)
Basis Gr. (база)	Bases (базы)
Criterion Gr. (критерий)	Criteria (критерии)
Medium Lat. (среда)	Media (среды)

Most word roots are never used alone. They may have prefixes and suffixes to them. Once you recognize word root, you will see connections among many words. This will make it easier for you to understand and remember their meanings. Every time you look up a word in the dictionary, look at its word root (most roots in English come from Latin or Greek).

Example:

DUC → to lead ← DUCT

↓ ↓

to induce	***viaduct***
conductive	***to conduct***
ductile	***to deduct***
a duct	

1. ***to conduct*** = to lead

The inspector was conducted around the factory.

2. ***conductive*** = helpful; that contributes to

A dark room is more conductive to sleep than a bright one.

3. ***a duct*** = a tube or canal that carries fluids, or one that carries electric power, telephone cables

Most glands in human bodies have ducts to carry their secretions.

4. ***to deduct*** = to subtract, or take away

Income tax is deducted from the paycheck of a wage earner.

5. ***ductile*** = easily lead; pliable

Copper is a ductile metal.

6. ***to induce*** = to cause an effect

Political repression and poverty induced many people to leave their homeland and emigrate.

7. ***viaduct*** = a long high bridge which carries a road or railroad

Some of the old viaducts are not high enough for today's tall trucks to go under.

8. ***aqueduct*** = a system of canals and bridges which carry water

Some of the aqueducts built by the Romans still bring water to modern cities.

Exercise 2.1. Write two examples of words for each of the Greek/Latin root below.

	Root	**Meaning**	**Examples**
1	Aster	star	
2	Auto	self	
3	Bio	life	
4	Capit	head	
5	Corp	body	

6	Cycl	wheel, circle	
7	Domin	master	
8	Dynamo	power	
8	Flex	bend	
9	Form	shape	
10	Gen	birth	
11	Geo	earth	
12	Hetero	other, different	
13	Hydro	water	
14	Leg	law	
15	Loc	place	
16	Mar	sea	
17	Mob	move	
18	Nom	name	
19	Omni	all	
20	Phone	sound	
21	Port	carry	
22	Rupt	break	
23	Scope	watch	
24	Spec	look, watch	
25	Term	end, limit	
26	Tract	draw, pull	

Task 2.8. ***RENDERING PRACTICE***

Preparation for rendering: Read the text / Find key words / Make up a plan /Retell the text in your own words.

Tungsten and Tungsten Alloys

Tungsten and tungsten alloys are presently considered as candidate materials for the helium cooled divertor and possibly for the protection of the helium cooled first wall in DEMO designs, mainly because of their high temperature strength, good thermal conductivity, and low sputter rates. There are two types of applications for these materials which require quite different properties: one is for their use as plasma-facing armor or shield component, the other is for structural purposes. An armor material needs high crack resistance under extreme thermal operation conditions and compatibility with plasma–wall interaction phenomena, while a structural material has to be ductile within the operation temperature range. Both material types have also to be stable with respect to high neutron irradiation doses and helium production rates.

The long-term objective of the present EFDA program is to provide structural as well as armor materials in combination with the necessary production and fabrication technologies for future divertor components. On a European level, fusion materials research is strengthened by integrating new partners, in particular large-scale facilities like synchrotron and neutron laboratories, into the materials development and characterization process by the FP7 coordination action "FEMaS". Presently there are many unsolved issues, contradictions, and problems related to the use and properties of tungsten materials. Therefore the roadmap is structured into four lines of classical engineering research: (1) Fabrication process development, (2) structural material development, (3) armor material optimization, and (4) irradiation performance testing. They are complemented by an additional basic research line: (5) Materials science and modeling.

Irradiation performance testing provides experimental information on neutron irradiation damage of tungsten and tungsten alloys. In the near future, this area will be kept at a low level, since all the presently available tungsten grades, which have been irradiated, show extreme post-irradiation brittleness. Also, this EFDA program and the cooperation with external irradiation programs will give new directions for improvement, which will have to be formulated into a metallurgical specification to fabricate improved W-based materials and/or W-alloys for functional and structural applications. However, the main objective of all research areas is the identification of applicability restrictions for tungsten and tungsten-based materials for their use as helium cooled divertor parts. This will be performed in the short- and mid-term program so that by the end of 2012 possible show stoppers will be identified and possible alternative solutions might be presented, if necessary. To make the program as economic as possible, the different research areas are also interlinked to other EFDA and external groups with respect to information and materials exchange.

Task 2.9. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 2.10. Discuss the text with your partner.

Task 2.11. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com
https://coggle.it

Task 2.12. Watch the video, in your own words report the main idea of it.
https://www.youtube.com/watch?v=AVEGJZxglIg

Task 2.13 Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

WRITING A PARAGRAPH

A paragraph- a group of related sentences that discuss mainly one idea. It

- can be long enough;
- the number of sentences is unimportant;
- visually organized

2.13.1.Three parts of a paragraph:

- The topic sentence - states the main idea of the paragraph
  - names the topic
  - limits the topic to one specific area
- The controlling idea - announces the specific area
- Supporting Sentences - develop the topic sentence;
  - explain or prove the topic sentence;
  - give more information
- Concluding sentence - signals the end of the paragraph;
  - summarizes the paragraph. with important points to remember.(It can do this in two ways: by summarizing the main points of the paragraph or by repeating the topic sentence in different words)
  - is needed only for stand-alone paragraph.

Exercises :

I. Agree or disagree with the following points about paragraphs

1). *A good topic sentence:*

a) is a complete sentence with a subject, a verb, and a controlling idea;

b) states the main idea of the paragraph

c) is neither too general nor too specific;

d) the controlling idea limits the topic to one specific area that can be discussed.

e) is usually the first sentence in the paragraph

f) the helpful guide to both: the Writer and the Reader

2. Good supporting sentences :

a) develop the topic sentence (explain or prove the topic sentence by giving more information about it).

b) are specific and factual

c) can be examples, statistics, or quotations

3. A good concluding sentence:

a) signals the end of the paragraph and leaves the reader with important points to remember.

b) summarizes the important points briefly or restates the topic sentence in different

UNIT 3

TEXT 3. Electronegative and Electropositive Plasmas

The fluid equations for active plasma generated by electron impact containing more than one species of positive ion are examined in detail when the ionization frequencies are assumed to be spatially constant with a view to generalizing the Bohm Criterion. It is shown that in this specific situation the various ion spatial distributions and transverse ion speed distributions are geometrically similar and thus each species arrives at the sheath with its own Bohm speed, when the plasma is collisionless. The collision situation is also examined with the conclusion that in that case as well, ion densities and ion speeds are again geometrically similar. The transition between the collisionless and collision cases is discussed but not examined in detail.

The current interest in using plasmas formed from molecular gases for plasma processing means that there is a need to understand the way in which more exotic plasmas differ from simple electropositive ones. Much effort has gone into the understanding of electronegative plasmas with two negative species, namely, electrons and negative ions, from Thompson (1959) to more recently Lieberman and Lichtenberg (1994), Franklin and Shell (1999), Lichtenberg et al (2000), Franklin (2000) and references therein.

This paper is concerned with the converse situation where there are several species of positive ions, and electrons. An earlier consideration of this situation was discussed by Valentini and Hermann who, amongst other things, sought to generalize the Bohm Criterion. They effectively set up the relevant plasma equations but did not solve them in detail. This paper takes essentially the same model and pursues it further. Their composite expression for Bohm Criterion is confirmed but, using the plasma generation and loss equations, it is found that there is a separate criterion for each species when all ions are generated by electron impact. Other relevant work concerning the Bohm Criterion with multiple ion species by examining the sheath equations has been performed by Benilov, who discussed matching sheath and plasma in the multi-ion situation.

We will give results separately for the collisionless and collision cases so far as the ion motion is concerned. It is to be expected that a generalization along the lines of that given by Forrest and Franklin (1996) for simple electropositive plasmas will allow the transition to be mapped out in a smooth manner but we have adopted the approach of introducing only two new parameters here. They are the ratio of the ionization frequencies, each being assumed to be constant, and the ratio of the ion masses. Describing the transition would require a further two new parameters, namely the ratio of collision frequency-ionization rate for each species. It is reasonable to expect that the transition will be smooth, but we examine that situation in a later paper.

We have solved the problem concerned both analytically and computationally, but in the light of insight gained from the computed results we concentrate on analytical work here. We set the ion temperatures to zero, but a systematic method of dealing with the regular singularities associated with non-zero ion temperatures. So the inclusion of non-zero ion temperatures is feasible.

Topic vocabulary:

Electronegative plasma – отрицательно заряженная плазма, converse situation – обратная ситуация, electron impact – электронный удар, sheath equation – уравнение для слоя, collisionless and collision cases – бесстолкновительные и столкновительные случаи, to map out - спланировать, ionization frequencies –

частоты ионизации, the ratio of collision frequency –ionization rate – отношение частоты столкновений к скорости ионизации, ion spatial distribution – пространственное распределение ионов, transverse ion speed distribution – распределение поперечной скорости ионов.

Task 3.1. Answer the questions

1) Why are the presented studies necessary?
2) Is it the first effort to study plasmas with more than one species of positive ion?
3) Does this paper study electronegative plasmas with two negative species?
4) Which model is pursued in this paper?
5) How was the Bohm Criterion with multiple ion species obtained in earlier works?
6) How are sheath and plasma matched in this paper?
7) Which new parameters are introduced in addition to the case of simple electropositive plasmas?
8) What ion temperature value is taken?
9) Is the solution analytical or computational?
10) Is the sheath-plasma transition described?

Task 3.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

The fluid equations for active plasma generated by electron impact containing more than one species of positive ion are examined in detail when the ionization frequencies are assumed to be spatially constant with a view to generalizing the Bohm Criterion. It is shown that in this specific situation the various ion spatial distributions and transverse ion speed distributions are geometrically similar and thus each species arrives at the sheath with its own Bohm speed, when the plasma is collisionless. The collision situation is also examined with the conclusion that in that case as well, ion densities and ion speeds are again geometrically similar. The transition between the collisionless and collision cases is discussed but not examined in detail.

The current interest in using plasmas formed from molecular gases for plasma processing means that there is a need to understand the way in which more exotic plasmas differ from simple electropositive ones. Much effort has gone into the understanding of electronegative plasmas with two negative species, namely, electrons and negative ions, from Thompson (1959) to more recently Lieberman and Lichtenberg (1994), Franklin and Shell (1999), Lichtenberg et al (2000), Franklin (2000) and references therein.

Google translation

Уравнения жидкости для активной плазмы, генерируемой электронным ударом, содержащим более одного вида положительного иона, детально исследуются, когда предполагается, что частоты ионизации являются пространственно постоянными с целью обобщения критерия Бома. Показано, что в этой конкретной ситуации различные пространственные распределения ионов и поперечные распределения скоростей ионов геометрически схожи, и, таким образом, каждый вид достигает оболочки с собственной скоростью Бома, когда плазма не сталкивается. Ситуация со столкновением также рассматривается с выводом, что в этом случае ионные плотности и скорости ионов снова геометрически схожи. Переход между случаями без столкновений и столкновений обсуждается, но не рассматривается подробно.

В настоящее время интерес к использованию плазмы, образованной из молекулярных газов, для обработки плазмы означает, что существует необходимость понять, чем отличаются более экзотические плазмы от простых электроположительных. Много усилий было уделено пониманию электроотрицательной плазмы с двумя отрицательными видами, а именно электронами и отрицательными ионами, от Томпсона (1959) до более поздних Либерман и Лихтенберг (1994), Франклин и Шелл (1999), Лихтенберг и др. (2000) , Франклин (2000) и ссылки в нем.

PROMT translation

Жидкие уравнения для активной плазмы, произведенной электронным воздействием, содержащим больше чем одну разновидность положительного иона, исследованы подробно, когда частоты ионизации, как предполагается, пространственно постоянные в целях обобщения Критерия Bohm. Показано, что в этой определенной ситуации различный ион пространственные распределения и поперечные распределения скорости иона геометрически подобны, и таким образом каждая разновидность прибывает в оболочку со своей собственной скоростью Bohm, когда плазма бесстолкновительная. Ситуация со столкновением также исследована с заключением, что в этом случае также, удельные веса иона и скорости иона снова геометрически подобны. Переход между бесстолкновительными случаями и случаями столкновения обсужден, но не исследован подробно.

Текущая процентная ставка в использовании плазмы сформированный из молекулярных газов для обработки плазмы означает, что есть потребность понять путь, которым более экзотические плазмы отличаются от простых электроположительных. Много усилия вошло в понимание электроотрицательного плазма с двумя отрицательными разновидностями, а именно, электронами и отрицательными ионами, от Томпсона (1959) позже Либерману и Лихтенбергом (1994), Франклин и Шелл (1999), Лихтенберг и др. (2000), Франклин (2000) и ссылки там

NB: Some common words and collocations:

mean – средний

a mean – средняя величина

a means – способ, средство

by means of – с помощью

by no means – ни в коем случае

by all means – обязательно, во что бы то ни стало

to mean значить, иметь в виду, подразумевать

Task 3.3. Translate into Russian:

1. By the modification we mean application of a partial summation technique.
2. These facts mean that talk about properties might well be in order.
3. The current interest in using plasmas formed from molecular gases for plasma processing means that there is a need to understand the way in which more exotic plasmas differ from simple electropositive ones.
4. These facts should be taken into consideration by all means.
5. The problem of stating a new system is by no means easy.
6. Those statements were similar in their meaning.
7. In the electron-cyclotron and lower hybrid frequency ranges the wave field is often calculated by means of ray tracing techniques.
8. Our present-day formulation of quantum electrodynamics means a theory in which the electron and the positron play a completely symmetric role.
9. Then the mean is the best estimate of ray peak location.
10. This question by no means can be answered at present, although one might be inclined to believe that anti-galaxies do not exist.

Task 3.4. Write your own sentences using the expressions with the word 'mean' from the above.

Task 3.5. Read the text and fill in the gaps with the correct words A, B or C from the box:

Let us see how we can understand the last mentioned ……(1) theoretically. First of all, we note that according to classical electromagnetic theory a ……(2) moving electron cannot ……(3) radiation. We can draw the same ……(4) on the basis of the photon theory ……(5). Consider the rest-frame of the electron before any possible emission: in this frame the total energy is mc^2. If an emission of one or more photons could take place these photons would ……(6) energy, and the total final energy after the emission would be larger than mc^2, which violates energy conservation. The emission should therefore not ……(7).

The situation is different, however, when the electron ……(8) the strong electric field of a nucleus in the target. It is then possible for the electron to transfer some energy and momentum to the nucleus, and the conservation equations for energy and momentum can be balanced. Let us see how this ……(9). The nucleus of mass M is originally at rest (in the laboratory frame) and the electron, of mass m and initial momentum p_i, impinges upon it. After the collision the electron has momentum p_j, and the nucleus has momentum p_n. The equations taken together give us four …….(10) equations.

There are, however, nine variables which characterize the final situation, ……(11) the nine components of the three vectors. The detailed investigation of the permissible range of these vectors is ……(12) involved and we shall not attempt it.

1	A term	B circumstance	C element
2	A uniformly	B steadily	C continuously
3	A produce	B issue	C emit
4	A jolt	B collision	C jerk
5	A as concerns	B as regards	C as follows
6	A carry away	B carry on	C carry out
7	A take into account	B take in turns	C take place
8	A passes away	B passes through	C passes by
9	A works out	B works away	C works off
10	A reservation	B conservation	C concentration
11	A namely	B surely	C exactly
12	A somehow	B somewhat	C somewhere

Task 3.6. Translate the text into English:

В статье проведен качественный анализ модели нейтрального экранирования и нейтрально-плазменной модели экранирования. Указаны основные физические процессы, определяющие формирование экранирующего облака, а значит, и скорость испарения. Для модели нейтрального экранирования приведены простые формулы, связывающие скорость испарения и параметры облака с параметрами фоновой плазмы и пеллета. Проведена сравнительная оценка эффективности нейтрального и плазменного экранирования, и показано, что основная доля потока энергии фоновых электронов задерживается в плазменном облаке. Получены формулы для скорости испарения и параметров плазмы в рамках модели нейтрально-плазменного экранирования. Обсуждается, почему модель нейтрального экранирования хорошо описывает скорость испарения пеллета, несмотря на то, что она не учитывает эффектов, связанных с ионизацией и взаимодействием ионизованных частиц с магнитным полем. Это связано с тем, что скорость испарения слабо зависит от потока энергии горячих электронов, поэтому ослабление этого потока за счет электростатического и плазменного экранирования слабо влияет на скорость испарения. Это обстоятельство обосновывает использование модели нейтрального экранирования для оценки скорости испарения (с точностью до двойки) для широкого диапазона параметров пеллета и фоновой плазмы.

GRAMMAR POINT

Need to do / need doing

I need to do something = it is necessary for me to do something.

Example: There is a need to understand the ways in which exotic plasmas differ from simple electropositive ones.

Need doing = need to be done (the meaning is passive)

Example: The way in which exotic plasmas differ from simple positive plasmas needs understanding.

Exercise 3.1. Make sentences with need + ing

1. This problem hasn't been studied yet. (study) It………………….. .
2. This theory is very sophisticated. (simplify) It ………………….. .
3. These calculus are not accurate. (rectify) They ………………… .
4. The results of two recent experiments haven't been summed yet. (sum up) The results ……………….. .

Noun as an attribute (существительное в роли определения)

В роли определения существительное может быть с предлогом (после определяемого слова) и без предлога.

Example: calculus of variations – вариационное исчисление

a simulation technique – метод моделирования

Существительные, выступающие в роли определения, обычно не имеют множественного числа и, иногда, может переводиться как прилагательное.

Example: a clay ball – глиняный шар.

Правило ряда:

Существительных в роли определения к другому (главному, определяемому) существительному может быть несколько. Поэтому при переводе следует помнить правило ряда. Его можно сформулировать следующим образом: если после артикля (или другого определителя существительного) стоит ряд слов, чаще всего существительных в единственном числе без предлогов, то артикль относится к последнему слову из этого ряда, и именно с этого слова следует начинать перевод. Все остальные слова будут являться определениями.

Example: isotopic correlation technique – метод изотопной корреляции.

Следует помнить о том, что часто внутри самого ряда встречаются существительные, определяющие одно из слов ряда, а не последнее слово.

Example: The Leningrad region nuclear instrument industry exhibition opened in Moscow yesterday. – Вчера в Москве открылась выставка промышленности ядерного приборостроения Ленинградской области. Все пять слов, в конечном счете, определяют слово 'exhibition'.

О возможности такой сложной связи внутри цепочки следует помнить всегда. Итак, при переводе ряда существительных связь между словами определяется из их лексического значения, при этом можно вводить множественное число, использовать разные падежи, предлоги, но во всех случаях определяемое слово будет последним.

Example: It is desirable to find a minimal order linear time-invariant differential feed back control system. – Желательно найти линейную, инвариантную во времени, дифференциальную систему управления с обратной связью минимального порядка.

Ряд, состоящий из двух слов, казалось бы, не должен вызывать трудности при переводе. Но на практике, именно при переводе подобного ряда допускаются ошибки, потому что существительное, играющее роль определения переводится прилагательным, что далеко не всегда правильно. Либо перевод начинается с первого слова, что приводит к искажению смысла.

Example: the particle velocity – скорость частиц (но не частичная скорость)

measurement parameters – параметры измерения (но не измерительные параметры)

Единственный способ избежать ошибки – это всегда помнить, что если двумя существительными нет предлога, то второе из них основное, определяемое и с него надо начинать перевод, а первое является определением к нему.

Example : regulation speed – скорость регулировки

regulation of speed – регулировка скорости

Часто ряд состоит из трех слов, среднее из которых может быть прилагательным, причастием или герундием. Перевод такого ряда, как обычно, следует также начинать с последнего слова и продолжать строго в обратном порядке, причем, при переводе должна быть соблюдена грамматическая форма среднего слова.

Examples: photon-absorbing region (Participle 1) – область поглощения фотонов

breaker-triggered system (Participle 2) – система зажигания с контактным прерывателем

flight training procedure (Gerund) – методика летной подготовки

Если среднее слово в таком ряду выражено прилагательным, например, таким как: dependent – зависимый (от), free – свободный (от), prone – склонный (к), то при переводе обычно следует вводить предлог.

Example: a replication dependent process – процесс, зависимый от репликаций

oxygen free gas – газ, не содержащий кислород

the failure prone device – прибор, склонный к отказам (ненадежный прибор).

Если в ряду первым стоит прилагательное, то оно обычно относится к последнему слову.

Example: The important measurement parameters are presented in Table A. – Эти важные параметры измерения представлены в таблице А.

Exercise 3.2. Translate these sentences into Russian, paying attention to the word groups **in bold:**

1. Particles with **large diffusion coefficients** fluctuate a considerable amount and vice versa.
2. **Quasi-elastic scattering techniques** often provide information on translational mutual diffusion.

3. In molecular biophysics diffusion predominantly occurs under **low Reynolds number conditions.**
4. One of the main restrictions of **current compact state – of – the – art THz (terahertz) imaging system** is the low spatial resolution which is limited to about 1mm due to a lack of available THz lenses with strong focusing capabilities.
5. **Argument force** rather than **force argument** should dominate.
6. They have constructed a **gas-filled high pressure cell**.
7. The detection scheme was conceived as follows.
8. On the other hand, we ensured that the **probe pulses** changed their **polarization state** due to the optically included change of the refractive index by the **momentary THz field**.
9. The **additional large centrifugal type heat pump water heaters** have been provided.
10. The **optical probe beam** is scanned over THz beam to determine **the spatial field distribution**.
11. **System identification** has arisen in different areas of application where **system model** is completely unspecified but one wants to predict the **system response**, to regulate the system or to simulate the system.
12. Here **frequency dependent rate equations** are applicable.

Task 3.7. *RENDERING PRACTICE*

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

A Test Stand for US ITER

Engineers at the Oak Ridge National Laboratory recently completed a new test stand for US ITER to demonstrate that large-scale 12 inch coaxial transmission lines can perform at ITER specifications for the ion cyclotron heating system. Testing to demonstrate continuous 6 MW operations will begin within the next month at ORNL's Energy Systems Test Complex. "These transmission lines are not off-the-shelf components," Rick Goulding, a scientist in the Plasma Technology and Applications Group at ORNL's Fusion Energy Division said. "They have to carry up to 6 MW each. This is roughly a factor of 3 higher than any radio frequency transmission line that has ever been built for fusion research, and in addition it must operate steady state."

The ion cyclotron resonance ring test stand will also test specific high power components such as gas barriers, phase shifters, coaxial switches, tuning stubs, capacitors and directional couplers. When their tests are completed, the researchers will be able to confirm that the transmission lines, as well as components with moving parts such as capacitors, will be ready to transfer power efficiently from the transmitters into the antennas and finally into the plasma. "As the plasma particles orbit the magnetic field lines, they can be heated at a frequency that is the same as the orbiting frequency, or is a multiple of that frequency. In this way, you can transfer energy from the radio waves or the microwave field to the ions and to the electrons," explains Goulding.

The ion cyclotron heating system will transfer its energy into the plasma via two launchers that each consist of an array of 24 antenna elements or "current straps." Energy moves through the massive transmission lines to the launcher array. Up to 20 MW of energy from the launchers is transmitted into the plasma through two ports located in the tokamak wall. The new test bed is shaped like a ring, with water cooling lines laid on the outside of the coax. Inside the ring they have configured a transmission line that simulates the power flow through these lines at ITER. Each section of line consists of an inner core of copper, an outer shell of aluminum, with ceramic and glass insulators to keep the two apart.

The test ring is called "resonant" because, much like giving a push at the right time to a child on a swing makes the swing go higher, the researchers can add power to the ring with an electrical field that matches the electrical field direction and timing inside the line. "Unlike the swing analogy, which is a standing wave, the waves in the ring will be traveling waves, but the resonance rise in the power will be the same," says electrical engineer Phil Pesavento, who helped to develop the test bed. In this way, a transmitter putting out less than 0.5MW can generate 6 MW of power through the ring. "We built the resonant ring so that we can duplicate the currents and voltages and the distribution of those that we will actually have in ITER," Goulding said. "We've confirmed this by first making low power measurements that agreed very well with circuit model predictions used in the design of the device. Next, we ran high power, but with no cooling other than natural convection."

"Without cooling, we can run it for 2 minutes before the copper core conductor reaches the high temperature limit, which is enough time for us to verify that we put 4 MW through it. We looked at how the temperature increases in different parts of the line. The temperature and the electrical measurements agreed with each other, confirming that we had the predicted power flowing through the system." With their eyes on 6 MW of power, the researchers rebuilt their ring, adding water lines for cooling plus circulating pressurized nitrogen gas between the inner and outer coax conductors. The circulating gas transfers heat from the copper inner conductor to the aluminum outer conductor, where the heat is removed by the water cooling lines. The pressurized nitrogen also improves the high voltage handling capabilities of the transmission lines.

Task 3.8. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 3.9. Discuss the text with your partner.

Task 3.10. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 3.11. Watch the video, in your own words report the main idea of it.
https://www.youtube.com/watch?v=b8iH1930p2s

Task 3.12 Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

LINKING PARAGRAPHS TOGETHER

Each new paragraph begins with a phrase that links it to the previous paragraph, in order to maintain continuity of argument:

- *Despite this (i.e. the lack of a conclusive link)*
- *All these claims (i.e. arguments in favour of the previous idea)*
- In order to begin a new topic you may use:
- *Turning to the issue of . . .*
- *Some (points,elements,arguments…)must also be examined . . .*
- *. . . is another area for consideration*
- Paragraphs can also be introduced with adverbs:
- *Traditionally, few examples were . . .*
- *Finally, the performance of . . .*

The following expressions make up links and connectors accounting for

a). Conjuncting
b). Adjuncting
c). Correlating
d). Opposing
e). Orientating
f). Coordinating
g). Determining

ahead, against, in order to, though, regardless, unless, concerning, notwithstanding; but, if, hence, since, rather than, namely, that is, above/ after all, aside, besides, according to, consequently, furthermore, according/ due to, because, nevertheless, regarding, respectively, with, without away, as well, counter, whether, only, versus, next, now, vice versa, otherwise, whereas, aside, back, backward, behind, neither, against, between, here, to trans-, under, up, upon, via, where, within, therefore, which, despite, after, still, while, as yet , such, with respect to, each, other, the same, something, what, , whose, why, thereby.

Task 3.12.1. Put these phrases under a corresponding title:

a)…

b)…

c)…

d)…

e)…

f)…

g)…

Task 3.12. 2. Analyze the text and say what linking phrases are used to maintain continuity of argument.

Layered generic component implementation.

Building a complex simulation from a set of coupled codes has numerous advantages, such as code reusability, ease of validation against others, extensibility and ease of maintenance. Nevertheless, it can also be considered as a burden if it requires developing a specific version of the physics code, tied to a specific framework without any guarantee about its long term maintenance. In order to reduce the amount of extra work on the developer, we followed a nonintrusive approach based on layers of wrapper codes as shown in Figure 1. Following this onion peel design, changing the common data structure to transfer data between components requires to modify only the Data wrapper, changing the coupling and execution platform requires to modify the Coupling wrapper and to adapt the implementation of the Simulation workflow. Of course, modifying the internals of the physics solver is always possible and only requires to modify the Native code, as long as its signature remains identical. Once all wrappers are implemented, several use cases can be investigated by modifying only the Simulation workflow, its parameters and its logic. In our specific case, native codes correspond to the implementation in Fortran of different physics models, while the data wrappers are converting the native codes internal data representation into the common CPO data structures (derived types in Fortran). These two layers are under the responsibility of the physics code developers, as deep knowledge of the physics codes is required to understand and translate CPO data into another representation. The implementation of the coupling wrapper necessitates a good knowledge of the coupling platform and its API, but it usually requires only an overview of the underlying physics layers (e.g the type of code and its signature). Consequently, implementation of this layer can be generated automatically or semi-automatically. At last, the simulation workflow is build by a modeller with good understanding of all underlying physics as well as knowledge of the coupling platform capabilities. Usage of high-level graphical tools, as offered by Kepler or MAD tools, tends to reduce the level of expertise required for designing a new simulation from scratch.

Task 3.12.3 Look at Punctuation rules in the Appendix and find examples of some rules in the Text 3.12.2

UNIT 4

TEXT 4. Electron-free, Positive- and Negative-ion (ion–ion) Plasmas

Relatively electron-free, positive- and negative-ion (ion–ion) plasmas have been achieved in the afterglow of pulsed-power CL_2 discharges. The application of a pulsed dc bias phase locked to the source power modulation and exclusive to the ion–ion plasma, allows selective bombardment by positive (CL_2^+) or negative (CL^-) ions onto a silicon substrate. This allows an equitable comparison of etching by equal energy ions of both polarities. We find that at 50 eV, CL_2^+ etches twice as fast as CL^-.

Halogen chemistry discharges, used extensively in modern semiconductor fabrication, are rich in negative ions; however, the mass and temperature disparity between positive ions and electrons leads to positive plasma potential confining negative ions to the discharge center even at high electronegativities. Negative ions could participate in ion-assisted etching and reduce wafer charge up if their surface flux could be made substantial; however, extraordinarily large electronegativities ($N_- / N_e \geq 1000$) are required to extract negative ions from the discharge center. Such high electronegativities are obtained in practice in ion–ion plasma. As reported in 1973 in an I_2 dc discharge and later in pulsed-power O_2 and CL_2 afterglows, ion–ion plasmas have extremely large electronegativities.

We had produced alternating fluxes of positive and negative ions to a processing surface (and mass spectrometer inlet) using an ion–ion synchronous low-frequency sinusoidal bias. This so called ‘‘ion–ion synchronous’’ bias is also pulsed and its modulation envelope is phase locked to the modulation of the plasma excitation such that the ac bias is exclusive to the ion–ion phase of the plasma. Such an ac bias can allow damage-free plasma processing, however, the etch rate has contributions from both negative and positive ions. In this work, a pulsed dc bias (of the ion–ion plasma) allowed us to discriminate between etching induced by positive and negative ions. The polarity and magnitude of the pulsed dc voltage, controls the polarity and the energy of the bombarding ions, respectively.

A Texas Instruments PAC-200 etch tool was converted to a Faraday shielded pulsed-power inductively coupled plasma (ICP) reactor. A nickel coated aluminum (Ni–Al) disk placed atop the lower electrode allowed dc biasing of the wafer. The wafer clamp was modified to allow a nickel wire to press against the top surface of the wafer and pick up the wafer surface potential (V_{serf}) as it was being processed. A Langmuir probe measured plasma properties 1 cm above the wafer. The probe was removed during etching. A grounded, nickel coated aluminum ring served as a reference electrode for probe measurements and the return path for dc currents in the etch experiments. An ENI-1000 amplifier supplied 500 W peak power at 13.56 MHz to the ICP antenna. The power was square-wave modulated at 1 kHz and 50% duty ratio. In a 3 mTorr CL_2 discharge under this excitation, electrons vanish 25μs into the afterglow by dissociative attachment providing an ion–ion plasma for 475 μs. The Ni–Al disk was biased with pulsed dc ± 50 V during this ion–ion phase of the afterglow using a HP 6826A DC amplifier. The disk is biased to zero during the electron–ion phase of the plasma. Boron doped 150 mm Si wafers with <100> orientation and resistivity 5–10 Ω-cm were patterned using Shipley 1813 photoresist with 21 points exposed and a small clearing along the periphery for the V_{serf} probe to contact. All exposed surfaces were treated with buffered-HF just before a 15 min etch process. After etch, the resist was stripped and etch depths measured using a Tencor Alpha-step 1000 profilometer. Figure 2(c) shows the measured wafer surface potential, V_{serf} , for ± 50 V biases. At first, we observed that V_{serf} did not equal the applied bias (V_{app}) for 150V, even though it did for 250V. That discrepancy between the voltage on the Ni–Al disk and the wafer surface was found to be the result of a Schottky diode contact between the disk and the wafer backside. This Schottky contact would not allow positive applied voltages to pass current through the wafer and attract negative ions!

Topic vocabulary:

Electronegativities - электроотрицательность, wafer – пластина (выполненная из кристалла), substrate – подложка, ion-ion plasma – ионно-ионная плазма, bias – наклон, уклон, направление/отклонение/смещение/искажение, synchronous low-frequency sinusoidal bias – синхронизированное низкочастотное синусоидальное смещение, to etch – травить, протравливать, etching bias – клин травления, dc bias – смещение, вызванное подмагничиванием постоянным током, ac bias – смещение, вызванное подмагничиванием переменным током, dc amplifier – усилитель постоянного тока, buffered HF – демпфированная высокая частота, afterglow - послесвечение, wafer clamp – фиксатор пластины, doping - легирование, modulation envelope – огибающая модуляционного сигнала.

Task 4.1. Answer the questions

1) Why is negative-ion etching investigated?
2) When is it possible to extract negative ions from the discharge center?
3) How are alternating fluxes of positive and negative ions produced with ac bias?
4) Why was an ion-ion synchronous bias applied earlier?
5) What is the advantage of a pulsed dc bias?
6) How are the polarity and the energy of the bombarding ions controlled in the experiment?
7) How is the surface potential picked up?
8) How are plasma properties measured?
9) How fast did an ion-ion plasma appear in the afterglow of a Cl_2 discharge?
10) How are the etch depth measured?

Task 4.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

Relatively electron-free, positive- and negative-ion (ion–ion) plasmas have been achieved in the afterglow of pulsed-power CL_2 discharges. The application of a pulsed dc bias phase locked to the source power modulation and exclusive to the ion–ion plasma, allows selective bombardment by positive (CL_2^+) or negative (CL^-) ions onto a silicon substrate. This allows an equitable comparison of etching by equal energy ions of both polarities. We find that at 50 eV, CL_2^+ etches twice as fast as CL^-.

Halogen chemistry discharges, used extensively in modern semiconductor fabrication, are rich in negative ions; however, the mass and temperature disparity between positive ions and electrons leads to positive plasma potential confining negative ions to the discharge center even at high electronegativities. Negative ions could participate in ion-assisted etching and reduce wafer charge up if their surface flux could be made substantial; however, extraordinarily large electronegativities ($N_- / N_e \geq 1000$) are required to extract negative ions from the discharge center. Such high electronegativities are obtained in practice in ion–ion plasma. As reported in 1973 in an I_2 dc discharge and later in pulsed-power O_2 and CL_2 afterglows, ion–ion plasmas have extremely large electronegativities.

Google translation

Относительно безэлектронная, положительная и отрицательная ионы (ион-ионные) плазмы были достигнуты в послесвечении разрядов импульсной мощности. Применение импульсной фазы смещения постоянного тока, привязанной к модуляции мощности источника и исключающей ионно-ионную плазму, позволяет проводить селективную бомбардировку положительными или отрицательными ионами на кремниевую подложку. Это позволяет справедливо сравнивать травление ионами одинаковой энергии обеих полярностей. Мы находим, что при 50 эВ протравливается вдвое быстрее, чем.

Галогенные химические разряды, широко используемые в современном производстве полупроводников, богаты отрицательными ионами; однако расхождение массы и температуры между положительными ионами и электронами приводит к положительному плазменному потенциалу, ограничивающему отрицательные ионы к центру разряда даже при высокой электроотрицательности. Отрицательные ионы могут участвовать в ионном травлении и уменьшать заряд пластины, если их поверхностный поток может быть значительным; однако, чрезвычайно большие электроотрицательности (/ 1000) необходимы для извлечения отрицательных ионов из разрядного центра. Такие высокие электроотрицательности достигаются на практике в ионно-ионной плазме. Как сообщалось в 1973 г. в разряде постоянного тока, а затем в импульсной мощности и послесвечении, ионно-ионная плазма обладает чрезвычайно большой электроотрицательностью.

PROMT translation

Относительно без электронов, положительный - и отрицательный ион (ион иона) плазмы были достигнуты в послесвечении выбросов пульсировавшей власти. Применение пульсировавшей фазы уклона dc, запертой к исходной модуляции власти и исключительной к плазме иона иона, позволяет отборную бомбардировку положительными или отрицательными ионами на кремниевое основание. Это позволяет равноправное сравнение гравюры равными энергетическими ионами обеих полярностей. Мы находим, что на уровне 50 эВ, запечатлевает дважды с такой скоростью, как.

Выбросы химии галогена, используемые экстенсивно в современном полупроводниковом изготовлении, богаты отрицательными ионами; однако, массовое и температурное неравенство между положительными ионами и электронами приводит к положительному плазменному потенциалу ограничивающий отрицательные ионы в центр выброса даже в высоких электроотрицательностях. Отрицательные ионы могли участвовать в помогшей с ионом гравюре и сократить тариф в вафле, если их поверхностный поток мог бы быть сделан существенным; однако, чрезвычайно большие электроотрицательности (/1000) требуются, чтобы извлекать отрицательные ионы из центра выброса. Такие высокие электроотрицательности получены на практике в плазме иона иона. Как сообщается в 1973 в выбросе dc и позже в пульсировавшей власти ипослесвечение, у иона иона plasmas есть чрезвычайно большие электроотрицательности.

Task 4.3. Match words or phrases in column A with their synonyms in column B. Find sentences in the text with the words from column A and translate them. Make your own sentences with the words from column B.

	A		B
a	property	1	usage
b	vanish	2	persuade/move to action
c	discrepancy	3	disappear
d	flux	4	feature
e	discriminate	5	distinguish
f	induce	6	difference
g	amplify	7	increase
h	application	8	application

Task 4.4. Find in the text English equivalents to the following expressions:

1. производство полупроводников

2. кремниевая подложка
3. алюминиевый диск с никелевым покрытием
4. несоответствие температуры и массы у положительно заряженных ионов и электронов
5. разнонаправленные потоки
6. богатый отрицательно зараженными ионами
7. усилитель постоянного тока
8. тыльная поверхность пластины
9. измерение глубины травления
10. кремниевые пластины, легированные бором

Task 4.5. Read the text and fill in the gaps with the correct words A, B or C from the box:

The success of scientific theories, particularly Newton's theory of gravity, led the French scientist the Marquis de Laplace at the beginning of the nineteenth century to argue that the universe was completely deterministic. Laplace ……(1) that there should be a set of scientific laws that would ……(2) us to predict everything that ……(3) happen in the universe, if only we ……(4) the complete state of the universe at one time. For example, if we new the positions and speeds of the sun and the planets at one time, then we ……(5) use Newton's laws to calculate the state of the Solar System at any other time. Determinism seems fairly obvious in this case, but Laplace went further to assume that there were similar laws ……(6) everything else, including human behavior.

The doctrine of scientific determinism was strongly resisted by many people, ……(7) felt that infringed God's freedom to intervene in the world, but it remained the standard assumption of science until the ……(8) years of this century. One of the first indications that this belief would have to be abandoned came when calculations by British scientists Lord Rayleigh and Sir James Jeans suggested that a hot object, pr body, such as a star, must radiate energy at an infinite rate. According to laws we believed at the time, a hot body ought to ……(9) electromagnetic waves (such as radio waves, visible light, or X rays) equally at all frequencies. For example, a hot body should radiate the same amount of energy in waves with frequencies between one and two million millions waves a second as in waves with frequencies between two and three million millions waves a second. Now since the number of waves a second is unlimited, this would ……(10) that the total energy radiated would be infinite.

1	A suppose	B think	C consider	D suggest
2	A let	B allow	C make	D force
3	A will	B would	C would have	D should have
4	A knew	B know	C had known	D have known
5	A could	B might	C may	D should
6	A ruling	B supervising	C governing	D conducting
7	A which	B that	C whom	D who
8	A early	B first	C forthcoming	D initial
9	A give out	B give away	C give off	D give in
10	A matter	B mean	C denote	D designate

Task 4.6. Translate the text into English:

Введение такого параметра как электронная температура подразумевает допущение максвелловской функции распределения электронов по энергиям (ФРЭЭ). Это заметно облегчает задачу диагностики плазмы (вместо многих значений ФРЭЭ надо определить всего лишь одно значение Te), которая и без того является непростой, поскольку цель диагностики – нахождение не усредненных по объему значений параметров плазмы, а их радиальных распределений. Допущение максвелловской ФРЭЭ широко и плодотворно используется в физике газового разряда и плазмы, однако всем ясно, что оно представляет собой определенную идеализацию. Численный расчет ФРЭЭ изучаемых в работе разрядов, например при помощи программы BOLSIG, показывает, что ФРЭЭ по сравнению с максвелловской обеднена электронами с энергиями, превышающими первый порог возбуждения инертного газа.

Words and expressions to help:

подразумевать – mean

допущение максвелловской функции – Maxwell function allowance

облегчать – to take smth easier

усредненный – averaged

радиальное распределение – radial allocation

численный расчет – digital calculation

порог – threshold

Task 4.7. Chose the appropriate equivalent to each of the following expressions:

1. An acrimonious argument
   a) long-winded
   b) sharp, biting, sarcastic
   c) dull, pointless, incoherent
2. A soporific lecture
   a) so boring as to put one to sleep
   b) brilliant and informative
   c) well-attended
3. An evanescent feeling
   a) compressed of both dread and desire
   b) fading away quickly
   c) so unique that it is experienced by very few people
4. To drive adroitly
   a) nervously
   b) inattentively
   c) skillfull

5. A facetious remark

a) totally irrelevant to the situation

b) tending to make peace between people in the conflict

c) witty and joking at an inappropriate time

GRAMMAR POINT:

Multiple comparatives.

Multiple Numbers can include ***half, twice, three times, four times etc***.

Study the following rule:

Subject + verb + number multiple + as + much/many + (noun) + as + noun/pronoun

Examples:

1. This encyclopedia costs ***twice as much as*** the other one.
2. Jerome has ***half as many records now as*** I had last year.
3. We find that at 50eV, Cl_2^+ etches ***twice as fast as*** Cl^-.

Exercise 4.1. Make some sentences of your own using number multiples.

Task 4.8. ***RENDERING PRACTICE***

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

A Phase-to-ground Fault

Carried by a double 400kV power line, an intense electrical current will run through the RTE switchyard that is situated on the southwest end of the platform. Under nominal operating conditions, power will pass through a complex array of conductors, busbars, switches, pantographs and circuit breakers to be dispatched to a set of seven transformers; the transformers in turn will convert the power to a lower voltage and distribute it to the ITER scientific installations. But conditions are not always nominal. "Things can happen," says Joël Hourtoule, section leader for ITER's Steady State Electrical Network Section. "Someone can make a mistake, an insulator might break ... and of course one never knows when and where lightning might strike."

Such incidents could cause what is known as a "phase-to-ground" fault: instead of being channeled into the transformers, the current could short-circuit with the ground and reach intensity some one thousand times higher than its nominal value (the value consumed under normal circumstances by the ITER plant systems). "For a very short moment until the circuit breakers operate," explains Joël, "we might have a current of more than 10 kA locally." This so-called "short-circuit current" could be damaging for the installation and dangerous for someone standing in and around the switchyard. In order to prevent the consequences of a phase-to-ground fault, switchyards are equipped with an "earth mat," which consists of a network of rods and copper cables buried some 50 cm underground. This conductive network will decrease the overall area resistivity and ensure that, in case of fault, all the different metallic structures present a homogenous electric potential (termed "equipotentiality").

RTE installed such an earth mat in the switchyard enclosure. However, according to codes and standards and the best industrial practice, it is important for ITER to know how far onto the platform, and with what intensity, the rise in earth potential would extend in case of a phase-to-ground fault. Two weeks ago, in order to measure the effects of a phase-to-ground fault, a generator placed in the RTE enclosure was used to "inject" current pulses into the ground. Teams were dispatched to several locations on the ITER site to measure what is called the step voltage—the voltage that would pass through (and possibly hurt) a standing person.

The RTE teams spent about two days performing measurements, not only on the ITER platform but also far into the nearby forest. "At a distance of 800 meters from the impact point, the earth potential, although already very feeble, was still measurable," says Joël. Measurements were also performed outside the ITER perimeter (almost two kilometers beyond the fence into the forest) in order to get a clear overall picture.

Measurements indicate that personnel operating outside the RTE switchyard will not be affected by a potential phase-to-ground fault. However, small potential differences can still induce perturbations in the control command signals of the installation's plant systems or in the electrical distribution networks. Consequently every building on the ITER platform will be surrounded with an "earth loop" buried some 50 cm underground. Once interconnected, the loops will form a network of several tens of kilometers of copper cable—an earth mat covering the 42-hectare of the platform.

Task 4.9. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 4.10. Discuss the text with your partner.

Task 4.11. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 4.12 Watch the video, in your own words report the main idea of it.

https://www.youtube.com/watch?v=ZW_YCWLyv6A

Task 4.13 Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

WRITING AN ESSAY

4.13.1. Some steps that should be taken into consideration while preparing an essay

- Brainstorming
- Organizing
- Drafting
- Reviewing
- Revising
- Publishing

4.13.2. Choosing a topic

The topic must:

- not be too broad
- not be too narrow
- be interesting and important
- be something that you know about
- be researchable
- have a point.

4.13.3. Writing a thesis statement in an essay

A thesis statement for an essay functions like the topic sentence of a paragraph; it tells the reader **the main idea of the essay**. However, while a topic sentence of a paragraph is often the first sentence, the thesis statement of an essay is usually **the final sentence of the introduction.**

UNIT 5

TEXT 5. Compact Toroid Plasmoid

Several advantages are gained by fueling directly in the core of fusioning tokamak plasma, varying from more efficient utilization of DT fuel to improvement in the energy confinement time. The conventional method of fueling by pellet injection may not be adequate for large hot fusion-grade plasmas because of the demanding technological requirements needed to accelerate pellets to the necessary high velocities ≥ 10km/s. However, compact toroid (CT) plasmoids have been produced and routinely accelerated to velocities of > 10^3 km/s in the RACE coaxial gun experiments of Hammer, Hartman and Eddeman. By virtue of their high velocities, fueling tokomak plasmas by hypervelocity plasmoid injection has recently been proposed by Perkins, Ho and Hammer as a candidate fueling scheme for the experimental test reactor (ETR).

This letter describes a model for the interaction between a moving CT plasmoid and magnetized plasma in relation to the feasibility of the scheme. We first examine how the moving CT is held fixed in equilibrium by the background tokamak magnetic field, which is diamagnetically excluded from the interior of the CT. We then estimate its deceleration time and the time to decay by surface and volume resistive dissipation processes. We specialize to the case of a spherically shaped CT without the hole, i.e., a spheromak. For definiteness we choose ETR parameters. The CT mass for a ~ 10% density perturbation (1-Hz rate coaxial injector) is around M_1 ~ 4.5 mg. Bearing in mind that the CT must be small enough to pass through a wall aperture, we choose a radius r_1 ~ 10 cm, giving an average CT ion density of $n_1 \sim 2 \times 10^{17}\ cm^{-3}$.

We assume that the CT is injected with velocity V_{inj} **X** perpendicular to the undisturbed background magnetic field B_∞ **Z.** After the CT exits the gun, it is for an instant deconfined. Its poloidal magnetic field will then appear to have a dipole character, with dipole moment **m** $\sim \pi I_1 r_1^2/c\mathbf{x}$ originally oriented perpendicular to the background magnetic field, where I_t is the toroidal current inside the CT. As soon as the CT enters the vacuum tokamak magnetic field region, it will begin to rotate under torque **m x B**∞ until the magnetic moment and B_∞ are aligned parallel to each other. The characteristic time constant for this being τ_{tilt} □ $(mB_\infty/I_m)^{1/2}$ in which $I_m = \frac{5}{2}M_1 r_1^2$ is the appropriate moment of inertia. The characteristic magnetic field inside the CT, B_1, must be comparable to B_∞ in order that the closed magnetic field line topology remain intact. Since $I_t \propto r_1 B_1$, the 'tilt time' can be expressed as $t_{tilt} \sim \tau_{AI} \equiv r_1/V_{AI}$ where $V_{AI} = B_\infty/(4\pi n_1 m_i)^{1/2}$ is the Alfven speed in the CT. Taking the above parameters with B_∞ = 50kG gives V_{AI} = 154km/s and $t_{tilt} = 0.65\,\mu$s. This will be seen to be the shortest time scale of interest here so that the realignment of the CT with its axis of rotation parallel to the background magnetic field occurs almost immediately after its encounter with this field. Numerical magnetohydrodynamics (MHD) simulations also show that the CT tilts 90° in about an Alfven time τ_{AI}.

In the following, we demonstrate how the CT, once embedded inside the tokamak magnetic field, may propagate across the field without expanding and stopping prematurely. We consider the mode of propagation in which the injected kinetic energy density at injection exceeds the ackground magnetic field energy density $\frac{1}{2}m_i n_1 V_{inj}^2 > B_\infty^2/8\pi$. This assures penetration of the CT through the background magnetic field which will be excluded from the interior of the CT and slip around its periphery. Since the injection energy goes into translational kinetic

energy and the energy needed to exclude the magnetic field, the CT begins to move through the field with initial velocity
$V_{CTO} = (V^2_{inj} - V^2_{AI})^{1/2}$.

The final configuration is such that no external magnetic flux links the CT region making it possible for it to easily penetrate the tokamak plasma region without stretching or breaking field lines. A spheroidal current sheet appears at the boundary separating oppositely directed tangential magnetic fields on each side of it. Since the speed of the CT is such that $V_{CT} << V_{AO}$ where $V_{AO} = (B^2_{\infty}/4\pi m_i n_0)$ is the Alfven speed of the background tokamak magnetic field B_0 will respond quickly by setting up a series of quasiequilibria characterized by vanishing current density, $VxB_0 \cong 0$, to lowest order in V^2_{CT}/V^2_{AO}.

Topic vocabulary:

Confinement - удержание, pellet injection – инжекция пеллет, compact toroid plasmoid – компактный тороидальный плазмоид, coaxial gun experiment – эксперимент с коаксиальной пушкой, volume resistive dissipation process – процесс объемной резистентной диссипации, poloidal magnetic field – полоидальное магнитное поле, toroidal current – тороидальный ток, tilt - наклон, tilt time – время наклона, mode of propagation – режим распространения, tangential magnetic field – тангенциальное магнитное поле, aperture - апертура, premature – преждевременный.

Task 5.1. Answer the questions

1. What are the advantages of fuelling directly in the plasma core?
2. Why is injection of compact toroids proposed for ITER fuelling?
3. Which processes of interaction between the CT and the tokamak plasma are considered in this paper?
4. What is a spheromak?
5. What happens after the CT exits the gun?

6. When does the CT begin to rotate?
7. How fast does the rotation axis become parallel to the background magnetic field?
8. Is there magnetic field inside the CT moving through the tokamak plasma?
9. Please describe the final magnetic configuration around the CT.
10. How does the deformed background tokamak magnetic field respond the CT injection?

Task 5.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

Several advantages are gained by fueling directly in the core of fusioning tokomak plasma, varying from more efficient utilization of DT fuel to improvement in the energy confinement time. The conventional method of fueling by pellet injection may not be adequate for large hot fusion-grade plasmas because of the demanding technological requirements needed to accelerate pellets to the necessary high velocities ≥ 10km/s. However, compact toroid (CT) plasmoids have been produced and routinely accelerated to velocities of > 10^3 km/s in the RACE coaxial gun experiments of Hammer, Hartman and Eddeman. By virtue of their high velocities, fueling tokomak plasmas by hypervelocity plasmoid injection has recently been proposed by Perkins, Ho and Hammer as a candidate fueling scheme for the experimental test reactor (ETR).

This letter describes a model for the interaction between a moving CT plasmoid and magnetized plasma in relation to the feasibility of the scheme. We first examine how the moving CT is held fixed in equilibrium by the background tokomak magnetic field, which is diamagnetically excluded from the interior of the CT. We then estimate its deceleration time and the time to decay by surface and volume resistive dissipation processes. We specialize to the case of a spherically shaped CT without the hole, i.e., a spheromak. For definiteness we choose ETR parameters. The CT mass for a ~ 10% density perturbation (1-Hz rate coaxial injector) is around M_1 ~ 4.5 mg. Bearing in mind that the CT must be small enough to pass through a wall aperture, we choose a radius r_1 ~ 10 cm, giving an average CT ion density of $n_1 \sim 2 \times 10^{17}\ cm^{-3}$.

Google translation

Несколько преимуществ достигается благодаря непосредственному заправке в ядре термоядерной плазмы, которая варьируется от более эффективного использования топлива DT до сокращения времени удержания энергии. Обычный метод заправки топливом путем впрыска гранул может быть недостаточным для больших горячих термоядерных плазм из-за высоких технологических требований, необходимых для ускорения гранул до необходимых высоких скоростей 10 км / с. Тем не менее, компактные тороидальные (CT) плазмоиды были произведены и постоянно ускорялись до скоростей> 10 км / с в экспериментах по коаксиальной пушке RACE Хаммера, Хартмана и Эддемана. Вследствие их высоких скоростей, Перкинс, Хо и Хаммер недавно предложили заправку плазмы токамаком путем впрыска сверхскоростного плазмоида в качестве возможной схемы заправки для экспериментального испытательного реактора (ETR).

В этом письме описывается модель взаимодействия движущегося КТ-плазмоида с намагниченной плазмой в связи с осуществимостью схемы. Сначала мы исследуем, как движущаяся КТ удерживается в равновесии с помощью фонового магнитного поля токамака, которое диамагнитно исключено из внутренней части КТ. Затем мы оцениваем время его замедления и время затухания с помощью процессов поверхностной и объемной резистивной диссипации. Мы специализируемся на случае КТ сферической формы без отверстия, то есть сферомака. Для определенности выбираем параметры ETR. Масса КТ для возмущения плотности ~ 10% (коаксиальный инжектор с частотой 1 Гц) составляет около М ~ 4,5 мг. Учитывая, что КТ должен быть достаточно маленьким, чтобы проходить через отверстие в стене, мы выбираем радиус r ~ 10 см, что дает среднюю плотность ионов КТ n ~ 2 × 10 см.

PROMT translation

Несколько преимуществ получены, питая непосредственно в ядре слияния токамака плазму, варьируясь от более эффективного использования топлива DT к улучшению в энергетическое время заключения. Обычный метод заправки инъекцией окатыша может не быть достаточен для большого горячего сорта сплава плазмы из-за требовательных технологических требований, должен был ускорить шарики к необходимым высоким скоростям 10km/s. Однако компактный тороид (CT) плазмоид был произведен и обычно ускорялся к скоростям> 10 км/с в ГОНКЕ коаксиальные эксперименты оружия Молотка, Хартмана и Эддемена. На основании их высоких скоростей, питая плазменный токамак гиперскоростью плазмоид инъекция был недавно предложен Перкинсом, Хо и Молотком как схема заправки кандидата экспериментального испытательного реактора (ETR).

Это письмо описывает модель для взаимодействия между перемещением CT плазмоида и намагниченной плазмой относительно выполнимости схемы. Мы сначала исследуем, как перемещение, CT считается фиксированным в равновесии фоном токамак магнитное поле, которое диамагнитным образом исключено из интерьера CT. Мы тогда оцениваем, что его время торможения и время разлагают поверхностью и объемом имеющие сопротивление процессы разложения. Мы специализируемся к случаю сферически имеющего форму CT без отверстия, т.е. сферомак. Для определенности мы выбираем параметры ETR. Масса CT для ~ 10%-го волнения плотности (уровень на 1 Гц коаксиальный инжектор) - вокруг M ~ 4,5 мг. Принимая во внимание, что CT должен быть достаточно маленьким, чтобы пройти через стенную апертуру, мы выбираем радиус r ~ 10 см, давая среднюю плотность иона CT n ~ 2 x 10 см.

Task 5.3. Match words or phrases in column A with their synonyms in column B. Find sentences in the text with the words from column A and translate them. Make your own sentences with the words from column B.

	A		**B**
1	conventional	a	possibility
2	core	b	spreading
3	velocity	c	reconstruction
4	by virtue	d	speed
5	feasibility	e	remember
6	realignment	f	for accuracy
7	bear in mind	g	disappear
8	application	h	owing to
9	for definiteness	i	generally accepted
10	propagation	j	very centre
11	embed	k	insert

Task 5.4. Fill in the gaps, choosing words from the list below:

Rainbow, star, atmosphere, feature, means, spectra, light, vary from, size, temperature, chemical, tell, center, colors, rotating, spectrum brightness, prism, since, opaque

We live in a galaxy that is about one hundred thousand light-years across and is solely……. (1); the stars in its spiral arms orbit around its……. (2) about once every several hundred million years. Our sun is just an ordinary, average-sized, yellow…….. (3), near the inner edge of one of the spiral arms. We have certainly come a long way……… (4) Aristotle and Ptolemy, when thought that the earth was the center of the universe!

Stars are so far away that they appear to us to be just pinpoints of…… (5). We cannot see their……. (6) or shape. So how can we……. (7) different types of stars apart? For the vast majority of stars, there is only one characteristic…….. (8) that we can observe – the color of their light. Newton discovered that if light from the sun passes through a triangular-shaped piece of glass, called a…….. (9), it breaks up into its component…….. (10) and its spectrum as in a……… (11). By focusing a telescope on an individual star or galaxy, one can similarly observe the……… (12) of light from that star or galaxy. Different stars have different……… (13), but the relative……… (14) of the different colors is always exactly what one would expect to find in the light emitted by an object that is glowing red hot. (In fact, the light emitted by any……… (15) object that is glowing red hot has a characteristic spectrum that depends only on its…….. (16) – a thermal spectrum. This……… (17) that we can tell a star's temperature from the spectrum of its light. Moreover, we find that certain very specific colors are missing from stars' spectra, and these missing colors may……… (18) star to star. Since we know that each…….. (19) element absorbs a characteristic set of very specific colors, by matching these to those that are missing from a star's spectrum, we can determine exactly which elements are present in the star's……… (20).

Task 5.5. Study the words which are often confused and do the exercises:

5.5.1. *question point theme topic aspect case factor*

a) *topic* – the topic of conversation, composition, lesson
b) *case* – is one particular example or one thing or person considered separately of others
c) *factor* – it is a part of a situation or an action
d) *point* – somebody's opinion or idea
e) *question* – something that is discussed or has to be decided
f) *aspect* – one of the parts that something consists of
g) *theme* – the theme of a book, film, play, speech

Ex. 5.5.1 Fill in the gaps with appropriate words:

1. The temperature fluctuations were the main ……………affected the results of calculations.
2. We discussed…………….of the problem thoroughly.
3. The scandal is the main……………..of conversation in the country at the moment.
4. The origin and Fate of the Universe is a ……………that runs through the whole monography.
5. My main…………….is that I don't think the assumption will work.
6. In the……………of that experiment, the conditions were entirely different.
7. The…………….of whose fault it was never arouse.

5.5.2. *defy* *decline* *dissent* *disown* *reject*

a) defy – to resist openly, to refuse to obey

b) decline – to refuse /decline the invitation – say politely that one cannot accept it/

c)dissent – to express a different opinion

d) disown – to refuse to acknowledge as one's own, to reject all connection with

e) reject – to refuse to accept, to react against

Ex. 5.5.2. Fill in the gaps with appropriate words:

1. She politely…………….to reveal the results of her scientific research.
2. The scientist……………his colleague's controversial remark.
3. All my suggestions were……………as totally unsuitable.
4. Very few academicians…………..from the general view.
5. He…………….the opinion of his senior colleagues and went ahead anyway.

5.5.3. *consideration view regard relation*

a)consideration – careful thought; *on no consideration* – no matter what the circumstances may be

b)view – what can be seen from specified point; *with a view to* – with the hope or intention of

c)regard – heed, consideration; *with regard to* – any concern or attention

d)relation – the way in which one thing is related to another, a connection or correspondence or contrast between people or things or events; *in relation to* – as regards, concerning

Ex. 5.5.3. Fill in the gaps with appropriate words

1. I am writing with…………….to our recent discussion.
2. On no…………….. , I decided that the proposition did not suit me.
3. I asked a number of questions in………………to the details of the scheme.
4. I contacted him with a………………to setting a date for a meeting.

NB: Latin expressions in scientific articles

1. i.e. – id est = that is – то есть, иными словами.

We specialize to the case of a spherically shaped CT without the hole, i.e., a spheromak.

2. et al. – et altrui = and others – и другие.

Nevertheless, the successful experiments by Gerlich et al. show that it is possible to reproduce important aspects of this thought experiment with large organic molecules.

3. e.g. – example gratia = for example - например, в качестве примера.

Erwin Schroedinger wondered whether it was possible to realize states of extreme superposition such as, e.g., that of a cat which is simultaneously dead and alive.

4. ita = Thus – итак, таким образом.

The international and interdisciplinary team of scientists ita sets a new record in the verification of the quantum properties of nanoparticles.

5. in facto = practically; in fact; virtually; actually – фактически.

This could, in facto, be described by a particular solution of Einstein's equations that had been known since 1917.

In facto, that confinement prevents one from observing an isolated quark or gluon might seem to make the whole notion of quarks and gluons as particles somewhat metaphysical.

6. in vivo = in natural conditions, in living organism – в естественных условиях, на живом организме.

Because the light propagates through water and air, an optical microscope can be used to see, in vivo, the details of living matter and other materials in their unperturbed natural conditions.

7. in situ = at its place – по месту, на своем месте, по месту нахождения.

This behaviour, along with in situ second-harmonic conductivity observations, led us to postulate an expanded two-carrier model.

8. in vitro = in the test-tube – в пробирке, в лабораторных условиях.

The crystal under study was produced in vitro.

9. v. – vide = see – смотри, обратись к…

Most of our understanding of stellar evolution is based on rather simplified numerical models (v. also STELLAR INTERIORS).

10. a.m. – ante meridiem = before noon – до полудня

11. p.m. – post meridiem = after noon – после полудня

12. viz. (vid.) – videlized/videlicet = namely – а именно, очевидно, ясно, разумеется, можно видеть.

The detailed properties of stellar matter vid. equation of state, radioactive transport and energy generation, often referred to as the microphysics, are treated in considerable detail.

Task 5.6. Translate the text into English.

Во многих случаях при расчетах режима работы токамака излучение примесей играет определяющую роль в балансе энергии. Такие ситуации возникают вблизи пластин дивертора, при инжекции примесных пеллет, при управляемых срывах разряда и в других ситуациях. Расчет излучения примесей – довольно громоздкая задача, поскольку мощность излучения определяется распределением по возбужденным состояниям ионов и скоростями элементарных процессов излучения и поглощения. Зачастую такой расчет является наиболее трудной частью общей проблемы. Целью данной работы является приведение в одной статье аппроксимационных формул, позволяющих любому исследователю, учитывающему в своих расчетах излучение плазмы, достаточно просто, не прибегая к специальной литературе, включить это излучение для наиболее часто встречающихся примесей. Для пяти примесей: бериллия, углерода, кислорода, неона и аргона приведены простые аппроксимационные формулы, описывающие ионизацию, рекомбинацию, и перезарядку, а также радиационные потери ионов с заданным зарядом. Приведены также оценочные формулы, позволяющие учитывать непрозрачность плазмы для резонансных фотонов при излучении в линиях.

GRAMMAR POINT

Modal auxiliary verbs expressing certainty, probability, possibility

Each modal verb has at least two meanings. One use of all modal verbs is to talk about the possibility or probability of a situation or event. Some of these verbs are used to say that a situation is certain; others that it is probable or possible; others that it is impossible.

1. Certainty - verbs used: ***must, will (won't), can't, couldn't, shall (shan't), would (wouldn't)***

Examples:

a) This mechanism ***must*** produce some straight line movements. – Этот механизм (сам) должен выполнять движения по прямой линии.

b) Poloidal magnetic field ***will*** then appear to have a dipole character. – Полоидальное магнитное поле тогда вероятно имеет дипольный характер.

c) That ***can't*** be professor Wilkins – he is in London, at the conference. – Не может быть, чтобы это был профессор Вилкинс – он в Лондоне на конференции.

d) I knew it ***couldn't*** be him. – Я знал, что это был не он.

e) We ***shall*** observe the results of the experiment tomorrow. – Завтра мы непременно будем наблюдать результаты опыта

f) It ***would*** be in year 1961. – Это произошло примерно в 1961 году.

g) You ***wouldn't*** know the answer to the question. – Вряд ли Вы знаете ответ на этот вопрос.

2. Probability – verbs used: ***should (shouldn't), ought to (oughtn't), may (may not)***

Example:

a) Such tasks ***should*** be significant in solving such scientific problems. – Должно быть, постановка таких задач является важным (условием) для решения таких научных проблем.

3. Weak possibility – verbs used: ***might (mightn't), could (couldn't)*** – in affirmative sentences.

Examples:

a) If an LH antenna is large enough, then it ***might*** be a reasonable approximation to consider just a single ray at the peak of the spectrum. – Если LH антенна достаточно большая, то может быть будет разумно рассмотреть единичный луч на пике спектра.

b) Eddington thought it simply not possible that a star ***could*** collapse to a point. – Эддингтон думал, что просто невозможно, чтобы звезда могла бы сжаться до точки.

4. Theoretical or habitual possibility – verbs used: ***can***

Examples:

a) The ‘tilt time’ ***can*** be expressed as $t_{tilt} \sim \tau_{A_1} \equiv r_1/V_{A_1}$, where … – «Время отклонения» может быть выражено как $t_{tilt} \sim \tau_{A_1} \equiv r_1/V_{A_1}$, где …

b) Although light is made up of waves, Planck’s quantum hypothesis tells us that in some ways it behaves as if it were composed of particles: it ***can*** be emitted or absorbed only in packets or quanta. – Хотя природа света волновая, квантовая теория Планка говорит о том, что свет некоторым образом ведет себя так, словно состоит из частиц, свет может излучаться и поглощаться только пакетами или квантами.

Exercise 5.1. Translate into Russian, paying attention to the meaning of the modals:

1. Consider a partition with two narrow parallel slits in it. On one side of the partition one places a source of light of a particular color. Most of the light ***will hit*** the partition, but a small amount ***will go*** through the slits. Now suppose one places a screen on far side of the partition from the light. Any point on the screen ***will receive*** wave from the two slits. However, in general, the distance the light has to travel from the source to the screen via the two slits ***will be different***. This ***will mean*** that the waves from the slits ***will not be*** in phase with each other when they arrive at the screen: in some places the waves ***will cancel*** each other out, and in others they ***will reinforce*** each other. The result is a characteristic pattern of light and dark fringes.

Words and expressions to help:

Partition – деление, разделение

Slit – прорезь, щель

Fringe – периферия, обрамление

2. The stars that we can see in our galaxy and other galaxies, the total is less than one hundredth of the amount required to half the expansion of the universe, even for the lowest estimate of the rate of expansion. Our galaxy and other galaxies, however, ***must contain*** a large amount of 'dark matter' that we ***cannot see*** directly, but which we know ***must be there*** because of the influence of its gravitational attraction on the orbits of stars in the galaxies.

3. Moreover, most galaxies are found in clusters, and we ***can*** similarly ***infer*** the presence of yet more dark matter in between the galaxies in these clusters by its effect on the motion of the galaxies. When we add up all this dark matter, we still get only about one tenth of the amount required to half the expansion. However, we ***cannot exclude*** the possibility that there ***might be*** some other form of matter, distributed almost uniformly throughout the universe that we have not yet detected and that ***might*** still ***raise*** the average density of the universe up to the critical value needed to half the expansion.

4. All of the Friedmann solutions have the feature that at some time in the past (between ten and twenty thousand million years ago) the distance between neighboring galaxies ***must have been*** zero. At that time, which we call the big bang, the density of the universe and the curvature of space-time ***would have been infinite***. Because mathematics ***cannot*** really ***handle*** infinite numbers, this means that the general theory of relativity predicts that there is a point in the universe where the theory itself breaks down. Such a point is an example of what mathematicians call a singularity.

5. The work of Lifshitz and Khalatnikov was valuable because it showed that the universe ***could have had*** a singularity, a big bang, if the general theory of relativity was correct. However, it did not resolve the crucial question: Does general relativity predict that our universe ***should have had*** a big bang, a beginning of time?

6. Light rays too ***must follow*** geodesics in space-time. Again, the fact the space is curved means that light no longer appears to travel in straight lines in space. So general relativity predicts that light ***should be bent*** by gravitational fields. For example, the theory predicts that the light cones of points near the sun ***would be*** slightly ***bent*** inward, on account of mass of the sun. This means that light from a distant star that happened to pass near the sun ***would be deflected*** through a small angle, causing the star to appear in a different position to an observer on the earth. Of cause, if the light from the star always passed close to the sun we would not be able to tell whether the light was being deflected or if instead the star was really where we see it.

Task 5.7. ***RENDERING PACTICE***

Preparation for rendering: Read the text / Find key words /Make up a plan / Retell the text in your own words.

The Wendelstein Fusion Experiment

The last major component of the Wendelstein fusion experiment, a section of the outer shell, is scheduled for installation on 21 December 2011. This completes the base machine: The research device, to be commissioned at the Greifswald branch of Max Planck Institute of Plasma Physics (IPP) in 2014, has then attained its final form.

The objective of fusion research is to derive energy from fusion of atomic nuclei, just as happens in the sun. To ignite the fusion fire, a future power plant must confine the fuel, hydrogen plasma, in magnetic fields and heat it to temperatures exceeding 100 million degrees. Wendelstein 7-X, the world's largest fusion device of the stellarator type, when finished, is intended to investigate the suitability of this configuration for a power plant. Discharges lasting up to 30 minutes are to demonstrate the device's essential property, its capability for continuous operation. The core of the device comprises 50 large superconducting magnet coils. Their bizarre shapes are owed to sophisticated optimization computation: They are to produce a highly stable and thermally insulating magnetic cage for the plasma.

The circular device is assembled from five structurally almost identical modules. Each module comprises a section of the plasma vessel, its thermal insulation, ten of the superconducting stellarator coils and four planar coils and the connections linking them, the piping for cooling the coils, and a section of the support ring, making for a total weight of about 120 tons per module. All five modules are meanwhile finished and, enclosed in a steel outer shell 16 meters in diameter, are in place at their final position on the machine's foundation. All that is missing to complete the ring is the "lid" on the last module, the final section of the thermally insulating outer shell. The component, weighing about 14 tones, is scheduled for installation on 21 December 2011. "As we have already done this four times, the 70-millimetre maneuvering gap on either side within which the crane has to place the large component meanwhile strikes us as extremely generous", states installation head Dr. Lutz Wegener. Once this is done, the device will then appear in its final form, viz. a steel ring with numerous ports projecting from it. "It's just a pity", states Dr. Hans-Stephan Bosch, Associate Director in the Wendelstein 7-X project, "that there will then be nothing more to be seen of the machine's interior, particularly of its hallmark, the coils."

There is plenty else to be done: Already installed are four-fifths of the ports linking the apertures in the plasma vessel through the cold coil region into the outer vessel – about 45 of them per module. These five major components have yet to be connected up: The brazing areas of the support ring, plasma vessel and outer vessel have to be closed, and the magnets be connected with the power and helium supplies. Then will come main power lines, cooling pipes, interior facilities in the plasma vessel and repeated control measurements and leakage tests: The base machine will then be ready. In parallel, the systems for heating the plasma will be incorporated. Then there are the supply facilities for electric power and cooling, the machine control and, lastly, the numerous measuring instruments for diagnosing the plasma's behaviour. After several years of strict adherence to its time schedule and budget, Wendelstein 7-X should be finished in 2014.

Task 5.8. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 5.9. Discuss the text with your partner.

Task 5.10. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 5.11 Watch the video, in your own words report the main idea of it.

https://www.youtube.com/watch?v=HFDrXppnNkc

Task 5.12. Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

WRITING AN INTRODUCTION AND CONCLUSION

An effective introduction explains the purpose and scope of the paper to the reader. The conclusion should provide a clear answer to any question asked in the title, as well as summarizing the main points.

5.12.1. **A common framework in an introduction**

In an introduction much depends on the type of research a person is conducting, but a common framework is:

a. Definition of key terms, if needed.

b. Relevant background information.

c. Review of work by other writers on the topic.

d. Purpose or aim of the paper.

e. Your methods and the results you found.

f. Any limitations you imposed.

g The organization of your work.

Task 5.12.1. Agree or disagree with the following statements which are considered to be parts of introduction:

- Background information or explanation
- An interesting story or event
- Some surprising information (a hook- a sentence or two to catch the reader's attention)
- A quotation or saying
- An unusual fact or some surprising statistic
- The beginning of a story
- A question (tricky to use affectively)

5.12.2. Parts of a conclusion

- summary of the main points of the essay
- no new arguments or important information
- the arguments (made in the body of the essay) can be logically extended by making recommendation or prediction
- it's not a novel; there are no surprising endings
- the best thing is if the conclusion can be tied back to introduction (hard to write)
- summary of the main points of the essay

- no new arguments or important information
- the arguments (made in the body of the essay) can be logically extended by making recommendation or prediction
- it's not a novel; there are no surprising endings
- the best thing is if the conclusion can be tied back to introduction

Task 5.12.2. Read the examples of Introduction and Conclusion. Find there the components presented above.

Introduction

Laser-ion acceleration has been promptly developing field with the growing installation of PW class lasers. The striking characteristics of laser accelerated ion stimulated a eclectic choice of applications in nuclear1 and medical physics. The prerequisite of a reproducible, high-repetition rate ion beam with fine energy spread and better efficiency is a challenging mission irrespective of extensive efforts5, primarily due to target behaviour with the interaction with modern high-repetition rate laser systems. Laser driven ion acceleration mechanism includes the target normal sheath acceleration (TNSA), radiation pressure acceleration (RPA), breakout afterburner (BOA), collisionless shockwave acceleration (CSA) and magnetic vortex acceleration (MVA).

TNSA is one of the most stable and well-understood mechanism, which necessitates long pulse durations and thin solid targets to approach high cut-off energies. By employing the solid-density planar target geometries, the highest proton beam quality has been observed with TNSA mechanism and highest proton energies experimentally reported with TNSA are 85 MeV. These ion beams have an inherently broad, thermal energy distribution whereas many potential applications of these compact sources require some degree of spectral control. This is motivating to investigate the new approaches to control the ion energy distribution at the source. Utilising foil targets at high repetition rates raises significant challenges with debris, electromagnetic pulse generation (EMP), target insertion accuracy at the laser focus and unwanted secondary radiation such as bremsstrahlung. Thus, the target choice also needs to avoid or suppress build-up of debris on optical elements in the target chamber to facilitate continuous use for extended periods of time.

In contrast to distinctive ion acceleration from laser-thin solid foil interaction, efficient ion acceleration has also been realized in near critical density (NCD) plasmas from high density gas jets which are measured to have gain of higher laser-plasma coupling. NCD targets which can be compatible to high repetition lasers may advance the acceleration mechanism to experience the high-energy ions at high repetition rate. Recently investigations where MVA mechanism has been studied theoretically and experimentally and concerned a excessive agreement owing to its estimation for attaining relativistic electron and proton beams.

Gas jet targets bid the opportunity for high repetition rates, but so far they have been limited to low particle energies and yields. Recently liquid targets have also shown a number of attractive features for meeting real world needs and can be rapidly delivered into the interaction region, and mitigate debris. In our former simulation research, proton acceleration with tightly focused linearly polarised (CP) PW laser pulses (2 PW-20 fs) was realised in NCD plasmas (~1.0n_c). The simulation consequences were obtained in a preionized near critical and above critical density hydrogen plasma which is still challenging to accomplish practically.

In this article, we demonstrate for the first time the generation of self-modulated high energy proton micro-bunches, of high energy and monochromaticity, driven by high-intensity short laser pulses from a novel plasma target of mixed ion species, specifically a gas target consisting of C and H atoms. Such plasma states can occur from the effectively instantaneous molecular dissociation and above barrier ionization of CH4 or other simple alkane gases, due to the high intensity of the prepulse for PW-class lasers. Hence, in our simulations, we consider a pre-ionized plasma (consisting of C and H fully ionized nuclei). Due to transverse (radial) field components of the plasma field in the generated plasma channel, micro-bunching of proton beams has been observed. These microbunches are naturally spaced at the plasma wavelength which may also favour the generation of a strong plasma wake. These observations could also contribute significantly to the advanced proton-driven plasma wakefield acceleration research (AWAKE project) which has recently demonstrated proton-driven plasma wakefields.

Our simulation results illustrate the generation of high-quality proton micro-bunches, of vital relevance for various applications such as proton cancer therapy, via a new laser-driven acceleration regime, which utilizes few-cycle (20 fs) high power (2 PW) laser pulses and gaseous targets. Such laser pulses are expected to become available, in the near future, at upcoming large scale facilities, such as the ELI project, while the use of gaseous targets holds great potential for high-repetition rate operation of the laser-driven accelerator, free from plasma debris which can disrupt the laser focusing optics and from EMP generation which can disrupt major optomechanical components, such diagnostic electronics and motorized stages for target handling. It has also been seen that the interactions between two or more ion species during plasma expansion can significantly modify the final ion spectral distribution. The specific changes to the spectra depend on the ions spatial distribution within the plasma and this provides an approach to achieving spectral control. The acceleration mechanism considered here seems to be a combination of ponderomotive acceleration, shock acceleration, and multispecies expansion. However, these mechanisms were not able to observe or show such microbunching or density modulation of proton beam. We emphasize in our simulation investigation of collimated proton microbunches of high energy which favours strong potential of utilising such mechanism for AWAKE kind of project.

Conclusion

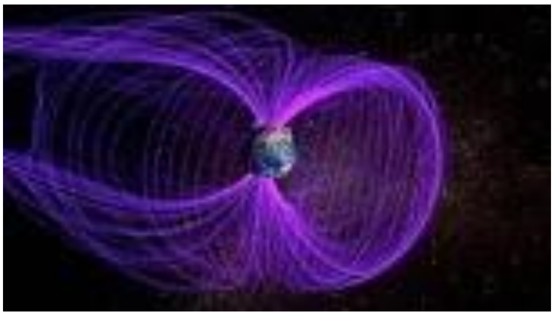
The formation of negative ions was proved to occur in low pressure RF capacitively coupled plasmas operated in a mixture of argon and aniline vapor. The experimental results show a great variety of negative species with a dominant negative ion found for a mass to charge ratio of 90 amu, and the formation of heavy negative ions reaching more than two times the mass of the aniline precursor. The initial deposition of a thin layer of pPANI on the electrodes appears to be a necessary condition for the production of negative ions in this type of plasma. Surface reactions on both electrodes probably involving positive ions are an essential part of the (probably multi-step) mechanisms leading to the formation of negative ions. In contrast to the positive ions and most negative ions whose density is decreasing with increasing distance between the plasma and the mass spectrometer sampling orifice, the negative ions with m/z = 26, 90 and 144 amu show a different behavior. Their signal shows a maximum value when the distance between the spectrometer and the plasma is increased to a certain range. This indicates a possible different production channel for these ions compared to other negative species created in this plasma. The attachment of low energy electrons to neutral species created by the plasma might be the reason for this phenomenon.

Deposition experiments in pulsed and CW discharges performed at different distances from the plasma suggest that the negative ions might contribute to the film growth. However, this contribution needs to be studied in more details.

5.12.3 Look at Punctuation rules in the Appendix and find examples of some rules in the Text 5.12.2

UNIT 6

TEXT 6. A detailed account of the measurements of cold collisions in a molecular synchrotron



Collision studies at low temperatures are of interest from both a practical and theoretical viewpoint. Interstellar clouds, which make out a large fraction of our universe, typically have temperatures well below 100 K. Collision data of simple molecules at low temperatures is crucial for understanding the chemistry that goes on in these clouds, which is of special interest because it is from these clouds that solar systems form. Furthermore, at low temperatures the de Broglie wavelength, associated with the relative velocity of the colliding molecules, becomes comparable to, or larger than, the intermolecular distances and quantum effects become important. Particularly interesting are resonances of the collision cross section as a function of collision energy. The position and shape of these resonances are very sensitive to the exact shape of the potential energy surface (PES) and thus serve as precise tests of our understanding of intermolecular forces. Precise knowledge of the PES is fundamental to fields such as combustion physics, atmospheric physics, or in fact any field involving chemical reactions.

Although several techniques have been developed to create samples of cold molecules, the obtained densities are low (typically 10^8 molecules/cm^3). As the cross sections of collisions involving neutral molecules or atoms are small (typically below 500 $Å^2$), the main challenge to studying cold collisions is to reach a sufficiently high sensitivity. In recent years, several experiments have managed to measure low energy collisions by leveraging the unique properties of the systems they study. For instance, by exploiting the extreme state-purity of Stark-decelerated beams combined with sensitive ion-detection techniques, van de Meerakker and co-workers have measured quantum-state changing collisions of OH and NO molecules with rare gas atoms to temperatures as low as 5 K. Costes and co-workers have studied inelastic collisions of O_2 and CO with H_2 molecules and helium at energies between 5 and 30 K using cryogenically cooled beams under a small (and variable) crossing angle. Even lower temperatures have been obtained by using magnetic or electric guides to merge two molecular beams. Narevicius and co-workers and Osterwalder and co-workers have exploited the advantages of metastable helium to study Penning ionization reactions with various atoms and molecules. In a similar fashion, Merkt and co-workers have measured collisions between ground-state hydrogen molecules and hydrogen in highly excited Rydberg states that were merged on a chip. Finally, cold collision have been studied by sending slow beams of atoms and molecules through trapped samples of calcium ions, lithium atoms and OH radicals, exploiting the fact that collision signal can be accumulated over long time-intervals.

We have developed a method that enables the study of collisions at low energy by exploiting the unique properties of a molecular synchrotron. Our approach combines the low collision energies obtained in experiments that use merged molecular beams with the high sensitivity of experiments that monitor trap loss. In Van der Poel et al., the total cross section for ND_3 + Ar collisions was determined from the rate at which ammonia molecules were lost from the synchrotron due to collisions with argon atoms in supersonic beams. This paper provides further details on this experiment. Before going into detail, we will first outline the main principles and virtues of our technique.

Topic vocabulary:

Task 6.1. Answer the questions

1. Why is Collision data of simple molecules at low temperatures crucial?
2. Why do quantum effects become important?
3. What are the position and shape of resonances of the collision cross section very sensitive to?
4. What does PES stand for?
5. What is the main challenge to studying cold collisions?

6. Name the experiments in which low energy collisions have been measured.
7. Who measured quantum-state changing collisions to temperatures as low as 5 K?
8. How were the advantages of metastable helium exploited?
9. Which method of studying collisions at low energy have the authors developed?
10. Which techniques does the approach combine?

Task 6.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

Collision studies at low temperatures are of interest from both a practical and theoretical viewpoint. Interstellar clouds, which make out a large fraction of our universe, typically have temperatures well below 100 K. Collision data of simple molecules at low temperatures is crucial for understanding the chemistry that goes on in these clouds, which is of special interest because it is from these clouds that solar systems form. Furthermore, at low temperatures the de Broglie wavelength, associated with the relative velocity of the colliding molecules, becomes comparable to, or larger than, the intermolecular distances and quantum effects become important. Particularly interesting are resonances of the collision cross section as a function of collision energy. The position and shape of these resonances are very sensitive to the exact shape of the potential energy surface (PES) and thus serve as precise tests of our understanding of intermolecular forces. Precise knowledge of the PES is fundamental to fields such as combustion physics, atmospheric physics, or in fact any field involving chemical reactions.

Google translation

Исследования столкновений при низких температурах представляют интерес как с практической, так и с теоретической точки зрения. Межзвездные облака, составляющие большую часть нашей вселенной, обычно имеют температуры значительно ниже 100 К. Данные о столкновении простых молекул при низких температурах имеют решающее значение для понимания химии, которая происходит в этих облаках, что представляет особый интерес, поскольку из этих облаков образуются солнечные системы. Кроме того, при низких температурах длина волны де Бройля, связанная с относительной скоростью сталкивающихся молекул, становится сопоставимой или большей, чем межмолекулярные расстояния, и квантовые эффекты становятся важными. Особенно интересны резонансы сечения столкновения в зависимости от энергии столкновения. Положение и форма этих резонансов очень чувствительны к точной форме поверхности потенциальной энергии (PES) и, таким образом, служат точным тестом нашего понимания межмолекулярных сил. Точное знание PES имеет фундаментальное значение для таких областей, как физика горения, физика атмосферы или фактически любая область, связанная с химическими реакциями.

PROMT translation

Исследования столкновения при низких температурах представляют интерес и с практической и с теоретической точки зрения. Межзвездные облака, разбирающие большую часть нашей вселенной, как правило, имеют температуры значительно ниже 100 К. Данные о столкновении простых молекул при низких температурах крайне важны для понимания химии, продолжающейся в этих облаках, который особенно интересен, потому что это - от этих облаков та форма солнечных систем. Кроме того, при низких температурах длина волны де Брольи, связанная с относительной скоростью сталкивающихся молекул, становится сопоставимой с, или больше, чем, межмолекулярные расстояния и квантовые эффекты становятся важными. Особенно интересный резонансы профиля столкновения как функция энергии столкновения. Позиция и форма этих резонансов очень чувствительны к точной форме поверхности потенциальной энергии (PES) и таким образом служат точными тестами на наше понимание межмолекулярных сил. Точное знание PES является основным принципом областей, таких как физика сгорания, атмосферная физика, или на самом деле любая область, включающая химические реакции.

Task 6.3. Match the words with their meaning.

1 combustion (n)	A (of a vehicle, machine, or process) reduce speed; slow down
2 leverage (n)	B involving or denoting a speed greater than that of sound
3 decelerate (v)	C the exertion of force by means of a lever or an object used in the manner of a lever.
4 merge (v)	D the degree of compactness of a substance
5 metastable (adj)	E behaviour showing high moral standards
6 fraction (n)	F combine or cause to combine to form a single entity.
7 supersonic (adj)	G gather together or acquire an increasing number or quantity of
8 virtues (n)	H (of a state of equilibrium) stable provided it is subjected to no more than small disturbances
9 accumulate (v)	I the process of burning something
10 density (n)	J a numerical quantity that is not a whole number (e.g., 1 / 2 , 0.5)

Task 6.4 Insert the prepositions into the gaps.

1. When the capacitor discharges those volts, it delivers an amperage comparable ….. stun guns.

2. He would walk up to the middle in a carefree manner, and set about his act ……. a masterly fashion.

3. Only in the study of quantum liquids …. temperatures close to absolute zero does experimental accuracy approach Heisenberg's limit

4. In its natural form it also has a couple of water molecules associated …….. the molecule

5. The same foolishness, the same sterility, obtains …….. the ‘not serious’ as in the ‘serious’.

Task 6.5. Match words or phrases in column A with their synonyms in column B. Find sentences in the text with the words from column A and translate them. Make your own sentences with the words from column B.

1	response	a	approach
2	exhibit	b	reply
3	shape	c	for example
4	controversially	d	ambiguously
5	approach	e	various
6	occurrence	f	realization
7	viewpoint	g	show
8	different	h	form
9	for instance	i	opinion
10	support	j	way

NB: ***Negative Prefixes dis-, mis-, de-, in-, im-, ir-, un-***

Dis- обычно выражает обратное, противоположное действие или отрицание.
Example: agree - ***dis***agree

Mis- обычно выражает ошибочное действие
Example: understand – ***mis***understand, matching - ***mis***matching

De- обычно выражает изъятие, удаление
Example: aerate – ***de***aerate, composition - ***de***composition

In-, im-, ir-, un- обычно выражают отрицания
Example: active – ***in***active, possible – ***im***possible, regular – ***ir***regular, known – ***un***known

Exercise 6.1. From the words given form nouns with the opposite meaning using prefixes

1. order, 2. place, 3. dependence, 4. increase, 5. application, 6. ability, 7. balance, 8. possibility, 9. rationality, 10. decent

Exercise 6.2. Fill in the gaps in the sentences with appropriate words with negative prefixes.

1. I'm not satisfied with the results of the experiment. I'm …………… with them.
2. The color of the liquid doesn't seem usual for me. It's very…………………. .
3. Cheating at the exams is not fair. It's very…………….. .
4. We are not able to solve this problem now. It is an…………………problem.

5. What makes an evaluative inference valid or……………..?
6. We can't avoid radiation loss. It is…………….. .
7. I don't see any logic in his speculations. His speculations are……………….. .
8. The synthetic utility of his transformation hasn't been explored so far. It remains…… .
9. In water-logged soil, which doesn't contain enough oxygen, there are bacteria that change nitrates back to nitrogen. These bacteria are called……………..bacteria.
10. Someone who has lost a lot of water from his body is……………….and feels weak or ill.
11. She knows a lot of French words, but she doesn't pronounce them properly. She tends to……………….them.

His extravagant ideas were not understood properly by scientific community. His ideas were………………….by scientific community

Task 6.6. Translate the text into English:

ИДЕЯ МАГНИТНОЙ ТЕРМОИЗОЛЯЦИИ

Термоядерные реакции синтеза ядер водорода происходят в недрах звезд при огромных температурах порядка сотен миллионов градусов и сопровождаются выделением огромного количества энергии, которая и поддерживает горение звезды. Вещество звезды при таких температурах находится в плазменном состоянии, когда электроны оторваны от ионов, а заряженные частицы, электроны и ионы, образуют в среднем электронейтральный газ - плазму. Говорят, что плазма находится в квазинейтральном состоянии, то есть небольшое разделение зарядов приводит к возникновению сильных самосогласованных электрических полей, которые и поддерживают примерное равенство электрических зарядов в среднем по пространству. Чтобы осуществить в лаборатории управляемый термоядерный синтез (УТС), необходимо выполнение двух условий. Во-первых, плазма должна быть нагрета до температуры порядка ста миллионов градусов, чтобы положительно заряженные ядра водорода могли преодолеть кулоновское отталкивание и сблизиться на расстояние, необходимое для начала реакции синтеза. В результате синтеза изотопы водорода превращаются в гелий и появляются свободные нейтроны, а сама реакция идет с выделением энергии. Во-вторых, концентрация плазмы должна быть достаточно большой и удерживаться в установке она должна достаточно долго, чтобы реакция была управляемой (в отличие от термоядерной бомбы), а энергия, выделяемая в результате реакции, превосходила бы энергетические затраты на нагрев плазмы до термоядерных температур. Наиболее естественный способ удержания плазмы основан на идее удержания заряженных частиц сильным магнитным полем.

Words and expressions to help:

в недрах звезд - in a subsoil of stars; поддерживает горение - sustains combustion; самосогласованные электрические поля - the self-coordinated electric fields; управляемый термоядерный синтез - controlled thermonuclear fusion.

GRAMMAR POINT

Subject - Verb Agreement

Remember that the subject and verb in a sentence must agree in person and number.

Examples: The apparatus (singular) works (singular) very well.

The apparatuses (plural) work (plural) work very well.

Sometimes it is very difficult to decide exactly what the subject is if the subject and verb are separated.

Example: The students (plural) in the room are studying (plural).

Very often, if the subject and verb are separated, they are separated by a prepositional phrase. The prepositional phrase has no effect on the verb.

Subject + prepositional phrase + verb

Examples: The study (sing.sub.) of languages is (sing.v.) very interesting.

The view (sing.sub.) of these disciplines varies (sing.v.) from time to time.

The results of the experiments (plural sub.) of the experiment are (plural v.) likely to be devastating.

The following expressions also have no effect on the verb:

together with *along with* *accompanied by* *as well as*

Examples: Dyre, *together with co-workers*, **has** suggested that the quasiuniversal spectral shapes contain only little information on microscopic details of the charge carrier dynamics.

Dyre, *along with co-workers*, **has** suggested that the quasiuniversal spectral shapes contain only little information on microscopic details of the charge carrier dynamics.

BUT

If the conjunction *and* is used instead one of the phrases, the verb would be plural.

Example: Dyre and co-workers **have** suggested that the quasiuniversal spectral shapes contain only little information on microscopic details of the charge carrier dynamics.

Exercise 6.3. Chose the right form of the verb in brackets

1. Mr. Smith, along with Mr. Johnes, (is/are) responsible for the project.
2. The quality of these shots (is/are) not very good.
3. If the duties of these officers (isn't/aren't) reduced, there will not be enough time to finish the project.
4. The levels of intoxication (vary/varies) from subject to subject.
5. Mr. Johns, accompanied by several members of the committee, (have/has) proposed some changes in the rules.
6. Finally, polarity reversion tests, as well as linear superposition tests, (has/have) shown that the signals are truly from the VING.
7. The voltage, together with the power produced by a single nanowire, (is/are) insufficient for real devices.
8. Finally, the integration of a VING with a ZnO nanowire-based pH or UV nanosensor (have/has) allowed the demonstration of a self-powered nanosystem solely built from ZnO nanowires.
9. The use of such devices (have/has) increased rapidly.
10. The output signals of the VING (was/were) stable over a long period of time.

Task 6.7. ***RENDERING PRACTICE***

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

Schlieren imaging: a powerful tool for atmospheric plasma diagnostic.

The number of industrial and biomedical applications of plasmas at atmospheric pressure has been steadily increasing over the past decade: nowadays, plasma applications include materials treatment for the activation of surfaces or coating deposition, ozone synthesis, fuel conversion and the treatment of liquids bacterial inactivation and plasma-assisted medical therapies, plasma actuators for active flow control on airfoils, gas turbine blades and wind turbines, and high temperature material processing, such as plasma spraying, arc cutting and arc welding, etc. This versatility is gained by several possible combinations of driving power supply, management and composition of working gas, formation and propagation of the discharge and source architecture.

The need for an optimization of plasma assisted processes has prompted the scientific community to thoroughly investigate the physics of plasmas and their complex behavior in interacting with various materials (e.g. biological materials, liquids, etc.) by means of a range of diagnostic techniques; among these, a prominent role is held by schlieren imaging, which is nowadays widespread and extensively used for the investigation of plasma processes by studying phenomena occurring in transparent media.

In fact, nearly all plasma processes have in common the fact that plasma is generated and propagates in a fluid medium. The fluid-dynamics inside and outside the plasma region play a critical role in determining plasma chemical composition and discharge morphology, the propagation of reactive species, interaction and mixing of plasma with the surrounding atmosphere, residence time of precursors in the plasma region and resulting deposition rates, among other process characteristics. From this perspective it is easy to understand why schlieren imaging, which allows one to see “the invisible”, is considered a powerful tool for characterizing atmospheric pressure plasma processes and why its use is steadily increasing.

Against this background, this paper is meant as an introduction to schlieren imaging and its use as a tool for plasma diagnostics, highlighting its potentialities and providing the readers with practical examples associated with different atmospheric pressure plasma processes. The expected audience includes plasma scientists that are current and potential users of this technique. The paper is developed along two main parts: a theoretical part, concerning the physical fundamentals of the technique, the many instruments used to implement it and their preferred configurations, and a more practical part meant to deal with several examples of its use for the study of the behavior of different plasma sources and processes, describing both the type and quality of the obtainable information and the setups and practical measures adopted. As a matter of fact, even focusing only on atmospheric pressure plasmas, the temperature ranges from room temperature to several thousand K, while power can go from a few W to several kW; the characteristics of the adopted schlieren setup should be accordingly tuned. To show how this tuning of schlieren optics is performed to achieve optimal results, a selection of best practices in the conduct of experimental activities to investigate different kinds of processes assisted by atmospheric pressure plasmas is also reported in the second part of this paper, similarly to a previous paper from some of the authors concerning best practices in ICCD diagnostics of plasmas.

Task 6.8. Match the words with their meaning.

1 deposition (n)	A the quality or state of being different or diverse; the absence of uniformity, sameness, or monotony
2 conversion (n)	B in a way that is appropriate to the particular circumstances
3 airfoil (n)	C important; famous
4 versatility (n)	D the fact or process of spreading over an area
5 precursor (n)	E the act or an instance of converting or the process of being converted
6 accordingly (adv)	F increase the amount or rate of (something, typically weight or speed)
7 gain (v)	G thick, soft, wet mud or a similar viscous mixture of liquid and solid components, especially the product of an industrial or refining process.
8 propagation (n)	H a person or thing that comes before another of the same kind; a forerunner
9 thoroughly (adv)	I a structure with curved surfaces designed to give the most favourable ratio of lift to drag in flight, used as the basic form of the wings, fins, and horizontal stabilizer of most aircraft.
10 prominent (adj)	J accurately, in detail

Task 6.9. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 6.10. Discuss the text with your partner.

Task 6.11. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com
https://coggle.it

Task 6.12. Reading formulae

How to read signs:

Sign	Noun	Verb
+	addition	Add
-	subtraction	subtract
x	multiplication	multiply
/	division	Divide

These signs ( ) are called brackets – we say open brackets, close brackets, or a plus b in brackets.

These signs [ ] are called square brackets.

These signs { } are called braces.

ABC – are capital letters; ***def*** – are small letters.

We read R_x – ***R*** subscript ***x***

How are these formulae spoken?

$a + b = c$ — ***a*** plus ***b*** equals ***c***

$a - b = d$ — ***a*** minus ***b*** equals ***d***

$a \times b = e$ — ***a*** times ***b*** equals ***e*** or ***a*** multiplied by ***b*** equals ***e***

$a/b = f$ — ***a*** over ***b*** equals ***f*** or ***a*** divided by ***b*** equals ***f***

$(a - b)(a + b) = y$ — ***a*** minus ***b*** in brackets times ***a*** plus ***b*** in brackets equals ***y***

a(7 – b) = x ***a*** open brackets ***7 – b*** close brackets equals ***x***

$\frac{10+(a+b)}{7a}$ ***= b*** ***10*** plus ***a*** minus ***b*** in brackets all over ***7a*** equals ***b***

x[(a –b)(a = b) – 7] = 0 ***x*** open square brackets ***a*** minus ***b*** in brackets times ***a*** plus ***b*** in brackets minus ***7*** close square brackets equals ***naught***.

$\frac{1}{b} + \frac{1}{c} = \frac{1}{d}$ ***one*** over ***b*** plus ***one*** over ***c*** equals ***one*** over ***d***

Exercise 6.1. Read out these equations:

1. d + e = c
2. a – d = b
3. d = a + b / c
4. x + y = A/(a – b)
5. K = a + (n – 1)d
6. V = IR
7. v = u + at
8. 1/R = - M/EI

How are these values spoken?

x^2 – ***x*** squared

x^3 – ***x*** cubed

x^n – ***x*** to the power (of) ***n***, OR ***x*** to the ***n***

x^{n-1} – ***x*** to the power (of) ***n*** minus one, OR ***x*** to the ***n*** minus one

x^{-n} – ***x*** to the power (of) minus ***n***, OR ***x*** to the minus ***n***

$\sqrt{y}$ – square root of ***y***

$\sqrt[3]{y}$ – cube root of ***y***

$\sqrt[n]{y}$ – ***n***th root of ***y***

Exercise 6.2. Practice reading these expressions:

1. $x^{-n} = \frac{1}{x^n}$
2. $x^{n/p} = \sqrt[p]{x^n}$
3. $x^2 - y^2 = (x + y)(x - y)$
4. $x = nk^{ab}$
6. $x - x_1 = \left(\frac{x_2 - x_1}{y_2 - y_1}\right)(y - y_1)$
7. $\frac{a^2}{x^2} + \frac{b^2}{y^2} + \frac{c^2}{z^2} = 1$
8. $d^2 = c^2(1 - b^2)$

5. x = $\dfrac{ab_1 + cb_2}{a + c}$

9. $m^2 + n^2 + 2pm + 2xy + d = 0$

10. $a = \sqrt{[(b_1 - b_2)^2 + (c_1 - c_2)^2 + (d_1 - d_2)^2]}$

Reading more complex formulae

symbol	meaning	example	spoken
$\equiv$	equivalent to	$a \equiv b$	***a*** is equivalent to ***b***
$\neq$	not equal to	$a \neq b$	***a*** is not equal to ***b***
$\approx$	approximately equal to	$a \approx 9$	***a*** is approximately equal to ***9***
$\rightarrow$	tends to	$y \rightarrow 0$	***y*** tends to ***nought***
<	less than	c<3	***c*** is less than ***three***
>	greater than	c>3	***c*** is greater than ***three***
$\ll$	much less than	$d \ll 10$	***d*** is much less than ***ten***
$\gg$	much greater than	$d \gg 10$	***d*** much greater than ***ten***
$\leq$	less than or equal to	$f \leq 2$	***f*** is less than or equal to ***two***
$\geq$	greater than or equal to	$f \geq 2$	***f*** is greater than or equal to ***two***
$\propto$	proportional to	$m \propto n$	***m*** is proportional to ***n***
∞	infinity	$z \rightarrow \infty$	***z*** tends to infinity
$\pm$	plus or minus	$a = \pm 1$	***a*** equals plus or minus ***one***
$\therefore$	therefore	$\therefore z = 0$	therefore ***z*** equals ***naught***
/	per	km/hr	***kilometers per hour***

Read and remember Greek alphabet

α A	alfa /' xlfq/	ν N	Nu /nju/
β B	beta /' bitq/	ξ Ξ	xi /ksQI/
γ Γ	gamma /' gxmq/	o O	omicron /qV'mQIkrqn/
δ Δ	delta /' deltq/	π Π	pi /pQI/
ε E	epsilon /ep'sQIlqn/	ρ P	rho /rqV/
ζ Z	zeta /' zitq/	σ Σ	sigma /'sigmq/
η H	eta /'itq/	τ T	tau /tQV/
θ Θ	theta /'Titq/	υ ϒ	upsilon /jup'sQIlqn/
ι I	iota /QI'qVtq/	ϕ Φ	phi /fQI/
κ K	kappa /'kxpq/	χ X	chi /kQI/
λ Λ	lambda /'lxmdq/	φ Ψ	psi /psQI/
μ M	mu /mju/	ω Ω	Omega /'qVmigq/

Exercise 6.3. Read out these expressions:

1. $\lambda > 90^{\circ}$
2. $y \to \infty$
3. $\beta \equiv \theta$
4. $c_1 \neq d_1$
5. $\pi = 3.142$
6. $E \geq \pm\ 0.5$
7. $\varepsilon \sqcup 2.5$
8. $\gamma \propto \kappa$
9. $\mu < 1$
10. $\omega \neq \varphi$

Exercise 6.4. Write down the formulae:

1. C equals one over three pi times the square root of RC
2. E equals lambda P to the power of five
3. Capital V subscript 2 equals two pi small y over capital U
4. Lambda equals Kappa subscript oh over two pi R all times C

5. Epsilon subscript oh equals five pi times 10 to the power of minus six over capital D small n to the power of minus one
6. E equals O over M squared minus omega squared N squared
7. U subscript 2 equals the square root of open brackets, two c over p times capital V subscript one, close brackets
8. V equals a half lambda subscript upsilon cubed all over S
9. Mu equals capital P small x small z all over capital N, plus capital R over Q
10. Sigma equals three P over four pi R squared times, open brackets, R squared minus sigma squared, close brackets

Exercise 6.5. Read the formulae:

1. $R = \frac{V}{I}$
2. $E = mc^2$
3. $P_1Q_1 = P_2Q_2$
4. $\frac{1}{a} + \frac{1}{b} = \frac{1}{c}$
5. $F = \frac{mv^2}{r}$
6. $\frac{2}{3R} = \frac{Q}{NP}$
7. $\frac{\eta}{Zn} = \frac{M}{2A_2}$
8. $C = 2\pi R_1 [R_1 - \sqrt{(R_1^2 \frac{c^2}{2})}]$
9. $\alpha = \frac{3Q}{4\pi R^2}(R - \beta^2)$
10. $F \propto \frac{P_1P_2}{2R}$

Task 6.13. Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

COMMUNICATING IN SCIENTIFIC ENVITRONMENT.

6.13.1. Describing texts (articles, scientific papers, studies, reviews, etc)

6.13.1.1. Setting a goal

...The chief/general aim...

...central/ key/ ultimate goal...

...main/particular purpose...

...major/ primary task of this paper/ study is …

...one of the main/ principal objectives is…

6.13.1.2. Describing the subject

The subject (matter) of this paper/ study/ analysis/ research/ discussion is …

The present paper/ investigation/article

… goes (inquires) into…

… focuses on…

… deals with…

... is devoted to the questions (problems/ issues) of …

. .. undertakes to survey/ identify the structure of

... considers what factors/ processes influence …

… the concluding/ final sections/ comments/ remarks concern/ focus on…

... In this article/ section the authors aim to determine…

... attempt to explain the mechanisms of…

... are intended to give/ show/ develop/ provide/ record

... examine the nature/ characteristics/ features/ functions of …

... (will) concentrate on/ argue that/ review

6.13.1.3. Sounding personal

I want to point to/ review/ introduce...

I can/ shall/ should provide …

I must emphasize that…

I must say a few words about …

I should/ would like to illustrate/ suggest/ posit/ stress that

I find it necessary to consider …/ to turn our attention to …

6.13.1.4. Going further:

One further remark…

Two further points …

Further questions…

A further aim of the paper…

The only step needed (here) is …

The issue that ought to be raised here concerns…

The second point I want to describe here has to do with…

This latter point requires justification.

6.13.1.5. Supplying evidence:

To lend support to our hypothesis…

To base our position…

This issue can serve as a basis for …

This matter can form a background for a judgment about …

This point requires justification/ should be examined in detail/ with accuracy.

This question requires (further) remark/ comment/ explanation.

This problem presupposes deep study/ minute analysis/ understanding of

This method should be precisely/ clearly/ accurately/ explicitly/ rigidly defined.

This approach can be extensively/ properly/ reasonably applied to…

This topic should be studied/ investigated closely/ carefully/ thoroughly.

6.13.1.6. References

According to…

Following…

I will refer to…

This result was obtained by…

Such problems are fully discussed by .. in …

The following passage from… illustrates that…

This aspect has (not) received attention (criticism/ scientific support) in the literature.

References should be made to…

6.13.1.7. Positive comments:

This article/book/discussion/study

...is an accurate/ comprehensive/ convincing analysis of …

...is an instructive/ minute/ profound/ thorough description of…

...is a good snapshot of functional analysis…

...supports the theory of…

...sheds new light on …

...allows a principled decision on …

...sounds attractive…

...proved to be successful…

...deals with the complex subject in an orderly manner…

...shows very convincingly, that …

...presents a wealth of data about…

...managed to answer the question with simplicity.

This approach

...is quite/ highly creative/ effective/ fruitful/

...is more flexible than…

...is the best

... is perfect / valuable for …

...has aroused wide interest

...has been the stimulus for analytic discussion

...opens prospects for further study of…

...casts (a new) light on the question

...gives convincing (direct/ exact/ good/ plausible/ serious/ sound/ strong/ sufficient/valid) reason to think that...

...gives rise to theoretical discussion

...is elaborated/ explained in detail.

6.13.1.8. *Criticism and objections:*

The study done by…

...is still under discussion

...does not allow us to answer the question whether…

...leaves many questions open.

The solution offered by .. has been criticized at length.

The approach/ strategy

...neglects (ignores)…

...has a number of disadvantages

...is not accurately formulated

...is a hot topic in debates

..draws sharp criticism

Objections can be raised...

There are a number of objections that can be raised...

There are counter-examples…

The negative side of the approach/ method…

6.13.1.9. Personal negative remarks:

I t seems (a bit) artificial

It seems unlikely that … .

It is nonsensical / an error to regard …

It is doubtful / I doubt that…

I am unsure whether …

I am afraid / not sure/ I am not convinced that…

I am skeptical / critical / suspicious of …

6.13.1.10. Exemplification of the problem:

This example can serve as an illustration to….

This procedure may be illustrated by …

Two sample cases (simple examples,) will help demonstrate …

Here I shall give examples which show that …

To illustrate the point (further), we may take / consider another example…

The following examples may serve as illustrations…

This point can be easily exemplified.

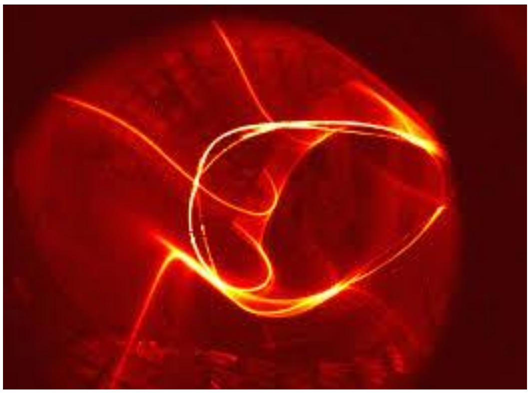
The point will be clearer if we consider another type of example.

Task 6.14. Find an article on your field of study, spot and underline the expressions presented above.

Task 6.15. Write a paragraph on the subject you study using some of the expressions.

UNIT 7

TEXT 7. Collisions of argon atoms with the stored packets of ammonia in the synchrotron



In its simplest form, a storage ring is a trap that confines molecules along a circle rather than around a point. As such, a storage ring for molecules in low-field seeking states can be made by bending an electrostatic hexapole focuser into a circle, which was demonstrated in 2001 by Crompvoets et al. Since in such a storage ring no longitudinal forces exist to keep the faster and slower molecules together, injected packets of molecules will disperse until the ring is filled homogeneously. As demonstrated in 2007 by Heiner et al., this can be prevented by breaking the ring into two half-circles and switch the voltages in such a way that molecules are bunched together as they fly through the gap between the two half rings. In 2010, an improved synchrotron, consisting of 40 straight hexapoles placed in a circle was demonstrated by Zieger et al. Using many segments rather than two has a number of advantages: Due to the high symmetry of the ring, instabilities resulting from the variation of the trapping force are less important and the transverse depth of the ring is increased. The longitudinal well is also increased as bunching happens many times per round-trip. Zieger et al. illustrated the stability of their design by demonstrating that they could observe trapped ammonia molecules (ND_3) in well-defined, mm-sized packets, after storing them for more than 10 s in the ring. The fact that elements can be switched individually implies that different packets can be injected and detected independently, allowing the synchrotron to hold up to 19 packets simultaneously. As the stored packets of ammonia molecules have both a small velocity spread (corresponding to a temperature of 10 mK) and widely (100–150 m/s) tunable velocities, they are well suited for collision studies, as will be demonstrated in this paper.

The main idea of our experiment is illustrated in Fig. 1. Beams of argon atoms are sent through the synchrotron and made to collide with the stored packets of ammonia. The argon beams moves in the same direction as the stored ammonia molecules such that low collision energies can be achieved. The experiment is triggered in such a way that some of the ammonia packets—the *probe* packets—encounter a fresh argon beam every round-trip, while other packets—the *reference* packets—do not. When after a certain number of round-trips the packets are detected, the probe and reference signals are compared to find the rate at which ammonia molecules are lost from the synchrotron due to collisions with the argon beam. The longer the packets are stored before detection, the more molecules are lost from the probe beam. In this way, collision signal is accumulated and the sensitivity to measure collisions is strongly enhanced.

The expected enhancement in sensitivity is illustrated in Fig. 2. The signals of the probe (red, S_{probe}) and reference packets (blue, S_{ref}), using numbers from the experiment that was discussed in Van der Poel et al., are shown as a function of storage time in the synchrotron. Both signals are modelled by exponential decays. While the probe and reference packets share the same background loss rate (in this calculation k_{bg}=1.46% per round-trip), the probe packets are modelled to experience additional loss due to collisions with particles from the collision partner beamline (at a rate of k_{col}=1.26% per round-trip). After a given number of round-trips *rt*, the loss rate due to collisions can be found using kcol=1/rtln(Sref/Sprobe).

The uncertainty in the loss rate is found from the statistical uncertainties in the probe and reference signals. Since the number of detected ions follows Poisson statistics, the uncertainty is given by the square-root of this number: σkcol=1/rt√(1/Sref)+(1/Sprobe).

(2)

The orange curve shows the ratio of the calculated loss rate k_{col} and its uncertainty σkcol, after a single measurement only (i.e., a single measurement of a probe and a reference packet, requiring two shots). This signal-to-noise ratio increases dramatically the first tens of round-trips, due to the factor of 1/rt in σkcol. After about 90 round-trips, roughly 2 times the 1/*e* lifetime of the probe packet, the statistical uncertainty in S_{probe} becomes the limiting factor and the signal-to-noise ratio decreases again. For the numbers used in this calculation, the expected signal-to-noise ratio at the optimal number of round-trips is ∼1 after a single measurement of the probe packet and reference packet. The uncertainty can thus be reduced to below 1% by measuring 20,000 shots, or a little over half an hour when measuring at a rate of 10 Hz. Note that the signal-to-noise ratio at the optimal number of round-trips is 34 times larger than after a single round-trip. Consequently, the sensitivity of the synchrotron reduces the measuring time by over a factor of 1000 with respect to a hypothetical crossed beam experiment with the same densities. This enhancement in sensitivity is what motivated us to do this experiment.

Topic vocabulary:

electrostatic hexapole focuser - электростатический гексапольный фокусировщик; longitudinal well - продольный провал; tunable velocities – регулируемые скорости; the experiment is triggered in such a way that – эксперимент проводится таким образом, что; enhancement in sensitivity - повышение чувствительности; signal-to-noise ratio – отношение сигнал-шум; beamline - экспериментальная станция источника синхротронного излучения

Task 7.1. Answer the questions

1. What suggestion was made for a storage ring for molecules in low-field seeking states?

2. What will be prevented by breaking the ring into two half-circles and switching the voltages?
3. What was the improvement in synchrotron demonstrated by Zieger et al.?
4. What are the advantages of using many segments rather than two?
5. How did Zieger et al. illustrate the stability of their design?
6. What is the main idea of the proposed experiment?
7. Why is the sensitivity to measure collisions enhanced?
8. What do the probe and reference packets share?
9. How is the uncertainty in the loss rate found?
10. How many shots are required to reduce the uncertainty to below 1%?

Task 7.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

In its simplest form, a storage ring is a trap that confines molecules along a circle rather than around a point. As such, a storage ring for molecules in low-field seeking states can be made by bending an electrostatic hexapole focuser into a circle, which was demonstrated in 2001 by Crompvoets et al. Since in such a storage ring no longitudinal forces exist to keep the faster and slower molecules together, injected packets of molecules will disperse until the ring is filled homogeneously. As demonstrated in 2007 by Heiner et al., this can be prevented by breaking the ring into two half-circles and switch the voltages in such a way that molecules are bunched together as they fly through the gap between the two half rings. In 2010, an improved synchrotron, consisting of 40 straight hexapoles placed in a circle was demonstrated by Zieger et al. Using many segments rather than two has a number of advantages: Due to the high symmetry ring of the, instabilities resulting from the variation of the trapping force are less important and the transverse depth of the ring is increased. The longitudinal well is also increased as bunching happens many times per round-trip. Zieger et al. illustrated the stability of their design by demonstrating that they could observe trapped ammonia molecules (ND_3) in well-defined, mm-sized packets, after storing them for more than 10 s in the ring. The fact that elements can be switched individually implies that different packets can be injected and detected independently, allowing the synchrotron to hold up to 19 packets simultaneously.

Google translation

В своей простейшей форме накопительное кольцо представляет собой ловушку, которая ограничивает молекулы вдоль круга, а не вокруг точки. Таким образом, накопительное кольцо для молекул в состояниях поиска в слабом поле можно изготовить путем изгиба электростатического гексапольного фокусера в круг, что было продемонстрировано в 2001 г. Crompvoets et al., Поскольку в таком накопительном кольце не существует продольных сил для удержания чем быстрее и медленнее молекулы вместе, то инъецированные пакеты молекул будут рассеиваться, пока кольцо не будет заполнено однородно. Как продемонстрировано в 2007 году Heiner et al., Это можно предотвратить, разбив кольцо на два полукруга и переключив напряжения таким образом, что молекулы собираются в пучки, когда они пролетают через зазор между двумя полукольцами. В 2010 году Зигер и др. Продемонстрировали улучшенный синхротрон, состоящий из 40 прямых гексапол, помещенных в круг. Использование множества сегментов, а не двух, имеет ряд преимуществ: из-за кольца высокой симметрии нестабильности, возникающие в результате изменения силы захвата менее важны, а поперечная глубина кольца увеличивается. Продольная яма также увеличена, так как группировка происходит много раз за круговое путешествие. Цигер и соавт. проиллюстрировал стабильность их конструкции, продемонстрировав, что они могут наблюдать захваченные молекулы аммиака (ND3) в четко определенных пакетах размером в мм после хранения их более 10 с в кольце. Тот факт, что элементы могут переключаться индивидуально, подразумевает, что различные пакеты могут быть введены и обнаружены независимо, что позволяет синхротрону одновременно хранить до 19 пакетов.

PROMT translation

В простейшем виде кольцо хранения представляет собой ловушку, ограничивающую молекулы по окружности, а не вокруг точки. По существу, кольцо для хранения молекул, находящихся в состоянии поиска низкого поля, может быть выполнено путем сгибания электростатического фокуса гексаполя в круг, что было продемонстрировано в 2001 году Crompvoets et al. Поскольку в таком накопительном кольце не существует продольных сил для удерживания более быстрых и медленных молекул вместе, впрыскиваемые пакеты молекул будут диспергироваться до тех пор, пока кольцо не будет заполнено однородно. Как показано в 2007 году Heiner et al., это может быть предотвращено путем разрыва кольца на два полукруга и переключения напряжений таким образом, что молекулы сгущаются вместе, когда они пролетают через зазор между двумя полукольцами. В 2010 году улучшенный синхротрон, состоящий из 40 прямых шестигранников, помещённых в круг, был продемонстрирован Цигер и др. Использование многих сегментов, а не двух имеет ряд преимуществ: из-за высокой симметрии кольца, неустойчивости в результате изменения силы захвата менее важны, и поперечная глубина кольца увеличивается. Продольная скважина также увеличивается, так как бурение происходит много раз за кругосветное путешествие. Цигер и др. Иллюстрируют стабильность их конструкции, демонстрируя, что они могут наблюдать захваченные молекулы аммиака (ND3) в хорошо определенных пакетах размером мм после их хранения в течение более 10 с в кольце. Тот факт, что элементы могут переключаться индивидуально, подразумевает, что различные пакеты могут вводиться и детектироваться независимо, что позволяет синхронизатору одновременно удерживать до 19 пакетов.

Task 7.3. Match the words with their meaning.

1 confine (v)	A discover or identify the presence or existence of.
2 disperse (v)	B keep or restrict someone or something within certain limits of (space, scope, quantity, or time).
3 bunch (v)	C strongly suggest the truth or existence of (something not expressly stated)
4 transverse (adj)	D a number or quantity that when multiplied with another produces a given number or expression.
5 imply (v)	E situated or extending across something
6 detect (v)	F distribute or spread over a wide area
7 probe (n)	G the state or process of rotting or decomposition.
8 reference (n)	H collect or fasten into a compact group.
9 decay (n)	I study, investigation
10 factor (n)	J standard, model

Task 7.4. Translate the text into English

НЕОКЛАССИЧЕСКИЙ ПЕРЕНОС ЧАСТИЦ

Уже в первых экспериментах на токамаках выяснилось, что уход плазмы на стенки происходит намного быстрее классического. Одна из причин связана с развитием в плазме многочисленных неустойчивостей и переходом плазмы в турбулентное состояние. В то же время уже в конце 60-х годов XX века стало понятно, что особенности траекторий заряженных частиц в магнитных ловушках должны приводить прежде всего к увеличению классических коэффициентов переноса, то есть коэффициентов переноса, вызванных парными столкновениями и не связанных с развитием турбулентности. Соответствующая теория была разработана А.А. Галеевым и Р.З. Сагдеевым, а новый механизм переноса назван неоклассическим.

Чтобы понять механизм неоклассического переноса, рассмотрим траектории частиц в токамаке. Магнитное поле в токамаке состоит из основного тороидального магнитного поля, которое создается намотанными на тор катушками, и полоидального поля, создаваемого током, текущим по тору. Вместе они дают магнитное поле, которое, как нитка, намотано на вложенные друг в друга тороидальные поверхности (рис. 3). Эти поверхности, которым принадлежит магнитная силовая линия, называются магнитными поверхностями. Основное тороидальное магнитное поле есть просто поле тороида (соленоида, свернутого в тор) и поэтому спадает с расстоянием от магнитной оси.

На частицу, вращающуюся по ларморовскому кружку, так же как на виток с током, действует при этом сила стремящаяся вытолкнуть ее в направлении внешнего обвода. В этом же направлении действует центробежная сила, связанная с движением частицы вдоль силовой линии. Если на частицу в магнитном поле действует постоянная сила, то центр ларморовской окружности испытывает дрейф в направлении, перпендикулярном силе и магнитному полю, со скоростью ug = F / eB. Этот дрейф, называемый тороидальным, зависит от знака заряда - для ионов он направлен вниз, а для электронов - вверх.

Words and expressions to help:

уход плазмы на стенки - plasma exit to the walls

магнитные ловушки - magnetic traps

коэффициент переноса - transfer factor

внешний обвод - outer contour

GRAMMAR POINT

Cause and effect (so, such):

The following constructions are used to indicate a cause and an effect (result) relationship

1. ***subject + verb + so + adjective/adverb + that + subject + verb***

Note: don’t use a noun after ‘so’

Examples: Judy worked so diligently that she received a scholarship.

The student behaved so badly that he was dismissed from the class.

Her essay was so good that she was asked to make a report at the scientific conference.

2. subject + verb + so + many/few + plural countable noun + that + subject + verb

Examples: I had so few offers that it wasn't difficult to select one.

There were so many people at the conference hall that he failed to meet his colleagues from Spain.

subject + verb + so + little/much + uncountable noun + that + subject + verb

Examples: He has invested so much money to the project that he cannot abandon it now.

The glass received so little water that it turned brown in the heat.

3. subject + verb + such + a + adjective + singular countable noun + that + subject + verb

or

subject + verb + so + adjective + a + singular countable noun + that + subject + verb

Note: the first model (***such + a + adjective)*** is more common of the two.

Examples: It was such a hot day that we decided to stay indoors. = It was so hot a day that we decided to stay indoors.

It was such an interesting book that I couldn't put it down. = It was so interesting a book that I couldn't put it down.

subject + verb + such + adjective + plural countable noun/ uncountable noun + that + subject + verb

Examples: She has such exceptional abilities that everyone is jealous of her.

This is such difficult homework that I will never finish it.

Note: It is not possible to use 'so' in the above rule.

Exercise 7.1.1. Put either 'so' or 'such' in the following sentences.

1. He worked…………….carefully that it took him a long time to complete the project.
2. The program was…………..informative that nobody wanted to miss it.

3. Those were……………difficult assignments that we spent two weeks finishing them.
4. The book looked……………interesting that he decided to read it.
5. There were……………few students registered that the class was cancelled.
6. Ray called at……………an early hour that we were not awake yet.
7. We had……………wonderful memories of the place that we decided to come back.
8. The project was……………expensive that it was decided to suspend it.
9. It was…………..a good opportunity that we decided to take it.
10. Professor Sands gives…………interesting lectures that his classes are never boring.
11. He has……………heavy workload that it is difficult for him to travel.
12. It has been such a long time since I've seen him that I'm not sure if I will remember him.

Task 7.5. *RENDERING PRACTICE*

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

Subcooled heat transfer performance of tested surfaces and Effects of subcooling on heat transfer performance

The subcooled pool boiling heat transfer performance of the tested surfaces is shown in Fig. 4. It is found that the boiling curves of each tested surface in the natural convection heat transfer region shift to the left when the subcooling increases due to the enhanced natural convection effect. In the nucleate boiling heat transfer region, different heat transfer performance can be observed from SS and the micro/nanostructured surfaces. The boiling curves of SS shift to the left with the increase of subcooling, which means the increased subcooling can enhance the pool boiling heat transfer performance. However, the boiling curves of micro/nanostructured surfaces under different subcooled degrees are close to each other, indicating the effect of subcooling on heat transfer is not clear. The similar phenomenon was also discussed in some published literature. El-Genk and Suszko found that the pool boiling heat transfer coefficient on dimpled copper surfaces decreased with the increase of subcooling. Suroto et al. also observed a similar phenomenon on a mixed-wettability surface. Conversely, Ji et al. found the boiling heat transfer is enhanced with the increase of subcooling on copper porous coating surfaces, while subcooling has no distinct influence on boiling heat transfer in the literature. In fact, although the increased subcooling enhances natural convection, subcooled working fluids confines the departure of nucleated bubbles, which decreases the nucleate boiling heat transfer.

Effects of processing spacing on heat transfer performance

The comparison of boiling heat transfer performance on all tested samples is illustrated in Fig. 5. The heat transfer of all micro/nanostructured surfaces indicates pronounced enhancement compared to SS. In addition, the heat transfer performance is significantly affected by the processing spacing. As for LS30 and LS70, the boiling curves are very steep and the wall superheat decreases with the increase of the heat flux near CHFs. Regarding LS100, LS200, LS400 and LS800, the excellent boiling heat transfer performance can also be observed, but the wall superheat increases clearly with the augmentation of heat flux close to CHF. The possible reason is the existence of the flat region on the top of micro-pillars (as shown in Fig. 1(c)–(f)) restrains the merging of the small bubbles, which is beneficial to maintain the stability of nucleate boiling heat transfer. Therefore the steady heat transfer can still be maintained when the wall superheat increases notably. Compared to SS, the enhancement of boiling heat transfer performance on the micro/nanostructured surfaces climbs up and then declines with the increase of processing spacing. The best heat transfer performance is achieved from LS200, with the lowest onset nucleate boiling superheat (6.5–9.6 K) and the highest CHF.

Task 7.6. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 7.7. Discuss the text with your partner.

Task 7.8. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 7.9. Study the following information and do exercises

Describing qualities of materials

Properties of materials

Exercise 7.1. Match the materials with their properties:

Materials	*Properties*
Glass	stiff
Rubber	flimsy
Steel	strong
Polythene	weak
Wood	resilient
Wool	tough
Paper	brittle
Porcelain	flexible
	elastic
	rigid
	pliable
	soft
	hard
	fragile
	ductile

Exercise 7.2. Make sentences to describe the materials like this:

Steel is strong or *Steel is a strong material*

Exercise 7.3. Choose the correct alternative to complete these statements. (In one case, two of the alternatives are correct. In all the other, only one is correct)

1. If you can see very clearly through a material, the material is …

   a translucent b translucent c transparent

2. If you cannot see through a material, it is ………

   a opal b opalescent c opaque

3. A substance that dissolves in liquid is ……….

   a dissolute b dissolvable c soluble

4. A liquid that dissolves substances is a ………….

   a solvent b solution c soluble

5. A material that is hard but breaks easily is …………

   a battle b brittle c bristle

6. If a material bends easily, it is ……………

   a bendable b flexible c floatable

7. A material that does not bend easily is …………..

   a rancid b rigorous c rigid

8. A metal that can easily be beaten into new shapes is ……………

   a beatable b malleable c multiple

9. A material that conducts electricity is ………..

   a conducive b conductive c conductor

10. A material that catches fire easily is …………..

    A flameable b flammable c inflammable

How to describe colors and appearance. Modifying the description of colors:

light	red
dark	blue
pale	green
deep	yellow
bright	orange
dull	purple
shiny	brown
glossy	grey
mat/matt	pink

We can use the modifiers to name the exact color:
Light blue; deep blue; dull brown.

When an object is not exactly one color, we can add *–ish* to the color;
Red - reddish Blue - bluish

When an object is between two colors, we often say: ***reddish-brown; bluish-yellow; etc.***

We can also say: ***lightish blue; darkish grey.***

What colors are these?
Amber, bronze, crimson, mauve, turquoise, khaki

Exercise 7.4. Write sentences of your own using these colors.

Texture of surfaces can be:

smooth, rough, uneven, coarse, grainy, corrugated, pitted, abrasive

Exercise 7.5. Complete these descriptions:

1. Glass is a ………..solid which usually has a ……….surface.
2. Chalk is a porous solid which has a …………..surface.
3. Some cardboard is ……………to give it extra strength.
4. The inside of a camera has a…………surface.
5. Mercury is a liquid metal which has a……………..appearance.
6. Sandpaper has a …………surface.
7. An unplained piece of wood has a ………surface.
8. A piece of rubber has a…………surface.

Exercise 7.6. Describe the *color, appearance* and *texture* of the following objects:

A pen, the walls in the room, the floor, the surface of a tree trunk, a leaf.

How to form verbs and nouns from the adjectives

adjective	**verb**	**Noun**
hot	heat	Heat
warm	warm	warmth
cool	cool	coolness
cold	cool	Cold/coldness

Exercise 7.7. Form nouns and adjectives from these verbs:

melt, freeze, boil, liquefy, solidify, vaporize

Exercise 7.8. Complete these statements:

1. At normal temperatures, iron is a solid. However, when it is …….. above 1537°C, it………. .
2. Water is a liquid at normal temperatures. However, when it is ………..below 0°C, it………….. .
3. When water is ………….. to 100° C. it ……….. .
4. When a substance changes from a solid to a liquid, it is said to ……….. .
5. When a substance changes from a liquid to a solid, it is said to ……….. .
6. When a substance changes from a liquid to a gas, it is said to ……….. .

Exercise 7.9. Complete the table with regular formation of nouns and verbs from the adjectives:

adjective	**verb**	**Noun**
weak	weaken	Weakness
tough		
soft		
hard		
rough		
coarse		

Non-regular verb and noun formation is introduced in the following table:

adjective	**verb**	**Noun**
strong	strengthen	Strength
resilient	make something resilient	Resilience
brittle	embrittle	Brittleness
flexible	make something flexible	Flexibility
elastic	make something elastic	Elasticity
pliable	make something pliable	Pliability
smooth	smooth	Smoothness
rigid	make something rigid	Rigidity
ductile	make something ductile	Ductility
malleable	make something malleable	Malleability

Exercise 7.10. Fill in the missing words:

Hardening. Medium and high carbon steel are not very h……, and so they must be h………. . They are h…… slowly to a h……… temperature (above 700°C), and then rapidly c………. (or 'quenched'). Fully h……… steel is, however, extremely brittle, and has poor shock resistance. The b……….. of h………… steel can be reduced and the quality of the metal increased by tempering. This process is described below.

Tempering. The metal is re-h…….. to a comparatively l….. temperature and again q…….. at a carefully controlled temperature. The color of the film of oxide on the brightened surface of the h……… steel gives a good approximate indication of the temperature of the steel. The oxide first turns a very pale yellow, and changes through a range of colors to dark blue as it is h……….

Exercise 7.11. Make sentences from the notes:

Example: water/ heat/ 100 degrees C/ boil *When water is heated to 100 degrees C, it boils*.

1. aluminum/ heat/ 659,7$0^0$C/ melt
2. water/ cool/ 0^0C/ freeze
3. steel/ hard/ become/ brittle
4. hardened steel/ heat/ 270^0C/ turn/ purple
5. water/ heat/ above/ 100^0C/ vaporize
6. ice/ heat/ 0^0C/ melt
7. liquid steel/ cool/ solidify
8. rubber/ vulcanize/ become/ tougher
9. copper/ heat/ become/ more ductile
10. glass/ tough/ become/ more resilient
11. blue copper sulphate crystals/ heat/ turn/ white
12. steel/ heat/ 300^0C/ film of oxide/ turn/ dark blue

Exercise 7.12. Construct statements which give the main properties and appearance of these substances.

For example: *Mercury is a bright shiny white liquid metal*.

1. silver
2. water
3. copper (Cu)
4. iron (Fe)
5. coffee
6. glass
7. sulphur (S)
8. milk
9. sulphuric acid (H_2SO_4)
10. coal
11. sand
12. sugar

Exercise 7.13. Complete the text using the correct words and expressions given below:

condense evaporate liquefy solidify vapour vaporize boiling point melting point

1. The temperature at which a solid becomes a liquid is its………….. .
2. The temperature at which a liquid becomes a gas is its…………….. .
3. When a gas or liquid becomes a solid, it……………. .
4. When a gas or a solid becomes a liquid, it…………….. .
5. When a substance becomes a gas or……………..,
   it……………or…………….; if it returns to its previous state,
   it…………….. .

1.3. Cause and reason

When we ask a question beginning with *why*, we want to know the cause of something or the reason for it.

Exercise 7.14. Match the questions 1 – 6 to the answers A – F

1	Why does copper bend easily?	A	Because there is a magnetic force between them.
2	Why does an electric current flow	B	Because there is a movement of

	through a conductor?		electros through it.
3	Why do like magnetic poles repel each other?	C	Because helium is lighter than air.
4	Why do gases expand when heated?	D	Because it is extremely brittle.
5	Why does glass break when it hit?	E	Because it is very ductile.
6	Why does a balloon filled with helium float?	f	Because they absorb heat energy.

Exercise 7.15. Make statements of reason like this:

Alcohol / used in room thermometers – less expensive than mercury.

Alcohol is used in room thermometers because it is less expensive than mercury.

1. copper / used in electric connections – an extremely good conductor
2. a suction pad / stick / to a flat surface – no air between the pad and the surface
3. steel / tempered – brittle when hardened
4. heat / pass along a conductor – the molecules of the conductor vibrate
5. rubber / not break when it is hit – extremely resilient
6. the earth / have / day and night – revolve / about its own axis
7. mercury / used in laboratory thermometers – have high boiling point
8. hydrogen / dangerous – highly inflammable

To state the **cause** of something we can use the following structure: *If a copper bar is heated, it will expand.* If we want to make the **cause** very clear (i.e. if we want to **emphasize** the cause, we re-phrase the statement: *Heating a copper bar will cause it to expand*.

Exercise 7.16. Complete these sentences in the same way:

1. Hitting a piece of glass …………… break.
2. Applying a tensile force to a wire ………….. extend.

3. Cooling a metal bar …………. conduct.
4. Heating water to 100 degrees C ………….. .
5. Cooling water to 0 degrees C ………… .
6. Filling a balloon with air ……………. .
7. Holding a piece of wood in a flame ……………. .
8. Placing sugar in hot coffee ……………. .
9. Puncturing a balloon ……….. .

Task 7.10. Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

Speech patterns and rhetorical devices

7.10.1. Intensification

Task 7.10.1. Translate these words into Russian.

absolutely, actually, adequately, broadly, completely, considerably, constantly, effectively, entirely, equally, essentially, especially, extremely, exactly, far, fully, fundamentally, inevitably, highly, immediately, greatly, keenly, largely, manifestly, markedly, naturally, necessarily, particularly, peculiarly, perfectly, primarily, purely, radically, significantly, specially, specifically strongly; totally, truly; ultimately, uniquely.

Task 7.10.2. Make up your own sentences with these words.

Task 7.10.3. Translate these sentences, pay special attention to intensifiers.

a) It seems highly probable that the situation might change.
b) This approach is highly complex (controversial) and can't be accepted at present.
c) This problem is still left largely unaddressed (unexplored), though one can find a lot of references to it.
d) This theory …

... largely ignores mathematical....

...was greeted with a storm of criticism.

... strongly affects/ depends on/ influences / indicates that ...

... is completely comprehensive/ typical/ irrelevant/ unacceptable.

... is particularly useful.

... is particularly informative.

... is perfectly acceptable/ (formal/ functional).

... should not be taken as purely negative.

... is totally clear-cut/ self-sufficient.

... provides totally naturalistic explanation.

This method

...really entails/ needs/ relates to/ involves

...indicates how…

... can really be fruitful.

We cannot really understand the nature of this phenomenon.

e) I am not really in a position to speak about this method.
f) This technology will be a step to truly green economics.
g) Investigators can now see how electrons truly interact with one another.
h) This concept should be adequately and explicitly defined.

7.10.4. ***De-intensification:***

Task 7.10.4. **Translate these words into Russian.**

barely, basically, commonly, customarily, fairly, hardly, merely, mainly, nearly, normally, possibly, practice rather, slightly, somehow, virtually, weakly, typically, usually.

Task 7.10.5. **Read and translate the following sentences.**

a) Such studies have barely begun.
b) The approach developed has a fairly specific meaning.
c) The method used is hardly acceptable (necessary/ ever used).
d) This method gives merely probable results.

e) This notion/ definition is rather vague (controversial).
f) This constitutes a rather interesting case.
g) This   is simply irrelevant.
h) This gas   is somehow leaking into the air.
i) This distinction is slightly artificial (different/ odd).
j) This is a slightly odd form of presentation.
k) They are only weakly dependent.
l) This research is basically descriptive/ comparative.
m) I am basically in disagreement with this view.
n) This point of view commonly accepted/ assumed/ exploited/ used. ...is more frequent than the second one.
o) Such modifications are normally the result of implementation of new technologies.

7.10.6 *Emphatic quantification:*

Task 7.10.6. ***Translate these words into Russian.***

great, more, the most, most, much, variety, various;

Task 7.10.7. Use these expressions in sentences of your own.

great interest in .../...a great deal to be done in elaborating.../...pay a great deal of attention to.../...cost. ...may be very great./...one great value of.../...pay more attention to .../...no more alternatives to...

Task 7.10.8. Read and translate the following sentences.

a) Now let's look at a more realistic example.
b) This is he most elementary information of all.
c) The most basic feature/ transparent approach/ usual pattern.
d) The most complete/ explicit account of the problem is found in …

e) Finding a new approach is the most difficult task.

f) Much depends here on …

g) This volume provides much insight into the problem.

h) There is an infinite/ huge/ wide variety of phenomena (experiments/

i) This method is used in the manufacturing of a variety of items.

j) A variety of these anomalous features can be easily explained.

k) Various models have been put forward to explain the phenomenon.

7.10.9. Emphatic operators:

Task 7.10.9. Find Russian equivalents of the following words.

enough, non-, none, at least, indeed, by no means, even, just, mere, only, quite, very

Task 7.10.10. Read and translate the following sentences.

a) This concept is convincing enough (to be used).

b) He fails to make a convincing enough argument for the whole group.

c) Enough has been said to prove this approach.

d) It is easy enough to show that...

e) It should be understandable to non-specialists.

f) None of the errors proved serious.

g) The proposed mechanisms are at least plausible.

h) There are at least two applications of this method.

i) At least this is the conclusion of our study.

j) It is indeed remarkable that …

k) Such artifacts are indeed distorting the picture.

l) Actual content .is by no means the end of the story.

m) Even in simple cases, such quantities are difficult to calculate.

n) Even complex models may not simulate feedback effects accurately.

o) Even a short computer program can prove difficult to check out.

p) Recent work shows just how systematic such phenomena can be.

q) This principle is really just an extension of the notion of preference.

r) We shall adopt the scheme of just four categories.
s) It is relevant only when...
t) The only sure way of doing this is…
u) This algorithm is quite unacceptable/ appropriate/ adequate for / distinct from…
v) We can do that quite simply.
w) There is a very wide variety of

7.10.11. . General quantifiers

Task 7.10.11. Give Russian equivalents of the following quantifiers.

so far, any, both, alone, single, a bit, some, the same, the whole

Task 7.10.12. Make up sentences of your own to illustrate the usage of these words.

Task 7.10.13. Read the following sentences, pay special attention to emphatic quantifiers.

a) Economists do not seem to have made any progress in forecasting future economic situation.
b) They both have written extensively in this field.
c) These principles have been studied by both economists and lawyers.
d) This book should be of interest to both students and professors..
e) In he book the problem is discussed with both clarity and accuracy.
f) This theory portrays modern economic situation as both under government and market control..
g) The results that the company is going to achieve are both possible and desirable.
h) We can't come to this conclusion from this evidence alone.
i) Mathematics alone cannot give us the base for this approach.
j) No single topic in economics generates more controversy than the one describing quality standards.

k) It seems a bit artificial to forecast future.
l) Your point of view suggests that the budget figures need some revision.
m) It was assumed that the results might be positive but some probing proved otherwise.
n) Some people's immune systems fight AIDS rather effectively.
o) These procedures are approximately (essentially/ exactly) the same in different economic analytical schemes.
p) Both methods work in basically the same way.
q) If you follow the same rule you will get the same results.
r) This notion refers to a whole set of theories.
s) The experiments undertaken in the company changed the whole picture.
t) The company economists explore how these assumptions fit into the model as a whole.

7.10.14 . Emphatic connectors:

Task 7.10.14. Give Russian equivalents of the following emphatic connectors
Even if/ though, however, nevertheless, nonetheless, whatever, whenever.

Task 7.10.15. Use these words in sentences of your own.

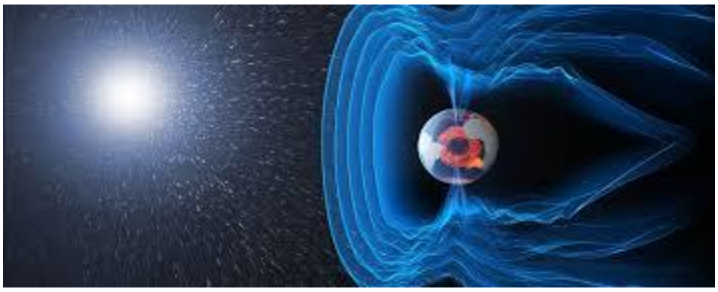
Task 7.10.16. Translate these sentences, pay special attention to emphatic connectors.

a) Karl Marks' and Adam Smith's theories might be compared even if they were not historically related.
b) The books written by a famous economist Porter are quite popular even if one is in disagreement with his views.
c) Even though this issue has been broadly disscused there hasn't been a unanimous
d) conclusion.
e) Modern scientists have no explanation of this phenomenon, however, they hope to find some.

f) In detail, however, we shall see that the budget figures are not so balanced.
g) However, this is what cannot be taken for granted.
h) Before looking at this matter, however, it is worth collecting all possible data .
i) His book has a variety of virtues; I do, however, have certain criticisms.
j) This approach is the most vulnerable; nevertheless it is rather informative and convincing.
k) There is no clear way of testing these products, none the less, the company technologists are trying to find one.
l) The situation in the market is vague, it is none the less clear that positive tendencies are vivid.
m) Whatever the outcome of the research might be they hope to double the output.
n) The results of the experiment should be at hand whenever necessary.

UNIT 8

TEXT 8. Schlieren imaging: a powerful tool for atmospheric plasma diagnostic



Schlieren imaging of atmospheric pressure plasmas is a powerful technique to address fundamental studies concerning their fluid-dynamics as well as to study, characterize and optimize processes assisted by them. Moreover, being completely non-intrusive, schlieren imaging presents a major advantage over other techniques, such as Particle Image Velocimetry (PIV), that use tracers, which could be affected by the electromagnetic field of the plasma. Since atmospheric pressure plasma sources show marked differences among themselves, the schlieren setups should be tuned case-by-case in order to achieve a thorough characterization of the plasma fluid-dynamics occurring in the processes under study.

From this perspective, even if not comprehensive of all the existing atmospheric pressure plasmas, three main categories of sources and processes have been identified among research papers in which schlieren imaging is performed on atmospheric pressure plasmas and the schlieren setups therein adopted are discussed in this work: non-equilibrium Atmospheric Pressure Plasma Jets (APPJs), plasma actuators for flow control and thermal plasma sources. For each category, a selection of the published work has been made in order to present useful considerations, suggestions and practical examples on the use of schlieren imaging to obtain qualitative and quantitative information. These solutions may be suitably implemented in the readers' optical setups to achieve new and optimal results during their research activities.

Non-equilibrium APPJs

In order to satisfy the requirements and demands involved in different biomedical and industrial fields for devices able to promote the production of different reactive and charged species at ambient temperature and deliver them into the surrounding environment, jet configurations were taken into account, leading to the development of the cold Atmospheric Pressure Plasma Jets (APPJs). In APPJs, usually working with noble gases such as helium, neon or argon, a plasma plume flows from the nozzle into the surrounding atmosphere.

Although devices with jet-like flows have been well studied in the industrial field, a thorough description of their behaviour requires the use of complex physical models, necessarily supported by direct experimental measurements, where schlieren imaging can play an important role for the visualization and interpretation of fluid-dynamic phenomena. Moreover, since plasma is a reactive and conductive gas, the fluid-dynamics of an APPJ may be strongly affected by the chemical and electrodynamics forces, driven by different physical quantities such as reactive and charged species concentrations, gas temperatures and electric fields. Under this view, schlieren imaging has been adopted to obtain reliable measurements of the flow characteristics of APPJs with the aim to evaluate reactive species transport and process feasibility.

Considering the best practices in the experimental setup of the schlieren imaging of APPJ, it is worth highlighting that the knife-edge is generally aligned with the axis of the jet produced by the plasma source, because the highest gradients of refractive index in the jet region are radial. Moreover, some groups have suggested investigating APPJs placed in a horizontal orientation in order to emphasize buoyancy effects due to the different density of the working gas (e.g. helium, argon…) in comparison with the surrounding air.

Regarding the choice of the light source for schlieren analysis of APPJ, no relevant trends can be found. Thanks to the low luminous intensity of the plasma plume produced by APPJs, there is a wide availability of light sources ranging from monochromatic lasers to broad-band- spectra lamps. As a general indication, on one hand, light sources with a narrow spectral range, such as LED or laser, lead to optimization of the light path because the interaction between radiation and optical components (lens, mirrors, detectors…) is a function of wavelength and leads to noise reduction from the self-luminosity of the plasma plume (for example using green light); on the other hand, high intensity lamps, such as xenon or mercury arc lamps, characterized by a continuum spectrum, guarantee that a great many photons reach the detector, enhancing the resolution of collected images and allowing the use of high-speed cameras for time-resolved investigation.

Topic vocabulary:

Schlieren imaging of atmospheric pressure plasmas - Визуализация пластов атмосферного давления по Шлиерену; fluid-dynamics- гидродинамика; atmospheric pressure plasma sources - источники плазмы атмосферного давления; schlieren setups - установки Шлиерена; non-equilibrium Atmospheric Pressure Plasma Jets - Плазменные струи с неравновесным атмосферным давлением; plasma actuators for flow control - плазменные приводы для управления потоком; ambient temperature - температура окружающей среды; jet configurations - конфигурации реактивных струй; plasma plume - плазменный шлейф; nozzle – сопло; buoyancy effects - эффекты плавучести.

Task 1.1. Answer the questions

1. What is the main advantage of Schlieren imaging technique?
2. Why should the schlieren setups be tuned?
3. What are three main categories of sources of atmospheric pressure plasmas?
4. What was the reason for presenting useful considerations, suggestions and practical examples on the use of schlieren imaging?
5. Why were jet configurations taken into account?

6. What led to the development of the cold Atmospheric Pressure Plasma Jets (APPJs)?
7. Why do schlieren imaging play an important role in complex physical models?
8. What the chemical and electrodynamics forces can affect the fluid-dynamics of an APPJ?
9. Why is it important to align knife-edge with the axis of the jet produced by the plasma source?
10. What light sources can be used?

Task 1.2. Compare the original abstract from the text with its machine-translated versions and edit the latter ones, pointing out the mistakes.

Original text

In order to satisfy the requirements and demands involved in different biomedical and industrial fields for devices able to promote the production of different reactive and charged species at ambient temperature and deliver them into the surrounding environment, jet configurations were taken into account, leading to the development of the cold Atmospheric Pressure Plasma Jets (APPJs). In APPJs, usually working with noble gases such as helium, neon or argon, a plasma plume flows from the nozzle into the surrounding atmosphere.

Although devices with jet-like flows have been well studied in the industrial field, a thorough description of their behaviour requires the use of complex physical models, necessarily supported by direct experimental measurements [38], where schlieren imaging can play an important role for the visualization and interpretation of fluid-dynamic phenomena. Moreover, since plasma is a reactive and conductive gas, the fluid-dynamics of an APPJ may be strongly affected by the chemical and electrodynamics forces, driven by different physical quantities such as reactive and charged species concentrations, gas temperatures and electric fields. Under this view, schlieren imaging has been adopted to obtain reliable measurements of the flow characteristics of APPJs with the aim to evaluate reactive species transport and process feasibility.

Google translation

Чтобы удовлетворить требования и требования, предъявляемые в различных биомедицинских и промышленных областях к устройствам, способным стимулировать производство различных реакционноспособных и заряженных частиц при температуре окружающей среды и доставлять их в окружающую среду, конфигурации струй были приняты во внимание, что привело к разработке холодных плазменных струй атмосферного давления (APPJ). В APPJ, обычно работающих с благородными газами, такими как гелий, неон или аргон, плазменный шлейф течет из сопла в окружающую атмосферу.

Хотя устройства со струйоподобными потоками были хорошо изучены в промышленной области, тщательное описание их поведения требует использования сложных физических моделей, обязательно подкрепленных прямыми экспериментальными измерениями [38], где визуализация по Шлирену может играть важную роль для визуализация и интерпретация гидродинамических явлений. Кроме того, поскольку плазма является химически активным и проводящим газом, на динамику жидкости APPJ могут оказывать сильное влияние химические и электродинамические силы, обусловленные различными физическими величинами, такими как концентрация активных и заряженных частиц, температуры газа и электрические поля. Согласно этой точке зрения, для получения надежных измерений характеристик потока APPJ была принята схема Шлирена с целью оценки переноса активных видов и осуществимости процесса.

PROMT translation

Визуализация пластов атмосферного давления по Шлиерену является мощным методом для изучения фундаментальных исследований, касающихся динамики их жидкости, а также для изучения, описания и оптимизации процессов, которым они помогают. Кроме того, будучи полностью неинтрузивным, шлиереновое изображение представляет собой основное преимущество по сравнению с другими методами, такими как велометрия изображения частиц (PIV), в которых используются индикаторы, на которые может влиять электромагнитное поле плазмы. Поскольку источники плазмы атмосферного давления показывают заметные различия между собой, установки шлиерена должны быть настроены в каждом конкретном случае, чтобы обеспечить тщательную характеристику динамики плазменной жидкости, происходящей в исследуемых процессах.

С этой точки зрения, даже если не все существующие плазмы атмосферного давления не являются комплексными, среди исследований были выявлены три основные категории источников и процессов, в которых изображение шлиерена выполняется на плазмах атмосферного давления, и принятые в них установки шлиерена рассматриваются в этой работе: Несбалансированные плазменные струи атмосферного давления (АПП), плазменные приводы для управления потоком и источники тепловой плазмы. По каждой категории была проведена выборка опубликованных работ, с тем чтобы представить полезные соображения, предложения и практические примеры использования schlieren визуализации для получения качественной и количественной информации. Эти решения могут быть соответствующим образом реализованы в оптических настройках считывателей для достижения новых и оптимальных результатов в ходе их исследовательской деятельности.

Task 8.3. Match the words with their meaning.

1 intrusive (adj)	A starter
2 tracer (n)	B causing disruption or annoyance through being unwelcome or uninvited
3 setup (n)	C a small flow of liquid
4 occur (v)	D a thing that traces something or by which something may be traced, in particular.
5 actuator (n)	E place or arrange (things) in a straight line.
6 ambient (adj)	F the way in which something, especially an organization or equipment, is organized, planned, or arranged.
7 plume (n)	G he state or degree of being easily or conveniently done
8 nozzle (n)	H of or relating to the immediate surroundings of something
9 feasibility (n)	I a cylindrical or round spout at the end of a pipe, hose, or

	tube, used to control a jet of gas or liquid.
10 align (v)	J to happen; to take place

Task 8.5. Translate the text into English:

АНОМАЛЬНЫЙ ПЕРЕНОС

В плазме обычно присутствуют различные колебания. Самые крупномасштабные из них, такие, как, например, приводящие к вытеканию воды из опрокинутого стакана, удается подавить за счет неоднородного профиля магнитного поля в магнитных ловушках. Однако многочисленные мелкомасштабные неустойчивости, как правило, переводят плазму в турбулентное состояние. Плазменная турбулентность характеризуется случайными колебаниями плотности и связанными с ними колебаниями электрических полей, которые возникают, чтобы поддержать квазинейтральность плазмы. Электроны и ионы под действием хаотического электрического поля и основного невозмущенного магнитного поля дрейфуют со скоростью E / B, то есть испытывают случайные блуждания, приводящие к диффузии. Амплитуда блужданий определяется уровнем плазменной турбулентности, а частота смены направлений движения зависит от характерных частот плазменных колебаний. Так как типов колебаний в плазме может быть много, то и соответствующих коэффициентов переноса может быть также несколько.

Величину аномального коэффициента диффузии можно оценить из следующих соображений. Каждый тип колебаний в плазме характеризуется инкрементом g - величиной, обратной характерному времени раскачки неустойчивости. В состоянии развитой стационарной турбулентности рост неустойчивости уравновешен диффузионным затуханием. Характерное время затухания соответствует времени смещения частицы на так называемую длину корреляции (среднюю длину волны), где фаза колебаний, которая является случайной величиной, уже совсем другая. Время диффузионного смещения в соответствии с (2) пропорционально квадрату длины волны (обратно пропорционально волновому вектору k^) и обратно пропорционально коэффициенту диффузии: Приравнивая время затухания ко времени раскачки колебаний (обратному инкременту), получаем оценку аномального коэффициента диффузии. Перебирая различные типы неустойчивостей, можно получить различные коэффициенты диффузии. По современным представлениям самый большой коэффициент аномальной диффузии соответствует коэффициенту диффузии Бома.

Words and expressions to help:
различные колебания - different oscillations

опрокинутый стакан - the overturned glass

мелкомасштабные неустойчивости - small-scale instability

случайными колебаниями плотности - accidental fluctuations of density

случайные блуждания - random wandering

временя раскачки неустойчивости - instability swing time

время затухания - attenuation time

GRAMMAR POINT

Study the words which are often confused and do the exercises.

Mistake error slip slip-up mix-up oversight howler blunder

Mistake – something incorrect that you do, say or write without intending to.

Example: Your essay is full of mistakes.

Error – (a mistake) – use this especially to talk about mistakes in calculating or in using

language, system or computer.

Example: An error occurred in the processing of the data.

Human error – when a mistake is caused by people, not a machine.

Example: The accident was caused by human error.

Slip – a small unimportant mistake that is easy to make.

Example: Don't worry, we all make slips from time to time.

Slip-up – a careless mistake that may spoil a plan or progress

Example: This whole situation only happened because of a slip-up by the bank.

Mix-up – a careless mistake that causes confusion about details, for example someone's name, the time of a meeting etc.

Example: There was a mix-up over the train times and I arrived two hours late.

Oversight – a mistake that you make by not noticing something or by forgetting to do something.

Example: I am sure it was just an oversight that your name was not on the list.

Howler – a very bad mistake, especially one that shows you do not know something.

Example: He read out a selection of howlers from student's exam answers.

Blunder – a stupid mistake caused by not thinking carefully enough about what you are saying or doing, which could have very serious results.

Example: It seems to be another public relations blunder by the government.

Fixed expressions:

Spelling mistake, typing error, human error, computer error

Exercise 8.1. Match the word with the Russian equivalent

1	Mistake	A	промах
2	Error	B	оплошность, ошибка
3	Slip	C	недосмотр
4	Slip-up	D	ошибка, заблуждение
5	mix-up	E	ошибка, недоразумение
6	Oversight	F	грубая ошибка, просчет
7	Howler	G	путаница
8	blunder	H	оплошность

Exercise 8.2. Choose which of the options fits each gap.

mistake error slip slip-up mix-up oversight howler blunder

1. She stopped, finally aware of the terrible…………….she had made.
2. Celia corrected………………..with a pen.
3. People doing this kind of precision work can't afford to make the slightest………….. .
4. I'm afraid there's been a……………..in the booking. We were expecting you tomorrow.
5. If we were going to win the contract, we can't afford any more……………… .
6. Due to an administrative…………………, several members of the staff did not receive pay checks this month.
7. Many teachers collect……………….from students essays.

Task 8.6. ***RENDERING PRACTICE***

Preparation for rendering: Read the text / Find key words / Make up a plan / Retell the text in your own words.

Simulations tackle abrupt massive migrations of energetic beam ions in a tokamak plasma.

In the 2030s, large-scale fusion experiments with magnetically confined deuterium-tritium plasmas will be performed at the ITER tokamak, which is currently under construction in France. These experiments will test the idea of a self-sustained fusion plasma, where the energy deposited by fusion-born 3.5 MeV alpha particles eliminates the need for external heating. In order to ignite the plasma, however, a large amount of external heating will still be required, including a set of powerful negative-ion-based neutral beams (N-NB). Until now, the first and only tokamak equipped with such a system was JT-60U, which operated during 1985–2008 in Naka-city some 100 km north of

Tokyo/Japan. The two N-NB lines in JT-60U were able to accelerate deuterium to energies as high as 400 keV at a combined power of up to 5 MW. Its successor JT-60SA, which is scheduled to begin operation in 2020, will be equipped with an upgraded N-NB system designed to achieve 500 keV acceleration at 10 MW.

The N-NB-driven plasmas in JT-60U were found to exhibit short but intense perturbations dubbed abrupt large-amplitude events (ALE). During an ALE, the magnetic fluctuations can reach amplitudes 10 times larger than what is seen between these events. Figure 1 shows a typical example. Following the first observations of ALEs in the late 1990s, intensive studies during subsequent experimental campaigns revealed that ALEs are usually accompanied by a massive migration of energetic deuterons from the plasma core into the periphery. Since both JT-60SA and ITER will heavily rely on N-NB drive, it is important to understand ALE-like relaxation events and develop the ability to predict their occurrence in future experiments.

The current theoretical understanding is as follows. Since N-NBs are injected tangentially into the plasma torus, as illustrated in Fig. 2, the beam ions are deposited with a steep density gradient and in a narrow range of pitch angles. Moreover, the velocity of fully accelerated ions is near or beyond the plasma's Alfvén velocity. Under such conditions, and because the beam ions gradually slow down due to collisions with electrons, many particles will have a chance to interact with shear Alfvén waves through efficient transit resonances. Such a resonance occurs whenever the guiding centre velocity of the particle matches the local phase velocity of an Alfvén wave. The combination of a steep beam ion density gradient and efficient resonant drive can cause the waves to form globally coherent structures that withstand phase mixing (continuum damping) and reach large amplitudes. An example of such a wave field is also shown in Fig. 2.

This fundamental wave–particle interaction process can produce a large variety of phenomena in magnetised plasmas and has also analogies in other areas of physics. The particular phenomenology depends on the magnetic geometry, plasma parameters and the distribution of energetic ions, so that numerical simulations are usually needed to determine the response of a particular system.

Previous numerical studies aiming for an explanation of ALEs used educated guesses for what the energetic ion distribution may look like shortly before an ALE. The simulation codes used in those studies employed efficient hybrid models, where the thermalized ($\lesssim$10keV)($\lesssim$10keV) bulk plasma is described as a magnetic hydrodynamic (MHD) fluid and the gyro averaged motion of energetic ions ($\gg$10keV)($\gg$10keV) is simulated using the particle-in-cell (PIC) method. These studies have given us valuable insights concerning the response of the plasma on relatively short time scales of 1 ms or less. With suitably chosen initial conditions, it has even been possible to reproduce the experimentally observed abrupt flattening of the energetic ion density profile.

Until now, the spatial and velocity distribution of the N-NB ions has been computed using orbit-following Monte-Carlo (OFMC) simulations, which did not account for any MHD activity. When the OFMC simulation result was used as an initial condition for the N-NB ion distribution in a hybrid simulation, the MHD fluctuation grew excessively large. The initial energetic ion pressure had to be reduced artificially by about a factor 2 in order for the hybrid simulation to reproduce the relative drop in the energetic ion pressure that had been inferred from neutron measurements before and after an ALE in a JT-60U experiment.

Task 8.7. Match the words with their meaning.

1 sustained (adj)	A (of a slope, flight of stairs, angle, ascent, etc.) rising or falling sharply; nearly perpendicular.
2 dubbed (v)	B remain undamaged or unaffected by; resist.
3 steep (adj)	C continuing for an extended period or without interruption.
4 pitch (n)	D make or become flat or flatter.
5 shear (n)	E give an unofficial name or nickname to (someone or something).
6 withstand (v)	F deduce or conclude (information) from evidence and reasoning rather than from explicit statements.
7 abrupt (adj)	G of or relating to space.
8 flatten (v)	H the steepness of a slope, especially of a roof.
9 spatial (adj)	I sharp; precipitous.
10 inferred (v)	J a strain in the structure of a substance produced by pressure, when its layers are laterally shifted in relation to each other.

Task 8.8. Work in pairs. Make up 5 questions on the text and address them to your partner.

Task 8.9. Discuss the text with your partner.

Task 8.10. Create an infographics or a mind map based on the information you have read. Present it to the group in the classroom. You may use the websites: https://www.mindmeister.com

https://coggle.it

Task 8.11. Study the following information and do exercises

Describing graphs

Graphs have a number of uses in physics:

- they give an immediate, visual display of the relationship between physical quantities;
- they enable the values of quantities to be determined;
- they can be used to confirm or disprove a hypothesis about the relationship between variables.

Here are some words and phrases you need to describe graphs.

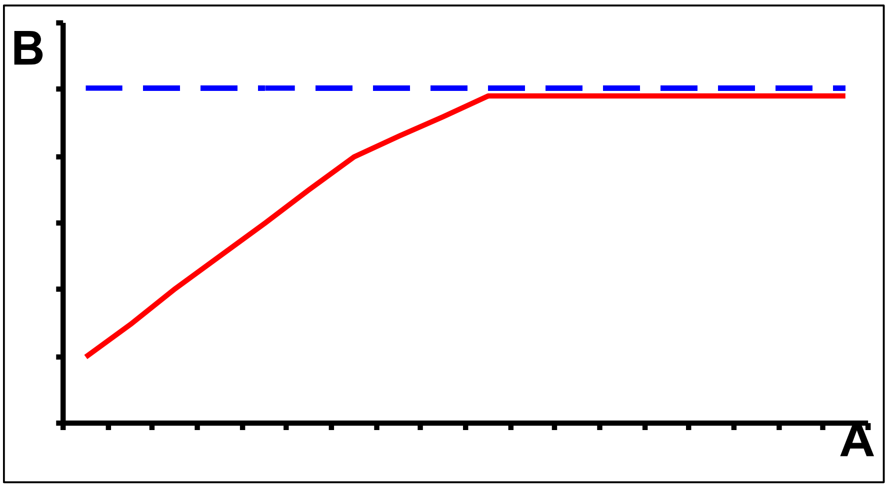
	verbs	nouns
UP	go up; take off; shoot up; soar; jump; increase; rise; grow; improve; rocket	an increase; a rise; a growth; a surge; an improvement; an upturn; an upsurge; an upward trend
DOWN	go/come down; fall; fall off; drop; slump; decline; decrease; slip; plumme;t shrink	a fall a decrease a decline a drop a downturn a downward trend
NO CHANGE	remain stable; level off; stay at the same level; remain constant; stagnate stabilize	
AT THE TOP	reach a peak; peak; top up	peak
AT THE BOTTOM	reach a low point; bottom out recover	

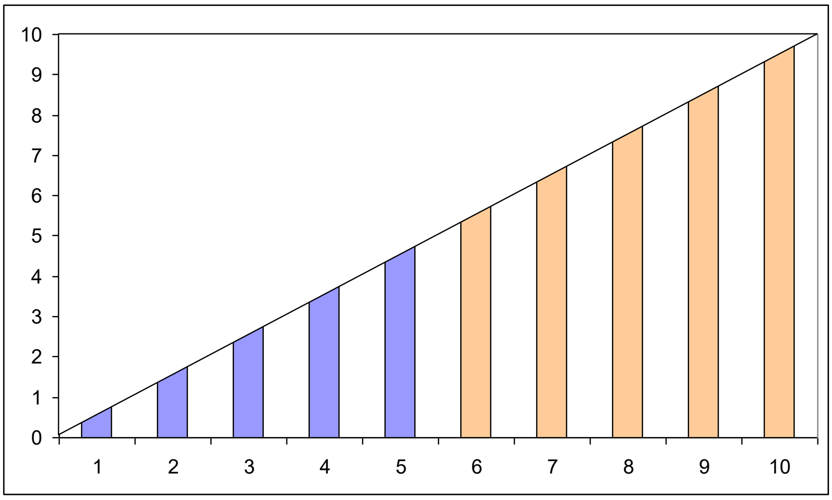
	adjectives	adverbs
DEGREES OF CHANGE	dramatic considerable sharp significant substantial moderate slight	dramatically considerably sharply significantly substantially moderately slightly

SPEED OF CHANGE abrupt sudden rapid quick steady gradual slow

PREPOSITIONS a rise **from …to…** to increase **by…** to fall **by…** an increase **of** 10 per cent **over** the previous experiment

Exercise 8.11.1. Describe the following graphs:





Task 8.12. Academic Writing

Study the information on academic writing skills and do the tasks and exercises.

8.12.1. Impersonal constructions accounting for backgrounds:

Task 8.12.1. Find Russian equivalents and make up sentences of your own with the following phrases.

It is …common knowledge (experience)
… well known/ commonplace that…
… a matter of common observation…
… generally agreed/ accepted that…
... claimed /being claimed
It is taken for granted that…
It is not entirely clear…
It is encouraging that…
It is hoped that…
It turns out/ proves to be …

It would be of great interest to …

8.12.2. Focusing:

Task 8.12.2. Find Russian equivalents and make up sentences of your own with the following phrases:

This ...implies/ proves/ shows/ yields/
...is meant to support our theory
...will allow me to propose…
...offers a way of
...is another way of approaching …

8.12.3. Commenting and demonstrating intentions:

Task 8.12.3. Find Russian equivalents and make up sentences of your own with the following phrases.

...it is important to view…
…it is particularly necessary to underline…
…it seems impossible …
…it will be shown that…
…it is easy/ (not) hard/ relatively simple to demonstrate/show/ prove/ verify that…
…it must be recognized that…
…to make a distinction between …one should…
…it may be difficult to understand …
…it can be/ is (not) easily shown/ proved…
…on further examination it was discovered that …
…to grasp this point we must…
…in order to achieve/ clarify...it is necessary to …
…to argue this, I'd like to…
... it is not sufficient to define …

8.12.4. Evaluating and prospecting:

Task 8.12.4. Find Russian equivalents and make up sentences of your own with the following phrases.

It is appropriate/ convenient/ desirable/ essential...
... to start with…
… to present/ to outline /to show…
It is ...fair/ fruitful/ helpful/ important/ instructive/ interesting/ logical to…
It is ...natural/ proper/ reasonable/ sensible to mention that…
It is ...safe/ suitable/ useful/ wise/ to introduce some terminology/definitions.
It is ...informative to turn to…
…wise to begin with …
... natural to recognize (conclude) that …
It seems …

...fair to say
...important to emphasize that…
...logical to ask whether …

It would be

...reasonable to assume that…
...safe to predict that …

It might be helpful to examine …
It is essential to make clear/ to see that …
It is (not) good (enough) to appeal to …
It is (none the less) clear that …
It became/ is (not) clear/ obvious that…
It is/ seems (quite) logical (to assume) ... that…
It is difficult/ possible to imagine that…
It is evident/ self-evident (for us)/ (un)likely/ (highly) probable that…

8.12.5. Choosing and stating:

Task 8.12.5. Find Russian equivalents and make up sentences of your own with the following phrases.

- It appears (seems/ may be/ is) fair/ reasonable to say that …
- It is (would be) accurate to say that…
- It goes without saying that…
- It is (not even a half) truth to say that…
- It's often easier to do … than…
- In doing ...it is better to use…
- Instead of working in terms of …it is more convenient to introduce…
- It might be less confusing to use the theory…
- In order to measure ...it is crucial to calculate…
- In conclusion, it may be said that …

8.12.6. **Arguing by negation**

Task 8.12.6. Find Russian equivalents and make up sentences of your own with the following phrases.

- It is beyond the scope of this paper
- It is not my purpose/ the purpose of this article
- It is doubtful/ seems unlikely that this theory …
- It is in principle impossible
- It would not be productive
- It is thus not surprising
- It needs no argument that…
- It is misleading/ nonsensical/ pointless/ not correct/ an error to focus only on…
- It would not be adequate to regard/ consider…
- It cannot/ can hardly be denied that..

8.12.7. Arguing by inversion:

Task 8.12.7. Find Russian equivalents and make up sentences of your own with the following phrases:

- It is here where these effects are most important.
- It is in this area of inquiry that much of the terminology originates.
- It is one of the basic principles of …
- It is exactly the case.
- It is precisely this that distinguishes…
- It is our aim to…

***8.12.8. Parenthesis* :**

Task 8.12.8. Find Russian equivalents and make up sentences of your own with the following phrases:

a) connecting :

- In view of…

- From this point of view
- In a broad sense
- In this connection
- In particular
- In detail
- In this framework…
- In our current conception…
- In response to this....
- In practice, …
- With regard to, …
- In discussing/ surveying …
- From this perspective, let us re-examine…
- Methodologically/ Technically, ...this seems to be…
- In any area of science, there will be issues …

b) **explaining:**

- Given the notion/ limitation/ difficulty of…we can explain…
- Given the fact that…the conclusion is evident
- Given that, we can extend the interpretation of
- With regard to…a certain clarification is necessary.
- Following … we will refer to…as …
- By exploring this paradigm,
- Admittedly, this problem is not new.
- Presumably/ That is to say,…
- Under certain/ experimental circumstances…
- In these (other) cases…
- According to the analysis given here…
- To this end,…

c) **comparing and inferring:**

- Accordingly/ alternatively/ equally/ equivalently/ similarly
- Likewise/ otherwise/ conversely/ consequently,

- By analogy/ contrast
- Because of this/ for this reason/ for the present,
- As compared with / in comparison with / as follows from …
- As a result (consequence)
- In this respect…
- As always…
- But/ however/ at best/ at the same time/ nevertheless/ still,
- Therefore/ hence/ so/ then/ thus/ whence/ on the contrary,
- On the one hand/ on the other hand…
- From the other side,...
- In reality/ In the latter (that/ this) case,

d) **generalizing:**

- Generally/ Typically/ Essentially/ Naturally/ Most important/ In general,
- On a more general level/ In a more general context,
- Typically, in other words/ As a general rule/ First of all,
- In effect/ In essence/ In a word/ In brief/ To simplify,
- In principle/ Seen as a whole
- In any case,
- To summarize the ideas…

e) **succession:**

- To begin with/ Next/ Again/ To repeat,…
- First(ly)/ Second(ly)/ Third(ly),…
- Ultimately/ In closing/ Finally,… .
- In short/ In summary /To summarize,…
- At this point,…
- Continuing in the same way,…
- Before looking at this matter, however, …
- Before we go into these problems,..
- As for …/ As far as … is concerned…
- Regarding …/ Apart from …/ Leaving aside…/ As matters stand,…
- To my very limited knowledge,…
- As far as we are aware,…
- In considering …
- In looking ahead and planning the work…

f**) additions and appositions:**

- What's more/Further/ Furthermore/ Moreover/ Besides/ Also/ In addition to…
- Above all/ After all/ Indeed/ Actually/ Virtually/ Rather
- In these terms/ In other words,
- In fact/ That is/ Namely/ More correctly,
- In abbreviated form,……
- Roughly/ strictly speaking, ...
- In a way,…
- This means…

j) **attitudes:**

- Clearly/ Evidently/ Interestingly (enough)/ Fortunately/ Regrettably,
- To be sure/ Little wonder/ Surprisingly,
- Obviously/ Surely/ Understandably,
- In our opinion,
- Unfortunately,
- Regrettably,

8.12.9. Interrogating:

Task 8.12.9. Find Russian equivalents and make up sentences of your own with the following phrases:

- Can we say…?
- What does it mean to say…?
- How can we begin to understand that…?
- We can frame the question as follows:
- There are some questions…:
- There are two crucial questions here…
- The question is whether …

8.12.10. Parameters and quantity intensifiers:

Task 8.12.10. Make up your own sentences using phrases expressing parameters and quantity intensifiers:
multitude, cost, considerable, extensive, frequent, global, enormous, length, infinite, pressure, multiple, rate, size, speed, weight; measure, parameter, value, degree, extent, range, scope, numerous, voluminous, single, to cost, weigh, to measure, stabilize, underscore.

Task 8.12.11. You are going to write a brief summary of you scientific article to present it to your scientific supervisor. Ty to do your best to present it in an adequate form briefly and logically organized. Use connectors and link words as far as different speech patterns and rhetorical devices.

CONSOLIDATION

Summarize your thoughts on the scientific problems of the part PLASMA PHYSICS and write an essay (200-250 words).

Are you creative enough to prepare a presentation (3-5 minutes) on any problem relevant to the subject of plasma physics? If you are, just do it via the Internet and PowerPoint.

Самостоятельная работа студентов в компьютерной обучающей среде

Организация самостоятельной работы студентов с использованием компьютерных технологий является особенно актуальной, поскольку в учебных планах технических факультетов отводится мало времени на аудиторное изучение иностранного языка.

Подготовка студентов к научно-исследовательской работе также подразумевает развитие навыков пользования электронными ресурсами. Приведенная ниже таблица с кратким описанием возможностей электронных ресурсов поможет ориентироваться в потоке информационных сайтов.

№	Вид ресурса	Краткое описание
1.	Программы машинного перевода PROMT, Google-translate и др.	Данные интернет-ресурсы знакомят с различными программами машинного перевода, что дает возможность проведения сравнительного анализа использования различных программ-переводчиков.
2.	http://www.intute.ac.uk/	Данный ресурс представляет собой обширную базу данных, в которой имеется широкая коллекция разнообразной информации по различным дисциплинам и сферам деятельности. Кроме того, на данном сайте можно найти и другие полезные сервисы, например, internet training, virtual

		training suite и т.д.
3.	http://www.academicearth.org/	На данном интернет-ресурсе представлена широкая подборка видео и аудиоматериалов по различным учебным дисциплинам, представляющих собой подборку лекций. На основе материалов данного ресурса возможно создание презентаций и проведение дискурсивного анализа.
4.	http://www.abc.net.au/rn/scienceshow/ http://www.podfeed.net/ http://www.bbc.co.uk/	Приведенные интернет-ресурсы обладают обширными базами данных по аудированию. На первом сайте имеется аудиозаписи, связанные с научной тематикой. Второй интернет-ресурс представляет собой постоянно обновляемую коллекцию подкастов по самым актуальным темам современности. Третий сайт позволяет аудировать радиопрограммы BBC.
5.	http://info.ox.ac.uk/bnc .	Британский национальный корпус, насчитывающий более миллиона слов. Сайт позволяет получить информацию об употреблении

		любого слова или словосочетания в разных контекстах. После введения искомого слова в поисковый экран пользователь получает до 50 аутентичных предложений из БНК, которые могут использоваться для перевода, составления глоссария и т. д.
6	http://www.lextutor.ca/	Сайт содержит большое количество различной информации, полезной для самостоятельного изучения английского языка. С помощью данного сайта можно проверить свои знания, постоянно обогащать лексический запас с помощью различных упражнений и чтения и прослушивания литературных произведений.
7	http://www.thesaurus.com/	Ресурс для поиска определений слов, их синонимов и антонимов
8	http://www.merriam-webster.com/	Ресурс для поиска определений слов, их этимологии и произношения.
9	http://www.multitran.ru/	Электронные словари, причем

	http://lingvo.abbyyonline.com/	Мультитран является наиболее эффективным ресурсом
10	http://www.concordancesoftware.co.uk/	Программы-конкордансы работают с большими объемами текстов, обеспечивая данные по частотности слов и их сочетаемости, представление заданного слова в контексте и т.д.
11	http://www.lingua.spbstu.tu/	Электронный ресурс факультета иностранных языков, в частности кафедры №2, имеет обширный раздел по грамматике английского языка, в котором теоретическая часть сопровождается упражнениями для самостоятельной работы.

KEYS

Unit 1

Task 1.3 a – 2, b – 5, c – 4, d – 3, e – 1, f – 6

Task 1.4 1 – subject to 2 – fluctuations 3 – juggle 4 – modify 5 – fluctuations 6 – environment 7 – motility 8 – transcription 9 – propulsion 10 – diffusion 11 – motions 12 – owing to 13 – techniques 14 – scattering 15 – scattering 16 – tracking 17 – motility 18 – foundations

Task 1.9 Video script.

Published on Sep 8, 2015

"Plasma" is one of the four fundamental states of matter, the others being solid, liquid, and gas. A plasma has properties unlike those of the other states.

A plasma can be created by heating a gas or subjecting it to a strong electromagnetic field applied with a laser or microwave generator. This decreases or increases the number of electrons, creating positive or negative charged particles called ions, and is accompanied by the dissociation of molecular bonds, if present.

The presence of a significant number of charge carriers makes plasma electrically conductive so that it responds strongly to electromagnetic fields. Like gas, plasma does not have a definite shape or a definite volume unless enclosed in a container. Unlike gas, under the influence of a magnetic field, it may form structures such as filaments, beams and double layers.

Plasma is the most abundant form of ordinary matter in the Universe , most of which is in the rarefied intergalactic regions, particularly the intracluster medium, and in stars, including the Sun. A common form of plasmas on Earth is seen in neon signs.

Much of the understanding of plasmas has come from the pursuit of controlled nuclear fusion and fusion power, for which plasma physics provides the scientific basis. Plasma is loosely described as an electrically neutral medium of unbound positive and negative particles . It is important to note that although they are unbound, these particles are not ‘free’ in the sense of not experiencing forces. When the charges move, they generate electric currents with magnetic fields, and as a result, they are affected by each other’s fields. This governs their collective behavior with many degrees of freedom. A definition can have three criteria:

Unit 2

Task 2.3 a – 2, b – 7, c – 3, d – 6, e – 8, f – 1, g – 5, h – 4

Task 2.4 1 – progress 2 – step 3 – pace 4 – track

Task 2.6 1 – a 2 – b 3 – c 4 – a 5 – b 6 – c 7 – b 8 – a 9 – a 10 – c

Task 7.12 1 – B, 2 – F, 3 – H, 4 – E, 5 – B, 6 – A, 7 -I, 8 – J, 9 – G, 10 - D

Unit 3

Task 3.5 1 – b 2 – a 3 – c 4 – b 5 – c 6 – a 7 – c 8 – b 9 – a 10 – b 11 – a 12 – b

Task 3.10 Video script

The Princeton Plasma Physics Laboratory - Advancing Fusion and Plasma Science

Published on Feb 28, 2014

The Princeton Plasma Physics Laboratory (PPPL) is a world leader in the coupled fields of fusion and plasma science. Top researchers are making new discoveries that will help develop fusion energy as a safe, clean, and virtually limitless source for generating electricity for the world. The National Spherical Torus Experiment Upgrade (NSTX-U) will greatly enhance national and global fusion research. As a national laboratory funded by the U.S. Department of Energy and managed by Princeton University, PPPL has access to some of the best minds and technologies in the world and attracts graduate students who are eager to engage in the mission of developing fusion energy.

Unit 4

Task 4.3 a – 4 b - 3 c – 6 d – 8 e – 5 f – 2 g – 7 h – 1

Task 4.5 1 – d 2 – b 3 – b 4 – a 5 – a 6 – c 7 – d 8 – a 9 – c 10 – b

Task 4.7 1 – b 2 – a 3 – b 4 – c 5 – c

Task 4.11 Video script

How Close Are We to Fusion Energy?

Published on Aug 16, 2018

Fusion energy might be the safe, efficient, reliable and clean energy source that could save our planet. But, how close are we to a world where fusion energy is powering our homes?

Unit 5

Task 5.3 1 – i 2 – j 3 – d 4 – h 5 – a 6 – c 7 – e 8 – g 9 – f 10 – b 11 – k

Task 5.4 1 – rotating 2 – center 3 – star 4 – since 5 – light 6 – size 7 – tell 8 – feature 9 – prism 10 – colors 11 – rainbow 12 – spectrum 13 – spectra 14 – brightness 15 – opaque 16 – temperature 17 – means 18 – vary from 19 – chemical 20 – atmosphere

Task 5.5.1 1 – factor 2 – aspect 3 – topic 4 – theme 5 – point 6 – case 7 – question

Task 5.5.2 1 – declined 2 – disowned 3 – rejected 4 – dissented 5 – defined

Task 5.5.3 1 – regard 2 – consideration 3 – relation 4 – view

Task 5.10 Video script

How Tokamak Research is Paving the Way for Successful Fusion Energy Reactors | Rachel McDermott

Published on Feb 18, 2013

Breaking the Wall to Control Fusion Power, Falling Walls 2012: Following the dream of fusion power, which would provide humanity with the same abundant energy as produced by the sun, scientific research is focusing on creating and controlling high-temperature, burning plasma, as it exists in stars, using deuterium, a type of hydrogen abundant in the oceans. Significant progress toward this goal has been made in the area of tokamak research that aims to confine the plasma through magnetic fields and provide the basis for ITER, the next-step fusion device already presented at the 2009 Falling Walls. New technologies have been developed to protect the walls of fusion reactors against temperatures of 200 million degrees. Fusion scientist Rachael McDermott received her PhD in Plasma Physics and Fusion Technology from the Department of Nuclear Science and Engineering at the Massachusetts Institute of Technology. She is now a member of the ASDEX Upgrade team, a tokamak project of the Max-Planck-Institut für Plasmaphysik, and of the Helmholtz Association Nachwuchsgruppe, and presented in 15 minutes, the most recent advances on the journey to the ultimate clean energy source.

Unit 6

Task 6.3 1 – I, 2 – C, 3 – A, 4 – F, 5 – H, 6 – J, 7 – B, 8 – E, 9 – G, 10 – D

Task 6.4 1. to, 2 in, 3 at, 4 with, 5 in,

Task 6.5 1 – b 2 – g 3 – h 4 – d 5 – j 6 – f 7 – i 8 – e 9 – c 10 – a

Ex. 6.1 1 - disorder 2 – misplacement 3 – independence 4 – decrease 5 - misapplication 6 - disability 7 - im/disbalance 8 - im possibility 9 - irrationality 10 - indecent

Ex. 6.2 1 – dissatisfied 2 – unusual 3 – unfair 4 – insoluble 5 – invalid 6 – unavoidable 7 – illogic 8 – unexplored 9 – denitrifying 10 – dehydrated 11 – mispronounce 12 - misunderstood

Ex. 6.3 1 – is 2 – is 3 – aren’t 4 – vary 5 – has 6 – have 7 – is 8 – has 9 – has 10 – were

Task 6.8 1 – G, 2 – E, 3 – I, 4 – A, 5 – H, 6 – B, 7 – F, 8 – D, 9 – J, 10 – C

Unit 7

Task 7.3 1 – B, 2 – F, 3 – H, 4 – E, 5 – B, 6 – A, 7 -I, 8 – J, 9 – G, 10 – D

Ex. 7.1.1 1 – so 2 – so 3 – such 4 – so 5 – so 6 – such 7 – so 8 – so 9 – such 10 – such 1 – so 12 - such

Ex. 7.3 1 – c, 2 – c, 3 – c, 4 – a, 5 – b, 6 – b, 7 – c, 8 – b, 9 – b, 10 – b and c

Ex. 7.5 1- transparent/clear, smooth shiny; 2 – rough powdery; 3 – corrugated; 4 – matt black; 5 – bright shiny silvery;6 - rough abrasive; 7 - coarse grainy; 8 – smooth matt

Ex. 7.7 melting, melting; freezing, freezing; boiling, boiling; liquid, liquid; vapor, vaporous

Ex. 7.8 1 – heated, melts; 2 – cooled, freezes; 3 – heated, boils; 4- liquefy; 5 – solidify; 6 – vaporize

Ex. 7.9 weaken, weakness; toughen, toughness; soften, softness; harden, hardness; roughen, roughness; coarsen; coarseness

Ex. 7.10 1 - hard; hardened; heated; cooled; hardened; brittleness; hardened;

2 – re-heated; low; quenched; hardened; heated

Ex. 7.13 1 – melting point 2 – boiling point 3 – solidifies 4 – liquefies 5 – vapour, evaporates, vaporizes, condenses.

Ex.7.14 1 – e; 2 – b; 3 – a; 4 – f; 5 – d; 6 – c

Unit 8

Task 8.3 1 – B, 2 – D, 3 – F, 4 – J, 5 – A, 6 – H, 7 – C, 8 – I, 9 – G, 10 - E

Ex. 8.1 1 – e 2 – d 3 – a 4 – h 5 – g 6 – c 7 – b 8 – f

Ex. 8.2 1 – blunder 2 – mistake 3 – slip 4 – mix-up 5 – slip-up 6 – oversight 7 – howlers

Task 8.7 1 – C, 2 – E, 3 - A, 4 – H, 5 – J, 6 – B, 7 – I, 8 – D, 9 – F

APPENDIX

SOME PUNCTUATION RULES IN WRITING

1. Spacing with Punctuation.

Rule 1

With a computer, use only one space following periods, commas, semicolons, colons, exclamation points, question marks, and quotation marks. The space needed after these punctuation marks is proportioned automatically.

Rule 2

Use no spaces on either side of a hyphen.
Example:
We borrowed twenty-three sheets of paper.

2. Periods

Rule 1. Use a period at the end of a complete sentence that is a statement.

Example: I know him well.

Rule 2. If the last item in the sentence is an abbreviation that ends in a period, do not follow it with another period.

Incorrect: This is Alice Smith, M.D..
Correct: This is Alice Smith, M.D.
Correct: Please shop, cook, etc. We will do the laundry.

Rule 3. Question marks and exclamation points replace and eliminate periods at the end of a sentence.

3. Commas

Commas and **periods** are the most frequently used punctuation marks. Commas customarily indicate a brief pause; they're not as final as periods.

Rule 1. Use commas to separate words and word groups in a simple series of three or more items.

> ***Example:*** *My estate goes to my husband, son, daughter-in-law, and nephew.*

Note: When the last comma in a series comes before *and* or *or* (after *daughter-in-law* in the above example), it is known as the **Oxford comma**. Most newspapers and magazines drop the Oxford comma in a simple series, apparently feeling it's unnecessary. However, omission of the Oxford comma can sometimes lead to misunderstandings.

> ***Example:*** *We had coffee, cheese and crackers and grapes.*

Adding a comma after *crackers* makes it clear that *cheese and crackers* represents one dish. In cases like this, clarity demands the Oxford comma.

> *We had coffee, cheese and crackers, and grapes.*

Fiction and nonfiction books generally prefer the Oxford comma. Writers must decide Oxford or no Oxford and not switch back and forth, except when omitting the Oxford comma could cause confusion as in the *cheese and crackers* example.

Rule 2. Use a comma to separate two adjectives when the order of the adjectives is interchangeable.

> ***Example:*** *He is a strong, healthy man.*
> We could also say *healthy, strong man.*

> ***Example:*** *We stayed at an expensive summer resort.*
> We would not say *summer expensive resort*, so no comma.

Another way to determine if a comma is needed is to mentally put *and* between the two adjectives. If the result still makes sense, add the comma. In the examples above, *a strong* ***and*** *healthy man* makes sense, but *an expensive* ***and*** *summer resort* does not.

Rule 3a. Many inexperienced writers run two independent clauses together by using a comma instead of a period. This results in the dreaded **run-on sentence** or, more technically, a **comma splice.**

> ***Incorrect:*** *He walked all the way home, he shut the door.*

There are several simple remedies:

> ***Correct:*** *He walked all the way home. He shut the door.*
> ***Correct:*** *After he walked all the way home, he shut the door.*
> ***Correct:*** *He walked all the way home, and he shut the door.*

Rule 3b. In sentences where two independent clauses are joined by connectors such as *and, or, but,* etc., put a comma at the end of the first clause.

> ***Incorrect:*** *He walked all the way home and he shut the door.*
> ***Correct:*** *He walked all the way home, and he shut the door.*

Some writers omit the comma if the clauses are both quite short:

> ***Example:*** *I paint and he writes.*

Rule 3c. If the subject does not appear in front of the second verb, a comma is generally unnecessary.

> ***Example:*** *He thought quickly but still did not answer correctly.*

But sometimes a comma in this situation is necessary to avoid confusion.

> ***Confusing:*** *I saw that she was busy and prepared to leave.*
> ***Clearer with comma:*** *I saw that she was busy, and prepared to leave.*

Without a comma, the reader is liable to think that "she" was the one who was prepared to leave.

Rule 4a. When starting a sentence with a dependent clause, use a comma after it.

Example: *If you are not sure about this, let me know now.*

Follow the same policy with introductory phrases.

Example: *Having finally arrived in town, we went shopping.*

However, if the introductory phrase is clear and brief (three or four words), the comma is optional.

Example: *When in town we go shopping.*

But always add a comma if it would avoid confusion.

Example: *Last Sunday, evening classes were cancelled.* (The comma prevents a misreading.)

When an introductory phrase begins with a preposition, a comma may not be necessary even if the phrase contains more than three or four words.

Example: *Into the sparkling crystal ball he gazed.*

If such a phrase contains more than one preposition, a comma may be used **unless** a verb immediately follows the phrase.

Examples:
Between your house on Main Street and my house on Grand Avenue, the mayor's mansion stands proudly.
Between your house on Main Street and my house on Grand Avenue is the mayor's mansion.

Rule 4b. A comma is usually unnecessary when the sentence starts with an independent clause followed by a dependent clause.

Example: *Let me know now if you are not sure about this.*

Rule 5. Use commas to set off nonessential words, clauses, and phrases.

Incorrect: *Jill who is my sister shut the door.*
Correct: *Jill, who is my sister, shut the door.*

Incorrect: *The man knowing it was late hurried home.*
Correct: *The man, knowing it was late, hurried home.*

In the preceding examples, note the comma after *sister* and *late*. Nonessential words, clauses, and phrases that occur midsentence must be enclosed by commas. The closing comma is called an **appositive comma**. Many writers forget to add this important comma. Following are two instances of the need for an appositive comma with one or more nouns.

Incorrect: *My best friend, Joe arrived.*
Correct: *My best friend, Joe, arrived.*

Incorrect: *The three items, a book, a pen, and paper were on the table.*
Correct: *The three items, a book, a pen, and paper, were on the table.*

Rule 6. If something or someone is sufficiently identified, the description that follows is considered nonessential and should be surrounded by commas.

Examples:
Freddy, who has a limp, was in an auto accident.
If we already know which Freddy is meant, the description is not essential.

The boy who has a limp was in an auto accident.
We do not know which boy is meant without further description; therefore, no commas are used.

This leads to a persistent problem. Look at the following sentence:

Example: *My brother Bill is here.*

Now, see how adding two commas changes that sentence's meaning:

Example: *My brother, Bill, is here.*

Careful writers and readers understand that the first sentence means I have more than one brother. The commas in the second sentence mean that Bill is my only brother.

Why? In the first sentence, *Bill* is essential information: it identifies which of my two (or more) brothers I'm speaking of. This is why no commas enclose *Bill.*

In the second sentence, *Bill* is nonessential information—whom else but Bill could I mean?—hence the commas.

Comma misuse is nothing to take lightly. It can lead to a train wreck like this:

> ***Example:*** *Mark Twain's book,* Tom Sawyer, *is a delight.*

Because of the commas, that sentence states that Twain wrote only one book. In fact, he wrote more than two dozen of them.

Rule 7a. Use a comma after certain words that introduce a sentence, such as *well, yes, why, hello, hey,* etc.

> ***Examples:***
> *Why, I can't believe this!*
> *No, you can't have a dollar.*

Rule 7b. Use commas to set off expressions that interrupt the sentence flow (*nevertheless, after all, by the way, on the other hand, however,* etc.).

> ***Example:*** *I am, by the way, very nervous about this.*

Rule 8. Use commas to set off the name, nickname, term of endearment, or title of a person directly addressed.

> ***Examples:***
> *Will you, Aisha, do that assignment for me?*
> *Yes, old friend, I will.*
> *Good day, Captain.*

Rule 9. Use a comma to separate the day of the month from the year, and—what most people forget!—always put one after the year, also.

> ***Example:*** *It was in the Sun's June 5, 2003, edition.*

No comma is necessary for just the month and year.

> ***Example:*** *It was in a June 2003 article.*

Rule 10. Use a comma to separate a city from its state, and remember to put one after the state, also.

> ***Example:*** *I'm from the Akron, Ohio, area.*

Rule 11. Traditionally, if a person's name is followed by *Sr.* or *Jr.*, a comma follows the last name: *Martin Luther King, Jr.* This comma is no longer considered mandatory. However, if a comma does precede *Sr.* or *Jr.,* another comma must follow the entire name when it appears midsentence.

> ***Correct:*** *Al Mooney Sr. is here.*
> ***Correct:*** *Al Mooney, Sr., is here.*
> ***Incorrect:*** *Al Mooney, Sr. is here.*

Rule 12. Similarly, use commas to enclose degrees or titles used with names.

> ***Example:*** *Al Mooney, M.D., is here.*

Rule 13a. Use commas to introduce or interrupt direct quotations.

> ***Examples:***
> *He said, "I don't care."*
> *"Why," I asked, "don't you care?"*

This rule is optional with one-word quotations.

> ***Example:*** *He said "Stop."*

Rule 13b. If the quotation comes before *he said, she wrote, they reported, Dana insisted,* or a similar attribution, end the quoted material with a comma, even if it is only one word.

Examples:
"I don't care," he said.
"Stop," he said.

Rule 13c. If a quotation functions as a subject or object in a sentence, it might not need a comma.

Examples:
Is "I don't care" all you can say to me?
Saying "Stop the car" was a mistake.

Rule 13d. If a quoted question ends in midsentence, the question mark replaces a comma.

Example: *"Will you still be my friend?" she asked.*

Rule 14. Use a comma to separate a statement from a question.

Example: *I can go, can't I?*

Rule 15. Use a comma to separate contrasting parts of a sentence.

Example: *That is my money, not yours.*

Rule 16a. Use a comma before and after certain introductory words or terms, such as*namely, that is, i.e., e.g.,* and *for instance*, when they are followed by a series of items.

Example: *You may be required to bring many items, e.g., sleeping bags, pans, and warm clothing.*

Rule 16b. A comma should precede the term *etc*. Many authorities also recommend a comma after *etc*. when it is placed midsentence.

Example: *Sleeping bags, pans, warm clothing, etc., are in the tent.*

4.Semicolons

It's no accident that a **semicolon** is a period atop a comma. Like commas, semicolons indicate an audible pause—slightly longer than a comma's, but short of a period's full stop.

Semicolons have other functions, too. But first, a caveat: avoid the common mistake of using a semicolon to replace a colon.

Incorrect: *I have one goal; to find her.*
Correct: *I have one goal: to find her.*

Rule 1a. A semicolon can replace a period if the writer wishes to narrow the gap between two closely linked sentences.

Examples:
Call me tomorrow; you can give me an answer then.
We have paid our dues; we expect all the privileges listed in the contract.

Rule 1b. Avoid a semicolon when a dependent clause comes before an independent clause.

Incorrect: *Although they tried; they failed.*
Correct: *Although they tried, they failed.*

Rule 2. Use a semicolon before such words and terms as *namely, however, therefore, that is, i.e., for example, e.g., for instance,* etc., when they introduce a complete sentence. It is also preferable to use a comma after these words and terms.

Example: *Bring any two items; however, sleeping bags and tents are in short supply.*

Rule 3. Use a semicolon to separate units of a series when one or more of the units contain commas.

Incorrect: *The conference has people who have come from Moscow, Idaho, Springfield, California, Alamo, Tennessee, and other places as well.*

Note that with only commas, that sentence is hopeless.

> ***Correct:*** *The conference has people who have come from Moscow, Idaho; Springfield, California; Alamo, Tennessee; and other places as well.* (Note the final semicolon, rather than a comma, after *Tennessee*.)

Rule 4. A semicolon may be used between independent clauses joined by a connector, such as *and, but, or, nor,* etc., when one or more commas appear in the first clause.

> ***Example:*** *When I finish here, and I will soon, I'll be glad to help you; and that is a promise I will keep.*

Rule 5. Do not capitalize ordinary words after a semicolon.

> ***Incorrect:*** *I am here; You are over there.*
> ***Correct:*** *I am here; you are over there.*

4. Colons

A **colon** means "that is to say" or "here's what I mean." Colons and semicolons should never be used interchangeably.

Rule 1a. Use a colon to introduce an item or a series of items. Do not capitalize the first item after the colon (unless it's a proper noun).

> ***Examples:***
> *You know what to do: practice.*
> *You may be required to bring many things: sleeping bags, pans, utensils, and warm clothing.*
> *I want the following items: butter, sugar, and flour.*
> *I need an assistant who can do the following: input data, write reports, and complete tax forms.*

Rule 1b. A capital letter generally does not introduce a word, phrase, or incomplete sentence following a colon.

Examples:
He got what he worked for: a promotion.
He got what he worked for: a promotion that paid a higher wage.

Rule 2. Avoid using a colon before a list if it directly follows a verb or preposition that would ordinarily need no punctuation in that sentence.

Not recommended: *I want: butter, sugar, and flour.*
Recommended: *I want butter, sugar, and flour.*
OR
Here is what I want: butter, sugar, and flour.

Not recommended: *I've seen the greats, including: Barrymore, Guinness, and Streep.*
Recommended: *I've seen the greats, including Barrymore, Guinness, and Streep.*

Rule 3. When listing items one by one, one per line, following a colon, capitalization and ending punctuation are optional when using single words or phrases preceded by letters, numbers, or bullet points. If each point is a complete sentence, capitalize the first word and end the sentence with appropriate ending punctuation. Otherwise, there are no hard and fast rules, except be consistent.

Examples:

I want an assistant who can do the following:

a. input data
b. write reports
c. complete tax forms

The following are requested:

- Wool sweaters for possible cold weather.
- Wet suits for snorkeling.
- Introductions to the local dignitaries.

These are the pool rules:

1. Do not run.
2. If you see unsafe behavior, report it to the lifeguard.
3. Did you remember your towel?
4. Have fun!

Rule 4. A colon instead of a semicolon may be used between independent clauses when the second sentence explains, illustrates, paraphrases, or expands on the first sentence.

> ***Example:*** *He got what he worked for: he really earned that promotion.*

If a complete sentence follows a colon, as in the previous example, authorities are divided over whether to capitalize the first word. Some writers and editors feel that capitalizing a complete sentence after a colon is always advisable. Others advise against it. Still others regard it as a judgment call: If what follows the colon is closely related to what precedes it, there is no need for a capital. But if what follows is a general or formal statement, many writers and editors capitalize the first word.

> ***Example:*** *Remember the old saying: Be careful what you wish for.*

Rule 5. Capitalize the first word of a complete or full-sentence quotation that follows a colon.

> ***Example:*** *The host made an announcement: "You are all staying for dinner."*

Rule 6. Capitalize the first word after a colon if the information following the colon requires two or more complete sentences.

> ***Example:*** *Dad gave us these rules to live by: Work hard. Be honest. Always show up on time.*

Rule 7. If a quotation contains two or more sentences, many writers and editors introduce it with a colon rather than a comma.

> ***Example:*** *Dad often said to me: "Work hard. Be honest. Always show up on time."*

Rule 8. For extended quotations introduced by a colon, some style manuals say to indent one-half inch on both the left and right margins; others say to indent only on the left margin. Quotation marks are not used.

> ***Example:*** *The author of* Touched, *Jane Straus, wrote in the first chapter:*
>
> > *Georgia went back to her bed and stared at the intricate patterns of burned moth wings in the translucent glass of the overhead light. Her father was in "hyper mode" again where nothing could calm him down.*

Rule 9. Use a colon rather than a comma to follow the salutation in a business letter, even when addressing someone by his or her first name. (Never use a semicolon after a salutation.) A comma is used after the salutation in more informal correspondence.

> ***Examples:***
> *Dear Ms. Rodriguez:*
> *Dear Dave,*

6. Parentheses and Brackets

Parentheses and **brackets** must never be used interchangeably.

Parentheses

Rule 1. Use parentheses to enclose information that clarifies or is used as an aside.

> ***Example:*** *He finally answered (after taking five minutes to think) that he did not understand the question.*

If material in parentheses ends a sentence, the period goes after the parentheses.

> ***Example:*** *He gave me a nice bonus ($500).*

Commas could have been used in the first example; a colon could have been used in the second example. The use of parentheses indicates that the writer considered the information less important—almost an afterthought.

Rule 2a. Periods go inside parentheses only if an entire sentence is inside the parentheses.

> ***Example:*** *Please read the analysis. (You'll be amazed.)*

This is a rule with a lot of wiggle room. An entire sentence in parentheses is often acceptable without an enclosed period:

> ***Example:*** *Please read the analysis (you'll be amazed).*

Rule 2b. Take care to punctuate correctly when punctuation is required both inside and outside parentheses.

> ***Example:*** *You are late (aren't you?).*

Note the question mark within the parentheses. The period after the parentheses is necessary to bring the entire sentence to a close.

Rule 3. Parentheses, despite appearances, are not part of the subject.

> ***Example:*** *Joe (and his trusty mutt)* **was** *always welcome.*

If this seems awkward, try rewriting the sentence:

> ***Example:*** *Joe (accompanied by his trusty mutt)* **was** *always welcome.*

Rule 4. Commas are more likely to follow parentheses than precede them.

> ***Incorrect:*** *When he got home, (it was already dark outside) he fixed dinner.*
> ***Correct:*** *When he got home (it was already dark outside), he fixed dinner.*

Brackets

Brackets are far less common than parentheses, and they are only used in special cases. Brackets (like single quotation marks) are used exclusively within quoted material.

Rule 1. Brackets are interruptions. When we see them, we know they've been added by someone else. They are used to explain or comment on the quotation.

Examples:
"Four score and seven [today we'd say eighty-seven] years ago..."
"Bill shook hands with [his son] Al."

Rule 2. When quoting something that has a spelling or grammar mistake or presents material in a confusing way, insert the term *sic* in italics and enclose it in nonitalic (unless the surrounding text is italic) brackets.

Sic ("thus" in Latin) is shorthand for, "This is exactly what the original material says."

Example: *She wrote, "I would rather die then [*sic*] be seen wearing the same outfit as my sister."*

The [*sic*] indicates that *then* was mistakenly used instead of *than*.

Rule 3. In formal writing, brackets are often used to maintain the integrity of both a quotation and the sentences others use it in.

Example: *"[T]he better angels of our nature" gave a powerful ending to Lincoln's first inaugural address.*

Lincoln's memorable phrase came midsentence, so the word *the* was not originally capitalized.

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