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Editorial introduction

Hermeneutic Dimensions of Science and Technology

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Abstract
The editorial discusses perspectives for a hermeneutics of science and technology. It begins by appreciating the original antagonism between hermeneutics and science, between hermeneutics and technology. While the former signifies the struggle to establish the purity, transparency, and objectivity of science, the latter concerns the symbolic dimension of technology as well as practices of sense-making in human interactions with technology. And while the antagonism of hermeneutics and science persists, the latter can be solved by treating technical works on a par with artworks. If there is a hermeneutic of science and not just a hermeneutic historiography or philosophical reconstruction of science, it can be found in the technical process of modeling as a mutual attunement of theory and reality by way of the model as mediator or hermeneutic device. This conclusion for the hermeneutics of science leads on to conceptions of a hermeneutics of technical works, including models as material compositions that establish what can be done in the fields of theory and practice. – From among the twelve papers in this special issue, a first group of papers struggles with and against the „original antagonism" of science, while the second group offers perspectives for a hermeneutics of technical works.

Keywords: Hermeneutics of science; Hermeneutics of technology; Georg Christoph Lichtenberg; Heinrich Hertz; Determinacy of meaning; Works and worlds; Prospective models

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Герменевтические измерения науки и техники

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Аннотация
В редакционной статье обсуждаются перспективы герменевтики науки и техники. Она начинается с оценки изначального антагонизма между герменевтикой и наукой, между герменевтикой и техникой. В то время как первая часть означает борьбу за установление чистоты, прозрачности и объективности науки, вторая касается символического измерения техники, а также практик смыслообразования во взаимодействии человека с техникой. И хотя антагонизм герменевтики и науки сохраняется, последний может быть разрешен путем рассмотрения технических работ наравне с произведениями искусства. Если существует герменевтика науки, а не просто герменевтическая историография или философская реконструкция науки, ее можно найти в техническом процессе моделирования как взаимной настройки теории и реальности посредством модели как посредника или герменевтического устройства. Этот вывод для герменевтики науки приводит к концепциям герменевтики технических работ, включая модели как материальные композиции, которые устанавливают, что можно сделать в областях теории и практики. – Из двенадцати статей этого специального выпуска первая группа статей борется с “изначальным антагонизмом” науки и против него, в то время как вторая группа предлагает перспективы герменевтики технических работ.

Ключевые слова: Герменевтика науки; Герменевтика техники; Георг Кристоф Лихтенберг; Генрих Герц; Определенность смысла; Произведения и миры; Перспективные модели

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INTRODUCTION TO THE INTRODUCTION

There has been increasing interest in recent years to adopt hermeneutical methods and approaches in studies of science and technology. A previous issue of this journal testifies to this (Wu & Luo, 2024) as do several workshops and discussion groups, important monographs (Kudina, 2023), or the proposal to pursue „hermeneutic Technology Assessment" (Nordmann & Grunwald, 2023). To be sure, some of these discussions take up and develop earlier suggestions from the philosophical tradition (e.g., Paul Ricoeur, 1973, or Don Ihde, 2023), others strangely forego any explicit mention of hermeneutics such as a prominent research program on „scientific understanding" (de Regt et al., 2013).

With all the excitement about hermeneutics of science and technology, it is easy to forget that, interestingly, such an endeavor or line of questioning should not even exist. Going back to Wilhelm Dilthey and his famous juxtaposition of *Erklären* (explanaining) and *Verstehen* (understanding), one would be taken away from science and technology when one embarks on a quest for understanding and when one becomes absorbed in the practice and process of *Verstehen.* Leaving the sphere of direct and transparent or technical communication, one would be entering a different realm, namely that of art and the humanities (Dilthey, 2010).

It might therefore prove valuable and will heighten the interest and relevance of the hermeneutics of science and technology if we step back and ask how it is even possible, that is, how it overcomes the „original antagonism" of science or engineering and hermeneutics. This serves to query and perhaps to establish the background, the rationale, or even the „foundations" of this decidedly non-foundationalist intellectual enterprise. The authors of this special issue ask this question. In more and less incredulous ways they probe the very idea of a hermeneutics of science while others turn to the hermeneutics of technology, with yet others straddling the line, concerned with science and technology. This editorial provides a skeptical backdrop and moves slowly from there. Under the impression of the „original antagonism" and the reasons that gave rise to it, it exhibits some of the hermeneutic pathways that were pursued during the last forty years by one of the editors of this special issue. That he presents himself as a case-study of the struggle for hermeneutic perspectives may serve as an excuse for excessive self-citation.

If nowadays it appears easy to adopt a hermeneutic stance in the study of science and technology, this is because historical contextualization and societal integration have become commonplace. The humanities no longer approach science and technology with respect for what it is or pretends to be. What used to be condemned as deconstruction, even subversion of the peculiar authority of scientific knowledge is nowadays no more than a comprehensive appreciation of scientific and engineering practice. The hermeneutics of science and technology grew up, tentatively, at the border beween the humanities (*Geisteswissenschaft*) and the sciences of nature and craft (*Natur- und Ingenieurwissenschaft*). Probing just how permeable that border proves to be, the hermeneutic stance has by now confidently absorbed scientific and engineering as just some among many world- and sense-making practices. These are no longer considered categorically distinct from the arts and the creation of fictions, thus reversing the divisions that had been instituted in the 18th and still dominated the 20th century.

ORIGINAL ANTAGONISMS

Hermeneutics was and is primarily concerned with the life of the mind as it is expressed in religious, legal, and literary texts as well as works of art. These texts and works require exegesis. As outlined by Friedrich Schleiermacher, Wilhelm Dilthey, Hans-Georg Gadamer, or Paul Ricoeur, the hermeneutic process and the practice of exegesis require that we enter the work as a composition of symbols or elements, and thus as a world onto its own. Within the horizons of this world we recover meaning, we make sense – and after this encounter we do not leave quite as we entered. As opposed to the knowing subjects of scientific research, the subjects of hermeneutic exegesis do not remain unchanged in their course of inquiry.

If this is a general characterization of hermeneutics, it appears to exclude scientific texts as well as technical works. It is precisely the achievement and perhaps the essence of so-called „normal science“ that scientific texts might interpret data and explore the meaning of theories, but the texts themselves do not require exegesis by other scientific readers. Science pursues an image of knowledge that emphatically excludes the need for exegesis. If there is nevertheless a hermeneutics of science, this is because the quest for transparency and the exclusion of exegesis need to be understood as well: how do scientists as readers and writers achieve the seemingly unproblematic intelligibility of their texts? Three examples may serve as different models for a hermeneutics of science that is consistent with the view that scientific reading and writing does not require hermeneutics.

Much more recent, and therefore perhaps even more interesting, is the question of a hermeneutics of technology. How much of a stretch is it to consider sense-making in respect to clocks, assembly lines, fireworks, or wastewater infrastructures? The hermeneutic approach to technology begins by undermining the distinction between works of art and works of technology. As we contemplate a machine or participate in its workings, do we also enter the work as a world onto itself, seeking orientation within the horizon of the work, allowing ourselves to be transformed by this experience? Again, some exemplary approaches are offered to answer this question.

HERMENEUTICS OF SCIENCE

According to Gaston Bachelard, the task of the philosophy of the science is to elucidate the difference between science and poetry: “All that philosophy can hope to accomplish is to make poetry and science complementary, to unite them as two well-defined opposites” (Bachelard, 1987, p. 2). Hermeneutics does not provide the criteria for this distinction – it *is* the distinction since poetry is nothing without hermeneutics and science succeeds only to the extent that it does not require hermeneutics. In other words, hermeneutics is implicated in the process of differentiating science and poetry. This is mirrored also in the literary ideals and conventions of the philosophy of science (Nordmann, 2011). Here are three ways in which hermeneutics *is*, indeed, implicated in this process.

Scientists often „interpret“ data, they also offer interpretations of theories, such as the famous interpretations of quantum mechanics. They do not, however, interpret each

other in what they say and write. Scientists do not usually ask „what did you mean when you used this word in this context?" and they do not say: „this turn of phrase opened my eyes, I suddenly look at the world in an entirely different way." Consider one of the few examples of a simple elegant phrase of scientific writing opening the door to a whole new way of doing science. When James Watson and Francis Crick first revealed the double helix, they concluded their short analysis of the molecular structure of DNA by writing: „It has not escaped our notice that the specific pairing we have postulated immediately suggests a possible copying mechanisms for the genetic material" (Watson & Crick, 1953, p. 737). Tellingly, however, even this magnificent example of world-making scientific prose presupposes a prepared mind – that the readers immediately recognize and understand the meaning of what they are only hinting at.

Indeed, one might argue with Thomas Kuhn and others that the apparent transparency of language is a precondition of science – „we understand each other because we are speaking the same language." In other words: The sphere of scientific discourse is special in that it does not require hermeneutics. Inversely, there are stories about science breaking down when scientists do not speak the same language as in the Chemical Revolution of the 18th century.

If this is so, then *one* job for a „hermeneutics of science" could be to study how this transparency is possible, how it is established and maintained. In personal relations, in politics, even in business and the law one often says „we do not understand each other even though we are speaking the same language." Perhaps it is only an illusion but science successfully maintains the conceit that *because* one speaks the same language, one will understand each other. One steps out of science (and into philosophy) by questioning a basic, albeit implicit tenet: The very fact of being socialized to use words in particular ways is sufficient to guarantee that no interpretation or translation of these words will be required by other speakers of the language.

There is another dimension to this. Philosophical hermeneutics considers the making of meaning as a process that involves how we understand ourselves. A powerful religious or literary text engages readers as persons who encounter propositions in a special horizon of meaning such that the „otherness" of the text provokes them to expose their habituated ways of thinking and feeling – and thereby the readers may emerge as if ever so slightly altered beings. (This is one of the reasons, of course, why we should read literary texts.) There is none of this in science, supposedly. Scientists may come up with a changed understanding of nature but they are not looking to change themselves, to develop their character or grow as a person. They are what they always are: Impersonal knowing subjects who experiment and observe, perhaps interpret, and draw conclusions. Inversely, in a scientific revolution, scientists in different camps discover that they think, perceive and act differently – that a new kind of scientist is emerging along with a new paradigm. But this again is a moment of breakdown. Science proceeds only once this episode in the history of science can be bracketed or backgrounded and „normality" returns.

To be sure, this program of a „hermeneutics of science" would not actually engage in hermeneutics since it seeks to show why scientists do not need to adopt a hermeneutic approach. Instead, it would provide a transcendental reconstruction of the conditions

under which hermeneutics is or is not required – how and when do humans become engaged with each other in the process of making meaning und understanding each other? And how do humans manage to define a sphere of public reason where shared meanings can be assumed along with a shared identity as scientists or citizens?

An exemplary case for this first approach comes from 18th century theories of electricity (Nordmann, 1986, 2021a). There was an empirically intractable debate about electrical fluids and electrical charge. Some argued that there are two fluids which are opposed to each other. Depending on which one prevails, one or another state of attraction or repulsion is induced or the forces cancel each other out. Others believed that there was only one fluid, sometimes too much of it, sometimes too little, again inducing three states of surplus or privation or a proper medium. Georg Christoph Lichtenberg discovered a phenomenon of which he thought that it might shed light on the debate (Fig. 1). He therefore proposed the neutral terminology of E+ and E-. The first of these terms – E+ or „plus E" – can serve as the name of one of the two fluids *or* it could indicate the state of preponderance of the single electric fluid. The notion of plus and minus, positive and negative also captured that everyone agreed on the existence of a neutral state, a kind of „0". As it happened, the new terminology established a common language. It mattered less and less what particular meaning anyone attached to the symbols – this was from now on a private, scientifically irrelevant question. Science could proceed without a debate about proper interpretation.

The case of Lichtenberg's linguistic intervention nicely shows how scientists create and maintain conditions of intelligibility that exclude the need for hermeneutics. As such the case is not itself a part of a hermeneutical exercise of sense-making.

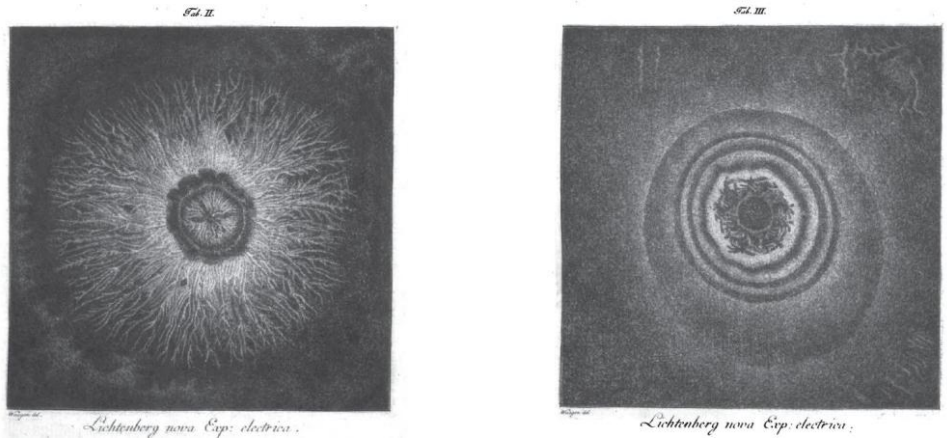

Figure 1. In his laboratory, Georg Christoph Lichtenberg produced miniature lightning strikes that discharged into a resin cake. When dust gathered on the cake, the discharge patterns became visible and they were different when positively and negatively charged. The Lichtenberg Figures became a scientific toy, with their many branches reminiscent of ice crystals and illustrative of a complex dynamics. Lichtenberg used them as a new method of writing and they later proved important for the invention of xerography, but do they also hold the key to understand the nature of electricity – two opposed electrical fluids or surplus and deficit of just one fluid? (Lichtenberg, 1779, compare Baird & Nordmann, 1994, Nordmann, 1986 and 2021a)

But then there is another role, a *second* possible job for the hermeneutics of science. Different interpretations of the data and also of theories are always possible, but often they are not mere interpretations as they suggest testable empirical implications. This allows for experimental evidence to settle questions of interpretation. Here again, the hermeneutic question of meaning arises only in a temporary, tentative, preliminary way. Such questions may be a part of science but mark a state of uncertainty and indeterminacy of meaning that needs to be overcome. On the other hand, this state will always reappear. There is thus a dialectic at work. When a theory is „interpreted," its empirical meaning is questioned. An experiment serves to specify the physical meaning and puts an end to speculation. The experiment simultaneously determines features of the world and the meaning of the descriptive vocabulary.

This tension between hermeneutic questioning and empirical determination – where one can give rise to the other, and where the latter puts an end to the former – appears in the works of Heinrich Hertz as one of „philology" (idle disagreements about words) and „philosophy" (the fixation of determinate physical meaning). Hertz cherished the times when the scientist in the laboratory is „alone with nature" – only then a true scientist. As soon as Hertz would publish his work, his findings become subject to philology. Different, empirically equivalent models can then be constructed to account for and interpret his findings, often without any presently available means to put them to a physical test. This was the state in which he found Maxwell's equations, proclaiming that „Maxwell's theory is the system of Maxwell's equations." In other words, physics proper cannot say anything more about the meaning of the terms in those equations than what is implied by the equations themselves. Hertz himself brilliantly exposed this by contrasting different interpretations of the equations (Hertz, 1893, pp. 20-28). But then, as an experimentalist alone with nature, he famously discovered radio waves and summarized this discovery by stating that the most important result of his experiments was the „philosophical" result of specifying the physical meaning of Maxwell's equations (Hertz, 1893, p. 19, see Nordmann 1998, 2009). To be sure, having done this, Hertz noted with some regret that rivalling interpretations of his discovery were offered – back to the philological condition where meanings become indeterminate.

Here, the task of hermeneutics is to trace the dialectical movement between the „philological" phase of indeterminacy of meaning to the (always superior) „philosophical" phase of the physical determination of meaning. The philological phase is then one of degeneracy and corruption (see Horgan, 2015). It is therefore a mark of progress when one can overcome this phase, establishes clarity of meaning and thus beliminates the need for hermeneutics.

There is quite another approach or *third* job for the hermeneutics of science which cannot be summarized easily. It was proposed by Margaret Morrison and Mary Morgan, and elaborated especially by Nancy Cartwright (Morgan & Morrison, 1999; Cartwright, 1983, 1989, 1999, see Nordmann 2008).[1] Of the three approaches presented here, only this one shows hermeneutics to be an essential part and not just the dialectical „poetic

[1] Cartwright did not use the word „hermeneutic" but responded very favorably to the suggestion that there are central hermeneutic moments in her philosophy of science (Cartwright, 2008).

other“ of science. On this third approach, it is not *people* (the scientists, readers) who interpret theory or interpret data. This is what *models* do and models interpret theory and data simultaneously. Models are mediators and „autonomous agents“ in that they do hermeneutic work – they achieve physical interpretations of theories by forging a fit between interpretable data and interpretable theories. By the way in which models relate features of theory and data, models show us how to „understand“ the data in light of the theory, and to „understand“ the theory in light of the data – they do so in a non-circular but also not independently testable manner by way of adaptation, calibration, or tuning. Models are sense-making devices. The criteria for the acceptance of models are not separate from those for the acceptance of the relevance of data and the acceptance of the „truth“ of theories. In the end – through patient work – calibration or attunement or „proper fit“ can be achieved, and this is a hermeneutic achievement. As opposed to the case of literature and art, it is not the readers or beholders who change in the process of sense-making or appropriation, but here it is the models that change since they are the hermeneutic agents of interpretation and with them their data take on new meaning as well as their theory. – But here again there comes a time when the hermeneutic process is over and done with. Once the model establishes a reasonable fit, it enables scientists to move between the levels of description, modelling, and theory back and forth with considerable ease. Again, a kind of transparency is achieved and a seemingly straightforward mapping relation: This achievement backgrounds or renders invisible the hermeneutic work of the model as mediator.

In order to find examples for this, one might turn to the current discussions of „fictionalism“ which can be traced back to Hans Vaihinger’s *Philosophy of the ‘As If’* (Vaihinger, 1935) but also to Nancy Cartwright’s *How the Laws of Physics Lie*. In that book she tells the story of „physics as theatre“: In order to truthfully represent a historical event on stage one needs to obey the requirements that come with the adopted representational framework of the theatre. These may require distortions of fact. If one wants to show how two persons conspire during a big assembly, one cannot have them whispering to one another during the proceedings. Instead, one has to come up with a way to send everyone else off stage to leave the conspirators alone for a while. This is not how it actually was and thus introduces a fictional element, but only with that fictional device can the story of the conspiracy be told (Cartwright, 1983, p. 140). Fictions can therefore serve as tools that foreground salient features. In other words, fictionalism is not about telling the truth by telling the right lies – there cannot be such a thing as a lie that is right (which is why some people find fictionalism scandalous). It is instead about telling lies rightly, that is, in the right kind of way such that acknowledged falsehoods can function as tools for foregrounding some truth. There never was a Prince of Denmark called Hamlet. Without claiming otherwise, the blatant fictional invention of that prince can serve to showcase truths about hesitation and doubt in the pursuit of justice or revenge. The system of lies or the representational scheme has some agency in that it can disclose or uncover meaningful structural relations in what might be called a hermeneutic process – *reading* through a specific set of glasses that exaggerate or distort and thereby render visible what would otherwise go unnoticed.

This concludes for now the discussion of the hermeneutics of science. To be sure, it was far from comprehensive. It failed to appreciate Patrick Heelan's attempt to establish a hermeneutic philosophy of science. Under the impression of quantum mechanics it was meant to pursue questions of meaning and truth in science (Heelan, 1998). Also, in quite another register, this review could have considered Hasok Chang's idea of "complementary science": Chang offered a hermeneutics of „temperature" in order to make concepts and strategies from the history of science available to contemporary science (Chang, 2004).

If these are but two of many omissions, there are more principled reasons for not considering two large areas of contemporary discussion. There is firstly the recent interest in understanding „scientific understanding." De Regt and other participants in this endeavor stay clear of „hermeneutics" and the whole tradition of *Erklären vs. Verstehen* (de Regt et al., 2013). The reason for this is simple enough and excludes them from consideration in this context. They want to characterize „understanding" as a particular state of knowledge, mostly in terms of capacity or skill. For example, a criterion of understanding might be that no explicit inferences or calculations are needed when using a theory to predict the behavior of some physical system. There is no interest either in the process of sense-making or the conditions of intelligibility and mutual understanding.

Then there is the interpretive work performed by historians of science who read scientific texts like any other kind of document that requires a reconstruction of its implied world-view or paradigm (Kuhn, 1962). While some of the contributions in this special issue are inclined to take this as indicative for a hermeneutics of science, in an of itself it confirms and does not undermine the original antagonism. If it is a defining characteristic of „normal science" that the shared paradigm relieves scientists of the task to perform hermeneutic work, historians of science re-open the black box by engaging in this task. For the most part, historians of science do not operate within a shared scientific paradigm. Thus, by having to recover what scientists mean to say, they simultaneously deconstruct and reconstruct the achievement of apparent transparency of meaning. The historian's hermeneutic work thus undoes what the paradigm is supposed to provide, it walks back the constructions of objectivity and conditions of determinacy of meaning. By problematizing what „normal science" takes for granted, historians begin from a position of antagonism to normal scientific practice. And by performing hermeneutic work this historiographic hermeneutics of science adopts a stance that needs to be bracketed by the scientists themselves: One needs to step out of science in order to do history or so-called hermeneutics of science. In the words of physicist and philosopher Carl Friedrich von Weizsäcker (1981):

> It is inherent in the methodological principles of science that certain fundamental questions are not posed. Physics, as it is practiced in modern times, characteristically does not really ask what matter is, biology does not ask what life is, and psychology does not ask what the soul is; instead these terms just vaguely circumscribe the area one intends to investigate. This fact is probably methodologically fundamental to the success of science. Were we to pose these most difficult questions while at the same time practicing science, we would lose the time and energy needed to solve the solvable questions. […] On the other hand,

> we must not deceive ourselves: the methodological procedure of science just characterized has something murderous in it if it no longer knows how questionable it is. The questions are difficult, but they are not unimportant. Heidegger's formula "Science does not think" can hardly be quoted to any scientist without provoking anger. In Heidegger's sense of the word "think," however, the formula is literally correct. For Heidegger takes "to think" as meaning "to put oneself in question once more," and precisely this science will not do in its normal practice. (p. 233)

Hermeneutics enters the world of a text or of art, more generally, in the way of thinking, that is, by putting oneself in question. In contrast, E+ and E- brackets the need to ask what electricity is. The experimental demonstration of radio waves finally puts to rest the philological debate about the physical meaning of a term in Maxwell's equations and settles the question of "action at a distance." Hermeneutics here serves to exhibit the processes by which science attains. If there is a hermeneutic of science and not just a hermeneutic historiography or philosophical reconstruction of science, we found it in the technical process of modeling as a mutual attunement of theory and reality by way of the model as mediator or hermeneutic device. This intermediary conclusion leads on to conceptions of a hermeneutics of technical works, including models as material compositions that establish what can be done in the fields of theory and practice (Nordmann, 2025).

HERMENEUTICS OF TECHNOLOGY

According to Gernot Böhme, all technical devices or socio-technical systems are models of social processes, they model the ways in which we intellectually and materially appropriate nature and society which we do by making things work for us in reliable and beneficial ways (Böhme, 2012, p. 21-22, see Böhme, 1993, p. 453-454). They are mediators and translators of sorts. Marco Tamborini (2022) builds on this by relabeling *homo faber* as *homo translator* – translating from the language of nature into the language of technology, as witnessed most explicitly in the case of so-called biomimetic technology. A famous example of biomimetic technology is Velcro: in the sphere of technology it takes up or reproduces how some things are done in the sphere of biology. Now, is this „mimicry" actually a hermeneutic process of sorts? The Velcro device makes sense of how a burr becomes attached to the fur or an animal. It makes sense, however, not by copying the original but by way of parody: It exaggerates what the burr does and reflects on the original by being raw or crude instead of sophisticated and subtle (Nordmann, 2021b). Velcro is a way of „reading" biological nature – it seeks its place within the horizon of the book of nature, materially fitting itself among all the other natural and technical things. However, each a world onto its own, all these things remain external to each other, questioning each other, or commenting.

Hermeneutics is a practice of reading that constitutes the meaningful world of a text, be it a prophetic or biblical, even legal text, be it a literary work or a work of fine

and technical art.[2] The world we constitute through our hermeneutic practice is and isn't our world – this is what it means to say that reader and text are external to each other, that they do not blend seamlessly but question each other. Even Gadamer's so-called "fusion of horizons" does not refer to fusion or identification but to the creation of conditions for a shared understanding from different points of view (Gadamer, 2013). There is no perfect transparency of meaning but a material irritation or resistance – the relation of original and copy, of representations and what they represent is disturbed, distorted, or obscured – another reason for distinguishing the production of true representations from hermeneutics as a process of understanding oneself by encountering and never quite understanding the other. The world thus constituted is and isn't our world also in the sense that we invest ourselves in our world by making meaning. At the same time it is not our world because it is the world of a text or of nature or of a created work that resists appropriation. It cannot be integrated seamlessly into the experiences, ideas, expectations of our daily lives, it cannot be absorbed entirely, and does not dissolve into our ordinary ways of sense-making. The world of a literary text or work of art – including technical works – never becomes quite familiar but retains a sense of strangeness, unfamiliarity. In the meantime we inhabit a life-world which also is and isn't our world. It is ours because we live and act in it, it is familiar. It is not ours because we were cast into it and it is co-produced by countless human and non-human actors, with an uncertain future over which we have only very limited control even in our private lives. This meeting, blending, fusing of different, even antagonistic literary and life-worlds makes for what one might call a hermeneutic encounter. We are so deeply implicated in this encounter that we cannot withdraw to the safe place of the observer or interpreter who casts out a net and retrieves some kind of account of what is said in a text and what it means. For the purposes merely of interpretation the reader is the measure of all things, recovering meaning on his or her own terms. In contrast, the reader is subject as well as object, agent as well as patient in the hermeneutic process – when I read a literary work, philosophical or legal text, the text happens to me just as much as I happen to the text.

If hermeneutics encompasses all of that, what does this signify for the hermeneutics of technology? The first impulse is to shift to discourse or text since there is much talking *about* technology in our societies. In particular we are drawn to technological visions as they are articulated by advocates and critics of emerging technologies, asking what this tells us about ourselves. By choosing to read government policies, calls for proposals, ethics reports, TV documentaries, NGO position papers as if they were literally texts, we become implicated in a societal conversation about anxiety and hope, visionary confidence and dystopic doubt about the technologies of the day. This is one way, for sure, to study the world we live in, though this is usually done from the safe place of the analyst or cultural critic and does not involve the hermeneutic process as described above.

However, as we have seen already, it is not the exclusive privilege of texts that they constitute a world for a reader to enter. Technical works are worlds in their own right, and we enter them as well – these include needleworks, artworks, musical and literary

[2] Compare this and the following couple of paragraphs to "Machine Hermeneutics" (Nordmann, 2023) which outlines the prospects for a hermeneutic approach to technical devices.

works as technical achievements, poetically brought forth by human ingenuity and labor. If works are worlds, this includes no less the world of the clockwork, the world of metal works or water works, that is, the world of the factory. There is now also, very prominently, the world constituted by electronic as well as social networks, that is, the worlds that correspond to socio-technical systems. To the extent that every technical process or device draws together material things as well as human developers and users, they can all be considered as worlds that result from the composition, literally "putting-together" of numerous elements.

Do designers and users enter these worlds as readers do a text? Readers or not, we seek orientation, hope to establish and maintain a measure of control, and contemplate the meaning of these works. Cosmological questions as to who we are in the world are raised by Dürer's Melancolia, Picasso's Guernica, and Malevich's Black Square, but no less so by Tatlin's tower or an 18th century astronomical clock that shows seconds and minutes, hours and days, months and years, and that exhibits the heavenly mechanics of the sun and the moon and the planets in their orbits (Fig. 2). A tower is a practical structure and so is the astronomical clock, but they are objects of contemplation as well.

Figure 2. An 18th century model of a Ptolemeian universe with the Earth at its center, a „world machine" that is operated by a crank, and an elegant piece of furniture, an object of contemplation: Armillary Sphere of unknown origin, purchased in London around 1790, Hessisches Landesmuseum Darmstadt. For a discussion of similar devices see Baird and Nordmann, 1994.

A hermeneutics of technology might be concerned, therefore, with the world of technical works – what they signify about the ways in which humans and things can live and work together. When archaeologists find a vase or bronze axe, they begin to reconstitute the ways of life and modes of production which might have resulted in this or that particular glaze. They come up with a world that is dissociated from our own world

of daily lived experience – and it is important not to simply assimilate these separate worlds as they can inform and critique each other. In the temporal order, a prototype is the complement to the archaeological artefact. It is also not of our time, and though we can see it right before our eyes, it is emphatically not of our world. If archaeological artefacts are *no longer* part of our world, or only as relics, prototypes are *not yet* part of our world or only as prospects. Similarly, the world of a prototype – of an artefact that supposedly heralds a future world – is not a mere extension or projection of our present world. Nor does it signify a latent world which only awaits to be realized. By claiming a way of being and doing things, these prototypes signify an alternative world which stands in an uneasy, as yet unresolved relation to our present world as we know it. How the present connects to the world of the archaeological artefacts is a question of hermeneutics, of telling a story which does not represent „the past" but constructs this pathway and connection and thus implicates ourselves – we change and become someone different in the telling of this story. And how our present world connects to the world signified by the prototype is also a question of hermeneutics, of telling a story which does not represent the future but claims a prospect – not a possible future world but a model for reenactment, a world for the making (Nordmann, 2025). If the prototype is a model for enacting in the real world what so far is only a construct or concept, this invitation and prospect implicates us. We change and become someone else by accepting or declining the invitation, though who or what we might become lies far beyond the design ambitions that produced the prototype.

We have so far assumed, fairly unproblematically, that technical works are like works of art, but also assumed, more problematically, that a work is a world and that, categorically, it is like our world at large, only smaller. This calls for a reflection on the work as a world – a world that we enter, within which we need to find our way or seek orientation, and a world of happenings or goings-on, a working order of things in which we participate physically and intellectually. And if there are many such worlds as well as the world at large, what do we learn about being in the world, what do we learn about what a world is? How do we know a machine when we intellectually or haptically participate in the working order of a machine?

These questions are central to current concerns about digital technologies and AI (Bylieva, 2023a, 2023b). Entering into, participating in, finding ourselves in the midst of an ambient technological environment – all this figures under the heading of immersion in a digital system that changes the user and the technology. This is particulary evident in the mediation of „virtual" and „real" worlds, and the materially composed worlds of software and hardware. These worlds construct images of reality, for instance regarding the phenomenology of time. How long do pregnancies last in real and game times, how long until the bar on the computer display reaches across, indicating that a task is completed?

The hermeneutics of technology in this case can clearly show what different hermeneutic processes look and feel like. These differences leave traces, with diverging paths dependent on the user experience. From their own cultural and social backgrounds, users fit the technology into the contexts and practices of their life. This process changes the users themselves – habits, ways of thinking, perception of the world, even social

connections. At the same time, modern digital technologies can respond to user interpretations, the act of use and interpretation changes the technology itself in its functional and semantic dimensions. The technology does not remain static: User patterns, unexpected ways of application (“workarounds”), support communities, public discussions, criticism, failure protocols, even deliberate misuse and behaviors that crash the system – all these becomes part of the "text" of the technology, redefining its meaning and impact. Self-learning systems or developers respond to this with updates and adaptations, which keeps modulating the user‘s world of experience..

Technologies can thus be understood in terms of their dynamic dialogue with the user. This also provides an expanded framework for researching and reflecting technologies. Each iteration of the hermeneutic circle renews the relation the elements and their whole, with the whole system refiguring the elements. Often enough this dynamics is not subject to conscious influence, unless the players know how to play the game, and steer in every so slightly to reflect their interests and desire. This form of interpretation of a technical system does not necessarily involve adaptation to it; sometimes, users will repurpose or destroy the “technological text.” Importantly, such rewriting and rethinking of the technologies leaves traces of the "divergent paths" in the digital systems themselves.

Moving to a more general level, the question of works as worlds calls for a separate paper. Beginning with Francis Bacon, it would feature Ludwig Wittgenstein as a central figure, and it might be rounded off with a consideration of Johan Huizinga‘s „magic circle“ that circumscribes a rule-bound world of play.

A brief consideration of Wittgenstein affords a short-cut (Nordmann, 2018, 2022). It reminds us of the difference between (hermeneutics of) science and (hermeneutics of) technology – where science is antithetical to hermeneutics while technological works invite hermeneutics no less than art-works do.

Readers of Wittgenstein’s *Tractatus Logico-Philosopicus* will encounter two conceptions of „world.“ One of these appears famously in the very first sentence of the book, the other is central to the equally famous „mystical“ ending of the book. The first sentences read: „The world is all that is the case“ – „The world is the totality of facts and not of things (Wittgenstein, 1922, remarks 1. and 1.1.). The other conception is distinctly different: „The feeling for the world as a limited whole is the mystical feeling“ (Wittgenstein, 1922, remark 6.45).

The world as the totality of facts is the world of science. There are indenumerable many facts, each of these facts is a contingent state of affairs: The fact exists but could be otherwise, and so the sentences that represent the facts can be true or otherwise. Itemizing and organizing the facts is the same as producing and organizing all true statements about the world. There are clear criteria for the truth of such descriptive statements – and no hermeneutics is required for thus producing a description of what is true in the world that is all that is the case.

But then, one can also contemplate and have a feeling for the world as a limited whole. In contrast to the scientific outlook on the world, to have a feeling for that whole is the mystical feeling. It is tempting to see this as a statement about religious transcendence. Beholding the whole of our world aesthetically, from a contemplative

distance and as God would, one is struck by a mystical feeling of wonder and admiration. But the reader of Wittgenstein's notes can quickly spot Wittgenstein, the engineer. He wonders whether it is silly to contemplate the stove in his room, and rejoins that it is not silly at all because while he contemplates the stove, the stove is his world, after all (Wittgenstein, 1961, entry dated 8.10.16). More importantly regarding the faultline between the worlds and between science and technology, Wittgenstein notes just before the remark on the stove: „As things among things, all things are equally insignificant, as world they are all equally significant" (Wittgenstein, 1961, entry dated 8.10.16). It is isolated things and the facts about the things that, due to their contingency and their truth-conditions, render all statements „*gleichwertig*," that is, of equal value and thereby insignificant (see Wittgenstein, 1922, remark 6.4). Things assume value only when they contribute to a working order, to a whole, or to a world – and to be sure, for a mere thing to be valuable, it becomes mystical.

In a working order, things form a world in which each has value and each is significant: „It can't be that there is an ordered world and then also an unordered world, which would allow us to say that our world is orderly. Instead there is in every possible world some, perhaps complicated order" (Wittgenstein, 1961, entry dated 19.9.1916). To have a feeling for the world is to have a feeling for how things work in this more or less complicated order. For the biologist Barbara McClintock this was described as a „feeling for the organism" (Keller, 1984). but many tinkerers and engineers have a „feeling for the mechanism." To understand a theory or system of equations one needs a feeling for the algorithm, a feeling for model dynamics, parameter dependencies etc. This feeling is mystical because it cannot be reduced to mere descriptions of one fact at a time. It requires participation in the workings of a thing. Any magical worldview relies on participation which is not identification or becoming one with a system or thing, but involvement in a hermeneutic process that negotiates externalities through feedback, through settlement on a way of doing things. By being subject and object, agent and patient we run up against the limits of our world, including the artworks as worlds that look back at us, including the technical works as worlds that demand from us sometimes more than we demand from them.

HERMENEUTIC DIMENSIONS OF SCIENCE

Despite hermeneutic approaches in the historiography, reflection, and reconstruction of science, and despite hermeneutical moments which are often signs of crisis, science remains antithetical to hermeneutics while technological works invite hermeneutics no less than artworks do. The papers in this special issue struggle with and against this „original antagonism" of science, while others offer perspectives for a hermeneutics of technical works.

Considering science as a project through which humanity expresses itself, Ilya Kasavin (2025) proposes a revision of the role of taxonomy in biology. He treats taxonomy as a hermeneutic practice, producing a fiction that affords intellibility. To demonstrate that the human dimension of sense-making is inseparable from scientific

objectivity, an example of “interpretive flexibility” is given in the history of the division of the rodent (Rodentia) and lagomorph (Lagomorpha) orders.

Walker Trimble (2025) defends the role of metaphors in science, even where they might be replaced by more concrete expressions. A study of metaphors for cooperation in biology shows that these provisional expressions illuminate only seemingly distant relations.

Criticizing the idea of an original antagonism between hermeneutics and the interpretation of scientific texts, Anna Sakharova (2025) shows that interpretation is an integral part of the construction of theories. As prime examples she considers opposing theories in various fields of science. Sakharova argues that hermeneutics reveals the “second layer” of the text – the values, traditions, implicit rules that constitute science as a social institution.

Alexandra Argamakova (2025) considers hermeneutic practices as integral to scientific activity. Scientific models show scientists how to “understand” data in light of theory, acting as hermeneutic agents of interpretation. Pluralistic views on theory formation give rise to alternative conceptual frameworks. Various classifications (galaxies or biological species) depend on the pragmatic goals of scientists. All this warrants the application of hermeneutic methods in science.

Generally agreeing that there is no place for hermeneutics in science, Alexander Antonovskiy (2025) goes on to show which aspects of science leave room for it. In particular, he notes “hidden worlds” associated with unobservable entities, the aesthetic aspect, the presence of a specific language of the scientist, as well as a personal history of victories and disappointments.

Alina Kostina (2025) reveals the hidden dimension of power through the hermeneutics of science. She shows how scientific institutions use hermeneutics as an instrument of metapolitical control, preserving the myth of the neutrality and autonomy of science. Kostina argues that the hermeneutics of science provokes resistance because it exposes technocratic hierarchies.

The paper by Konstantin Frolov (2025) introduces a distinction between “soft” and “hard” hermeneutics, where the latter is associated with self-reflection. Frolov focuses on the role of the personal dimension in scientific knowledge and shows that interpretation implicates the knowing subjects and thus the researchers themselves.

HERMENEUTIC DIMENSIONS OF TECHNOLOGY

Marking the transition to the second group of papers, Evgeniy Maslanov (2025) offers a practice-oriented approach to the hermeneutics of science and technology. The author focuses on the micro level of scientific activity – the training of scientists, interdisciplinary collaboration, and work with technologies – demonstrating that hermeneutics is integrated with routine research practice. Hermeneutics is required for the interpretation of research methods, especially where these involve tacit knowledge, technological routines, or expermental procedures.

Yingyu Zhu (2025) offers a general argument for the hermeneutics of technology by demonstrating the priority of technological understanding. After discussing the

distinction between scientific explanation and scientific understanding, she considers how technological understanding exceeds technological explanation.

Adopting a phenomenological-hermeneutic approach, Viet Anh Nguyen Duc (2025) focuses on the symbolic dimension of technical artifacts and how it is experienced. The symbolic dimension may be concealed, remain in the background, conceal itself, or provoke reflection.

Liana Tukhvatulina (2025) suggests using the hermeneutics of technology for legal forecasting and for working through legal uncertainties. The article shows that conflicting "images of the future" collide within the framework of legislation devoted to new technologies

Finally, seeking to explore the novelty of a hermeneutics of technology, Olga Stoliarova (2025) engages in a dialogue with AI. Asking for novel concepts, she receives answers that appear thoughtful and original at first sight but prove to merely summarize familiar approaches. She does not hold this against the AI system, however, since it exemplifies the familiar predicament that innovation is a reprocessing of what is already available. Such reprocessing and the AI system can still engage us in ways of questioning and reconstituting ourselves.

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