Aura Heydenreich and Klaus Mecke

Introduction

“Where are the scientists in Literature and Science?” This question was posed by Jay Labinger in the 2017 issue of the *Journal of Literature and Science* (Labinger 2017). Labinger’s question implies that for a scientific culture that is aware of its social responsibility and wants to focus on scientific and cultural innovations as well as on their social effects, epistemic implications and dangers, a genuine dialogue between science and humanities scholars is crucial and indispensable. Challenging the old topos of the “Two Cultures” this volume pursues the goal of establishing an epistemic discourse community to realize the productive potential of addressing shared problems in science and literature and to reflect on the intercourse between ways of knowledge production in an interdisciplinary way. This volume presents the proceedings of the inaugural conference of ELINAS, the *Erlangen Center for Literature and Natural Science*. With ELINAS Friedrich-Alexander-University of Erlangen-Nuremberg (FAU) hosts a research center based on established cooperation between science (physics, mathematics, medicine) and literary studies (German, English, American and Romance languages and literatures). Within ELINAS the natural sciences and the humanities bring their methodological and epistemological foundations into a constructive and balanced interdisciplinary dialogue. This unifying approach takes into account the interweaving of functionally differentiated discourses and the specific perspectives of literary and scientific methods of inquiry. The investigation of scientific concept formation requires competencies in philosophy of science and linguistics, while the analysis of the transformation and literarization of scientific knowledge requires both the expertise of literary studies and natural sciences. The ELINAS series of publications including this volume provides a platform for this goal: to develop the field of research historically and systematically by bundling together literary, cultural and scientific competences.

This volume examines concepts, categories, and principles in their respective interaction between physics and literature. Historical processes of knowledge transfer and synergy effects between the disciplines are in focus as well as the different linguistic strategies for modeling knowledge in physics and literature. Central questions concern processes of concept formation and concept transfer, epistemological premises, techniques of aestheticization of scientific knowledge in literary texts, as well as the question of how scientific knowledge is framed narratively and metaphorically. By aesthetically shaping the intellectual signatures of its time, literature functions as an interdiscourse that ties

different areas of knowledge back to life-world horizons. Literature transfers natural science knowledge from mathematical-symbolic forms to complexly coded literary forms by narrating it, dialogizing it, and coupling it back to historical and cultural horizons. In this way, even implicit assumptions of scientific models and their consequences for different world views can be questioned epistemologically.

For its part, natural science is increasingly reflecting on the linguistic constitution and the overall cultural dimensions of its research: On the one hand, physics asks about the knowledge-guiding power of metaphors (“field,” “quarks,” “uncertainty”) and the communicative, political and cultural conditions that determine the goals, priorities and ethical limits of research. On the other hand, physical terms and concepts have been transferred into the theoretical context of literary studies (“literary field,” “space-time” / “chronotopos”). Areas of overlap between scientific and literary-cultural practice are a field of research of great relevance. However, the necessary joint interdisciplinary work of two highly specialized expert discourses is still missing on a wide scale.

The present volume examines the reciprocal transfer of knowledge between literature, natural science and literary studies, and the forms of their respective modes of world modeling from both perspectives: that of literary scholars and that of natural scientists. The focus lies both on the theoretical and constructive potential of literary images in scientific texts and on the discursive functions of scientific models and theories in literary texts. A central task before any inherent work is to reach a reciprocal understanding about different truth claims and acceptable arguments for justification based on mutual respect between both communities (Habermas 1981). Only the establishment and habitualization of a shared discourse zone (Galison 1997) makes the interdisciplinary field of literature and natural sciences possible, in which joint research can be conducted, and where semio-ethical perspectives are also considered (Heydenreich 2022).

The increasing relevance of interactions between literature and natural science is attested by a huge number of publications (Beer 1983; Levine 1987; Schatzberg et al. 1987; Cunningham and Jardine 1990; Danneberg and Vollhard 1992; Vogl 1999; Gossin 2002; Vanderbeke 2004; Schmitz-Emans 2008; Klausnitzer 2008; Zehelein 2009; Klinkert 2010; Clarke and Rossini 2011; Breidbach and Burwick 2012; Albrecht 2014; Gamper 2020; Malinowski 2021). The journals *Configurations* (Johns Hopkins University Press 1993) and *Scientia Poetica* (De Gruyter 1997) as well as the annual conferences of the *Society for Literature, Science and the Arts* in the U. S. and Europe continuously demonstrated the relevance of this research topic. Nicholas Pethes (2003), Dirk Vanderbeke (2004) and Olav Krämer (2011) provide reviews of the situation. *The Routledge Companion to Literature and Science* (2011), edited by Bruce Clarke and Manuela Rossini,

the *Metzler Handbook of Literature and Knowledge* (2013), edited by Roland Borgards, Harald Neumeyer, Nicholas Pethes and Yvonne Wübben, as well as *The Cambridge Companion to Literature and Science* (2018), edited by Stephen Meyer, offer overviews of theoretical and historical approaches to this research field.

While intentionalist approaches were initially established (Richter 1972; Richter et al. 1997), a correlationist approach was then adopted (Novak 1980; Hayles 1984; Scholnick 1992; Maillard and Titzmann 2002). The cultural studies have favored discourse-analytical approaches based on circulation models (Borgards et al. 2013). Other approaches focused on historical epistemology (Gess and Janßen 2014) or on the practical turn of science and technology studies (Albrecht 2015). Although the importance of physics as a context (Metzner 1979) for literary texts has been recognized (Strehle 1992; Emter 1995; Freese 1997; Clarke 2001; Dilmac 2012; Özelt 2018) and examined from a cultural studies perspective (Gamper 2009; Specht 2010), the questions have not been formulated in dialogue with experts from the fields of physics. And on the physicists' side no systematic research approach to the topic exists to date. In addition to the media-specific epistemological achievements of literary textuality, the proceedings address the aesthetic modeling of scientific knowledge in scientific and literary texts. The volume reunites contributions from the fields of humanities and of natural sciences.

The great challenge of the *Literature and Science* community and in particular of the research center ELINAS is to institutionalize a constructive dialogue between highly specialized disciplines, based on different scientific languages and theoretical foundations. This volume thus counteracts increasing specialization by bridging the gaps between the scientific cultures, and practicing the ability to understand other scientific languages and to learn from one another. In order to build such an interdisciplinary discourse zone, one needs to tie in different approaches that meet the epistemic interests of both literary and natural sciences in different ways: Concept formation and concept transfer theories (Bal 2002; Nersessian 2008; Carey 2011; Vosniadou 2013), philosophy of science (Hacking 1999, 2008; Van Fraassen 1980, 2013; Frigg 2008; Suarez 2009), discourse and interdiscourse analysis (Fohrmann and Müller 1988; Link 1988, 2004, 2005; Keller et al. 2005; Hock and Mackenthun 2012), sociology of knowledge (Latour and Woolgar 1979; Latour 1987; Burke 2012; Nordheim and Antoni 2013), the material/practical turn (Bennett 2010; Albrecht 2015), Science and Technology Studies (Hayles 1984; Jasanoff 2005; Daston and Galison 2007; Daston and Lunbeck 2011), Literature and Science Studies (Levine 1987; Schatzberg et al. 1987; Levine 1993), and Rhetoric of Science (Gross 1990; Fahnestock 1999).

With its focus on (1) the epistemological achievements of literary textuality, (2) the textuality of scientific knowledge production, and (3) the exchange

movements and interferences between knowledge cultures (Heydenreich and Mecke 2015a, 2015b, 2015c, 2015d), the volume goes beyond the conventional approaches of the rhetoric of science, and the theory and history of science, to which it simultaneously remains related. Although the history of science already operates with metaphor-theoretical (Haraway 1976; Brandt 2004; Danneberg 2009) or linguistic approaches (Drewer 2003), extensive interdisciplinary research is still needed for an analysis of the linguistic, narrative and, in the broadest sense, aesthetic practices of scientific concept formation and knowledge production.

The volume presents both theoretical-systematic and historical contributions. A common focus is on the conceptualization, categorization and modeling of knowledge in specific disciplinary contexts, on the one hand, and on the conditions and possibilities of interdisciplinary knowledge transfer on the other. Concepts are considered to be dynamic-operative figures of thought, as intellectual tools (Neumann et al. 2012) and operative terms (Welsch 1997), which characterize the knowledge production practice of an epistemic community (Rheinberger 2001) and synthesize central problem complexes. Concepts are thus operationalized not only descriptively but also performatively and programmatically (Bal 2002), thus enabling the structuring of research discourses. To the extent that these concepts cross the boundaries between disciplines and are discourse-specifically adopted and transformed by different epistemic communities, they configure a semantically enriched interdisciplinary sphere of discourse or dissent (Hacking 1999; Heydenreich and Mecke 2015c). In this way, they enable an exchange between different epistemic communities on a meta-level, so that similarities and differences in practices of problem formulation and knowledge generation of different epistemic communities can be discussed.

The contributions in this volume take into account concept formation theories from the philosophy of science (Lenk 2004; Nersessian 2008), history of science (Kuhn 1970; Thagard 1993; Rheinberger 2008), and linguistics (Thielmann 1999, 2008). The cultural-analytical concept-transfer theories of Mieke Bal (2002) and Neumann, Nünning and Horn (2012) are also considered to be important. The analyses focus on five dimensions of interdisciplinary concept transfer:

- The analysis of the specific practices of conceptualization (basic principles, methodological norms, experimental methods) in epistemic communities, i. e. the reconstruction of the epistemological configuration, the matrix (Kuhn 1982; Hacking 1999) or the interdisciplinary discourse zone (trading zone, Galison 1997), in which the concepts arise (cf. papers of Labinger, Heydenreich, Thielmann, Plotnitsky, and Murphy in this volume).

- The analysis of the specific practices of codification of concepts, i. e. how meaningful signs are created in the process of conceptualization and how these signs are manifested in their specific materiality (text, graphics, mathematical notation, etc.) with their syntactic, semantic and pragmatic dimensions (cf. papers of Malinowski, Vignale, Labinger, and Heydenreich in this volume).
- The analysis of the functions ascribed to the concepts within the framework of the theory or of the literary text, i. e. theory-constructive, model-constitutive, categorizing, explanatory, explorative or narrative-strategical functions (cf. papers of Kompa, Bergengruen, Malinowski, Vanderbeke, and Kasper in this volume).
- The analysis of the concept's co-evolutionary or transformational dynamics in the formation and (re-)organization of different interdisciplinary research fields and for the development of further theoretical perspectives (cf. papers of Plotnitsky, Mairhofer, Mühr, and Özelt in this volume).
- The analysis of the commensurability or incommensurability (Kuhn 1982; Hacking 1999) of transferred concepts, which have been developed within the framework of different disciplines or historical, intellectual, or contextual (Chakrabarty 2008) traditions of knowledge production, literarization and aestheticization (cf. papers of Vanderbeke, Gencarelli, McGovern, and Kasper in this volume).

The volume provides analyses of concepts that are at the center of a particular scientific paradigm, where their introduction has led to theoretical innovations, such as Faraday's concept of 'induction' in Balzac's novels (cf. Murphy in this volume), the concept of 'indeterminacy' in Heisenberg and Musil texts (cf. Plotnitsky in this volume), the concept of "interference" in physics and in Brecht's theatrical poetics (cf. Mairhofer in this volume), the physical concept of possible worlds (cf. Vanderbeke in this volume) in cosmology and quantum theory compared to the transformation of the concept in the science fiction genre.

A particular practical benefit of the analysis of scientific conceptualizations lies in a close reading of scientific language that explores adequate ways of communicating abstract concepts. Desiderata in the natural sciences are science communication and ethics. It is also important for future research that scientists learn more about the general semantic flexibility of scientific terms and mathematical models. The interpretation of abstract quantities and mathematical objects is important not only in quantum theory, but also plays a crucial role for the development of basic concepts in all areas of physics. Linguistic and literary analysis can help to discover the richness of meaning of scientific terms beyond their usual, often quite formal definitions.

Physical knowledge is tied to language. Although applied mathematics is a formal tool and experiments are performed through practical methods, the formulation of ideas and concepts requires language as well as publications and communication with colleagues and the public. Scientific writing is characterized by standards that are imparted in the educational process (Gross 1990, 2002). Some of these norms will be examined from a historical linguistic (cf. Thielmann in this volume) as well as from narratological (cf. Heydenreich in this volume) and metaphorological perspectives (cf. Kompa in this volume). As early as the seventeenth century, a clear, reduced style was demanded so that the universal validity of empirical results would not be compromised by subjective narrative styles. Nevertheless, dramatic historical changes in writing styles can be observed: While in the early modern period there were still aesthetically shaped texts (e.g. Kepler, *Somnium* 1609) and Galileo still used the form of a dialogue that weighs pros and cons (*Dialogo* 1632, *Discorsi* 1638) (cf. Özelt in this volume), today, in the journal *Physical Review Letters* the expert article has become strictly reduced to four pages of formalized argumentation. In this thematic focus, the typical character of the scientific language will be examined in accordance with Winfried Thielmann's study on the technical language of physics as a conceptual instrument (Thielmann 1999). In addition to technical scientific language, it is important for the cultural dissemination of knowledge to take into account the popular language and textbook language of physics: Driven by the interest in appropriately presenting to the public not only its results but also the genesis of research processes, and in addition to present a coherent order of a research area in flux, a separate interest-driven specialist text genre emerged which, as a second-order reflection process, made use of other, often rhetorical, means than the (reducing) specialist article. While easily understandable publications remain marginal in the specialist discipline, they often represent a central source for literary and cultural studies dealing with scientific topics in the general public (Leane 2007; Gwozdz 2016). Despite the important function that these publications have for the dissemination of physical knowledge to the public, there are neither overview studies of the historical development of this genre, nor systematic discussions of the methods of representing physical knowledge or of the specific media-related strategies of communicating scientific knowledge that are used in these types of text. A desideratum is to examine based on a rhetoric of science (Bazerman 2000; Prelli 1989), which tropes, genre patterns and narratives are used to describe the research process in its cultural context, and which writing strategies are used to help theories to achieve broad resonance and social or scientific-political relevance.

The volume has three sections focusing on (i) the epistemic functions of narration and metaphor in science, (ii) the transfer of concepts between physics and philosophy of physics to literature and history of ideas, and (iii) the aestheticization and literarization of physics.

Nikola Kompa's paper "Insight by Metaphor – the Epistemic Role of Metaphor in Science" takes as a starting point conceptual metaphor theory and investigates the epistemic functions of metaphors as modes of thought. The question arises, why do some metaphors seem to be more successful than others for epistemic pursuits? Kompa proposes criteria for scientifically successful metaphors and claims that metaphors have heuristic, exploratory or explanatory values in scientific discourse. Epistemic metaphor search is purpose-driven: Kompa reviews Ludwig Fleck's theory of thought style and shows how metaphors can acquire heuristic functions by inducing processes of pattern recognition or by leading to inference drawing processes and guiding research. With reference to Evelyn Fox Keller's investigations, Kompa highlights the exploratory functions of metaphor and she examines Darwin's theory of evolution to discuss the explanatory function of metaphors. Kompa underlines that the understanding of how metaphors operate in scientific discourse depends on epistemic positions and on metaphysical background theories.

Aura Heydenreich's chapters aim at illuminating the epistemic value of narrativity in Einstein's theory of relativity. The paper reconstructs both Einstein's scientific modeling process and its narrative strategies for the development of the theory of special relativity. Besides considering the argumentative and descriptive discourse levels, the paper scrutinizes the epistemic functions of narrative strategies and thereby discusses key issues of a here proposed narratology of science. Which would be basic categories of science narratology? How can concepts be transferred from the classic narratology to the narratology of science in order to explore the epistemic functions of narrativity in science? What is the epistemic function of the writing/telling instance as a narrator, as a principle of form-organization in a scientific treatise? Can one elaborate on techniques of internal and external focalization not only in literary texts, but also in Einstein's thought experiments, which are employed as narrative strategies for the demonstration of the relativity of simultaneity? How can one (re-)define concepts of post-classical narratology like eventfulness, experientiality and tellability when addressing scientific discourses? Heydenreich's second chapter focuses on Einstein's same treatise on the theory of special relativity from a different perspective: it aims at analyzing the semiological foundations of the here proposed process of interformation. The paper thus correlates Einstein's fundamental treatise on the special relativity theory with his metatheoretical paper "Physics and Reality."

Giovanni Vignale states, as a physicist, that it is not in the power of physical science to explain reality “as it is,” or as it is “empirically perceptible.” Vignale shows that it lies in the tradition of physical investigation to discard a great deal of observable information that is not considered to be relevant in order to grasp the essential picture. Physical sciences can make reality understandable, sometimes predictable, through modeling practices and empirically adequate narratives. Vignale proposes the thesis that physics is a kind of mythopoesis by elaborating on a provocative assertion: Although truth and fiction are generally supposed to be mutually exclusive, Vignale states that the binary opposition between truth and fiction is itself fictitious. Vignale draws here on the epistemology of myth as a cultural practice of shaping and understanding the world. He also shows that the principles of mythopoesis are not unrestrained. On the contrary, both discourses have to respect strong internal constraints, as for example the constraints of mathematical language in physics or those of aesthetic composition, symmetry and consistency in literature.

The next section of the book focuses on problems of concept formation in physics and the search for an adequate scientific terminology from the perspective of linguistics and physical chemistry.

Winfried Thielmann’s paper “Concept Formation in Physics from a Linguist’s Perspective” investigates the asymmetries between theoretical innovation and the lack of a correlative lexical innovation in theoretical processes of concept formation in physics. The focus lies on the concepts of the “body” of “speed” and “force.” Thielmann analyses the successive transformations to which these concepts were subjected in the physics of Galileo and Newton and how they shaped the later development of modern physics. The starting point for Thielmann’s considerations is Konrad Ehlich’s model of the gnoseological function of language to represent and communicate knowledge (Ehlich 2007). Thielmann shows exemplarily that there is a large discrepancy between the empirical everyday understanding of the word and the way in which the concept of “force” was mathematically formalized and physically conceptualized. Galileo was the first to propose a form of concept formation based on “idealization” or “abstraction” that allowed deductive conclusions in which one no longer needed to take into account the diversity of individual empirical phenomena. As a result, the differences between natural objects and human artifacts were eliminated for experimental purposes. The abstract concept of the “physical body” symbolizes the extinction of this difference. The result is that artefacts are now used as operational concepts to describe laws of nature. The problem Thielmann points out is that this conceptual development was not accompanied by a terminological language innovation in physics. Although the concept of the body is used in physics as an operational concept, it still connotes

much of everyday semantics. In Thielmann's view, this suggests proximity to reality, vividness. Newton built on this concept of the body as an artefact and formed "operational concepts of the second degree," "mass" and "force." However, this decisive conceptual shift, which is not reflected linguistically and terminologically, leads to the fact that in modern physics purely operational concepts are ontologized in an unjustified way. A famous example of this is the controversy surrounding wave-particle dualism.

As a chemist, Jay Labinger examines in his essay the question of the impact of his engagement with literature on his scientific thinking and his work in the natural sciences. Or – to put it another way – what is the significance of language in scientific practice? Labinger's thesis is that scientific language, too, is characterized by the use of metaphor, and semantic ambiguities. The task of natural scientists would not be to purge language of this – in the sense of Francis Bacon or the ideal of the Royal Society –, but rather to consciously handle it virtuosically. Labinger deals with this issue in an exemplary case study on the problem of representation in scientific discourse. Using the example of molecular orbitals in chemistry and physics, Labinger refers to the controversy about the adequacy of representation, whereby formal-mathematical, linguistic, and graphic-visual media are available as modeling options: on the one hand the representation of the valence bond, on the other the representation of the molecular orbital. None of these visual representations are perfect reproductions of all the subtleties of the mathematical formalism. They set different accents in representation depending on which aspects of mathematical formalism need to be emphasized: reactivity or the possibility of localizing or specifying electron density. Labinger compares this process of transfer, in which mathematical precision must be dispensed with in favor of concise visual representation, with the process of literary translation. Labinger shows that the question of adequacy must by no means be answered dogmatically, but depends to a large extent on the context, target and addressee. The awareness of the semantic flexibility of scientific language is extremely important – according to Labinger – for adequate contextualization in the mediation of knowledge content.

The next section of the book deals with transfers of concepts between physics and philosophy of physics to literature and the history of ideas. Kieran Murphy's essay "Induction after Electromagnetism: Faraday, Einstein, Bachelard, and Balzac" is dedicated to Faraday's concept of electromagnetic induction and shows how this concept has shaped not only Einstein's scientific theories, but also literary and philosophical discourses, such as the works of Honoré de Balzac, Edgar Allan Poe and Gaston Bachelard. Against the background of Friedrich Steinle's studies on the history of physics, Murphy points out that Faraday's method for discovering electromagnetic induction was that of exploratory

experimentation. Faraday did not use the experiments to verify already conceived theories, but rather employed open-ended epistemic experimental methods and used their results to re-conceptualize existing theories. Finally, Murphy deals with Faraday's induction as an illustration of what Gaston Bachelard described in his historical epistemology as an "epistemological break." For Bachelard, Faraday's theory was one of the prime examples of the demonstration of radical breaks or discontinuities in the development of scientific theories based on "dynamic intuitions" or "cognitive induction."

Arkady Plotnitsky investigates the revisions of the concepts of causality, probability and complementarity in the light of the new epistemological problems posed by quantum theory. Plotnitsky also explores the transformations that these concepts have undergone as a response to Kant's philosophy in the nineteenth century in texts by Friedrich Hölderlin, Heinrich von Kleist and Percy Bysshe Shelley. The question arises, of how these conceptual revisions can possibly be paralleled. One starting point that would be worth considering is that Hume's and Kant's philosophies are part of the epistemic genealogy of both Romantic thinking and the philosophical Copenhagen interpretation of quantum mechanics. Plotnitsky regards Robert Musil's *Man Without Qualities* as the literary field that negotiates these controversial epistemic positions.

Stephan Mühr's paper "The Horizon of the Horizon: On the Physical History of Gadamer's Fusion of Horizons" claims that Gadamer's conception of '*Horizontverschmelzung*' relies on a longstanding tradition of travelling optical concepts between disciplines, that have been successively adopted and readapted as figures of thought across disciplinary boundaries. Mühr traces the transformation history of these optical figures at the interface between physics and hermeneutics from Galileo to Chladenius ("skopos," "point of view," "vantage point") and to Gadamer ("horizon"). Mühr states that in the seventeenth and eighteenth centuries the new emerging paradigm of empirical sciences that is correlated with the development of new optical technologies also involves a reevaluation of the abilities of human senses and the capability of language to describe the new world revealed through optical technologies. Citing Hans Blumenberg, Mühr states that the correspondences between the new reality revealed through the telescope and the Copernican reconceptualization of the cosmological view of the world was not only a matter of empirical observation. As shown in the special case of Galileo Galilei's *Sidereus nuncius*, in order to establish *evidentia* highly abstract processes of thought were required that had to be equated with persuasive rhetorical demonstrations. In the course of these argumentations, visual and optical concepts acquired epistemic connotations and were slowly transformed – through blending processes – into figures of thought.

Lukas Mairhofer proposes the concept of “Interference as a Methodological Metaphor” for the description of interrelations of different fields of knowledge in interdisciplinary interactions. Mairhofer first gives an overview of the experimental phenomenon of interference in the processes of quantum measurement and contextualizes these historically by relating them to the philosophical discussions between Heisenberg, Bohr and Einstein on the ontological and epistemological implications of these measurements. Heisenberg, Bohr and Einstein often used thought-experiments to expound their arguments. Mairhofer argues that Bertolt Brecht uses thought experiments relying on quantum theoretical concepts and functionalizes these for the aesthetics of epic theater. Mairhofer also discusses the use of the concept of interference in Science and Technology Studies by Karen Barad, and possible parallels between the new proposed concept of interference and Fauconnier’s and Turner’s blending theory.

The third book section focuses the processes of aestheticization and literarization of physical theories, models and concepts. Bernadette Malinowski’s study on “Literary Epistemology: Daniele Del Giudice’s Novel *Atlante occidentale*” follows Lyotard’s proposal to see contemporary science as an enterprise that requires the imperceptible reliance on scientific technologies. But then new questions arise at the nexus between the scientific representation of knowledge and the epistemological conceptualization of reality. The core question here concerns the empirical adequacy of the scientifically created image. Problems arise, as stated and reflected in Del Giudice’s *Atlante occidentale*, on the possibilities of perception, on adequate representations and on interpretations of scientific objects investigated at CERN. Malinowski’s study investigates the epistemological functions of literature by showing an intertwining between two experiments performed by the two protagonists of the novel, which can be read as physical and poetological experiments. The novel reflects on the technological premises and aesthetic practices that mediate the generation of scientific images. Read as such, the novel reveals and negotiates the boundaries and the interconnections between scientific investigations and aesthetic experiences. Malinowski’s study examines the levels of both the narrative discourse as well as the action and analyzes the epistemological functions of literature.

Angela Gencarelli’s study “The ‘Poetic Element’ of Science: Particle Physics and the Fantastic in Irtraud Morgner’s Novella *The Rope*” discusses the montage techniques of Morgner’s novella, which functionalizes particle physics discourse excerpts and mingles them up with literary textual materials in a blending procedure that creates an intertwined aesthetics of the phantastic prose. Morgner’s novella undermines Tzvetan Todorov’s conception of the fantastic as a narrative structure by incorporating citations of scientific texts. At the same time, it engages with the problems of perceptibility, representation

and interpretation of scientific results that arise in the experimental practices of particle physics due to the fact that particles as such are hardly identifiable by the human eye, except by their tracks in bubble chambers. Gencarelli's investigation focuses on the reconceptualization of the fantastic in the novella, as an imaginary modeling practice for the exploration and investigation of reality. As such the real and the imaginary are not dichotomously isolated from one another but rather engage with one another; they become the interconnected poles of a tense relation of mutual interrogations.

Dirk Vanderbeke's paper critically investigates the techniques of literarization of quantum physics concepts in various discourse types: literary fantasy by J. R. R. Tolkien, so-called quantum fiction by Vana Bonta, Terry Pratchett and Ian Stewart, and didactic and popularizing texts, which rely on fantastic literary techniques to explain physics, such as George Gamov's *The Adventures of Mr Tompkins*. Vanderbeke investigates the imaginative techniques employed for the textual construction of counterintuitive worlds, which may adopt the vocabulary of quantum physics but mostly use it metaphorically. Their function seems to be to suggest incomprehensibility in order to avoid other plausible explanations for the narrative construction of possible worlds. More than that, they often rely on rather sophisticated technologies, but simple mechanisms that do not require quantum physics. In these cases, the texts do not engage with the theoretical, operative concepts of physics and do not exploit their epistemological potential. Vanderbeke contrasts these techniques of narrativization with those in Tom Stoppard's *Arcadia*, Thomas Pynchon's *Gravity's Rainbow* and Umberto Eco's *The Island of the Day Before* and shows how physics concepts can be employed either to create unidirectional closed narratives or, on the other hand, open literary texts with divergent interpretations. Here quantum phenomena are not employed as explanatory models that close the possible modes of interpretation, but rather for their potential for open exploratory questing.

Maximilian Bergengruen's contribution is devoted to the dialogical form of the dramatic genre and here the reference to physics is made on a completely different level. Bergengruen is interested in the contribution of physics as a technique in the context of the practice of baroque theater performances. This is analysed by means of two dramas by Gryphius: *Catharina of Georgia* (1657) and *Carolus Stuardus* (1663). Gryphius' era predates the differentiation of scientific disciplines, so that physico-theological and natural-philosophical contexts play an important role. Bergengruen offers a comparative analysis of how the figure of thought of "the imitation of Christ" is textually configured in the two dramas. At this point, the performative theatrical practice of the time is confronted with a dilemma: Although ghosts and ghost appearances are allowed in drama and

staging techniques, they are theologically forbidden. Bergengruen proceeds on the basis of the technical staging instructions given by Gryphius, whereby the appearance of ghosts and visions is legitimized in performance practice. The technical-theatrical implementation of the *deus ex machina* machinery reinterprets Gryphius' ghostly phenomena: they are no longer demonic ghosts (Luther), but divine spirits. In this respect, Bergengruen works on the drama of the baroque era with an interesting connection between the mediation of metaphysical ideas and their theatrical representation through the most sophisticated stage technology of the time. These are supported by optical instruments and baroque illusion techniques, which the theater uses widely. An epoch's theatrical staging of metaphysical ideas thus goes hand in hand with its experimental practices of optics and mechanics, Bergengruen concludes.

Clemens Özelt's analysis offers an interesting insight into the epistemic function of the genre of philosophical dialogue in science in its sociohistorical context. Within the culture of the Weimar Republic, the philosophical dialogue played an important discourse-integrative function between politics, literature and physics. Özelt investigates the historicity of the aesthetic, philosophic and scientific debates of the Weimar Republic and their cultural practices. Their forms of argumentation often resort to the scholarly dialogues of the Renaissance, namely Galileo Galilei's *Dialogue Concerning the Two Chief World Systems, Ptolemaic and Copernican* (1632), as a paradigmatic example of the genre. Since its constitutive characteristic is a change of perspective, which can convey an experience of evidence, it is suited in an exemplary way to the cultural mediation of new worldviews. Inspired by this, Einstein also formulates the controversy with the so-called critics of the general theory of relativity according to the Galilean model in his *Dialogue about Objections to the Theory of Relativity* (1918). Özelt focuses on the transfer of these discursive forms and their epistemic functions in Brecht's conception of the theater of the scientific age and in Döblin's novel cycle *Amazonas*, and discusses the aesthetic, ethical and socio-political implications associated with it.

Lutz Kasper reflects on another aspect of the interrelations between physics and literature: science education. Can narrative forms and techniques provide access to the process of physics research and enquiry? Can they enhance the process of reflection on the cultural significance of natural sciences? What about reflection on the epistemic role of language and metaphors in the process of research or in teaching and learning science? What about the semantic reinterpretation of concepts due to different historical contexts? What about reflections on the historical contexts of the development of models and theories, or on different, competing perspectives on the same scientific phenomenon? These goals could be achieved by 'unpacking the stories hidden behind the formal

condensations.’ The goal would be to increase the metaconceptual awareness of students through reflections on real scientific debates. Kasper gives here an historical example of competing answers proposed by Émilie de Châtelet, Voltaire and Euler on the problem of “The Nature of Light, Heat and Fire” posed by the Paris Academy in 1737.

The physicist and poet Ignatius McGovern, takes up the work of William Rowan Hamilton, the Irish mathematician and poet, whose credo was that his mathematical researches on quaternions is an offspring of the interrelations between geometry, algebra, metaphysics and poetry. Quaternions are a number system introduced by Hamilton in order to extend the class of complex numbers. In the twentieth century it was this mathematics that was introduced by Erwin Schrödinger for the Hamilton formulation of wave mechanics in quantum physics. McGovern reflects on this complex genealogy poetically, in his own collection of sonnets *A Mystic Dream of 4*, which is devoted on the one hand to William Rowan Hamilton and his friend William Wordsworth, and on the other hand to number theory. The collection of poems explores for example the value of “4” as a mathematic and aesthetico-poietic principle for the making of sonnets.

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