VIRTUAL ENTITIES IN SCIENCE: A VIRTUAL WORKSHOP

March 5, 12, 19 and 26, 2021
2pm - 6pm CET

Book of Abstracts
Program

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The formation and development of the concept of virtual particles (A1)
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Virtual entities in science: a virtual workshop

March 5,12,19 and 26, 2021

Online

Official website and registration:

https://indico.cern.ch/event/951512/

Organizing committee

Robert Harlander – RWTH Aachen University
Jean-Philippe Martinez – RWTH Aachen University
Friedrich Steinle – Technische Universität Berlin
Adrian Wüthrich – Technische Universität Berlin

Contact: adrian.wuethrich@tu-berlin.de

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Outline

Not only since the sudden increase of online communication due to the COVID-19 situation has the concept of the "virtual" made its way into everyday language. In this context, it mostly denotes a digital substitute of a real object or process. "Virtual reality" is perhaps the best known term in this respect.

With these digital connotations, "virtuality" has been used also in science and research: Chemists use virtual laboratories, biologists do virtual scanning of molecular structures, and geologists engage in virtual field trips.

But the concept of the "virtual" has a much longer tradition, dating back to long before the dawn of the digital age. Virtual displacements and virtual images were introduced in classical physics already in the 18th century. They represented auxiliary objects or processes without instantiation, with the purpose of efficiently describing specific physical systems. Through Heisenberg's use of "potentia" in his late attempts to interpret quantum mechanics, the term "virtual" may even relate back to Aristotle.

In today's physics, the term virtual is mostly associated with the quantum world, first and foremost with the "virtual particle" of quantum field theory. It has become such an integral part of modern high energy physics that its ontological character may be considered to go beyond the purely auxiliary, which is typically associated with the virtual. The various possibilities for a virtual particle to manifest itself in a measurement highlights, furthermore, how "potentiality" continues to be a characteristic feature of virtual entities.

In other disciplines, however, use of the term "virtual" without a digital connotation is much rarer. While concepts like "virtual adrenaline" in medicine and biochemistry arise in the 1940s, and the "virtual moon" figures quite prominently in some (English translations of) Babylonian calendar texts, these examples seem to be rather singular occurrences of entities that were explicitly called "virtual". The basic idea behind the terminology of the virtual, however, could be much more common, even outside of physics. The "invisible hand" in economics, or the "vital force" in biology, for instance, do carry aspects of a virtual entity, even if they have not been called that way.

This workshop features contributions that address the historical formation and philosophical interpretation of concepts of virtual entities in physics and other disciplines – in whatever terms they may come. The main goal of the workshop is to bring to the fore similarities and differences in the meanings and functions of these concepts so as to be able to precisely characterize why certain entities are considered virtual in specific contexts, why a different terminology was often used in each individual case and in what sense the virtual entities relate to the real world.

The contributions deal with the role of these concepts in theoretical as well as experimental activities, and investigate into the origins of the terminology of the virtual as it was applied to the various disciplines of natural science. Many contributions to the workshop integrate philosophical and historical approaches.

Among other things, contributions focus on one of the following aspects which are usually associated with virtual entities, in particular if we think of the virtual particle of modern quantum field theory:

- The terminology of virtuality, including its etymology, and why it was applied to the entities in question: Why not other terms like “substitute” or “auxiliary”?
- The potentiality inherent in virtual entities to bring about certain effects, which may eventually be realized or not: How is this to be understood exactly?
- The ontology of virtual entities: How is it different from real entities, and how do we get epistemic access to virtual entities?

Friday March 5

2:00 – 2:10 pm	**Welcome**
2:10 – 2:30 pm	**Friedrich Steinle**, *General Introduction*
2:30 – 3:10 pm	**Edward Slowik**, *Virtual Presence in the Early Modern Conception of Immaterial Entities*
3:10 – 3:25 pm	**Break**
3:25 – 4:05 pm	**Matthew Gardhouse**, *Robert Grosseteste and Roger Bacon on Virtual States in Medium Propagation*
4:05 – 4:45 pm	**Urko Gorriñobeaskoa**, *Historizing the virtual: a promising methodology and a study of the ether*
4:45 – 5:00 pm	**Break**
5:00 – 6:00 pm	**Keynote**
	Arianna Borrelli, *The eye stays in the picture: The emergence of virtual images in early modern optics*

Friday March 12

2:00 – 2:30 pm	**Poster session 1** Brian Francis Connolly, Giora Hon and Bernard R. Goldstein, Stefano Furlan, Simon Beyne
2:30 – 3:10 pm	**Michael Stoeltzner**, *How possible is the virtual? Lessons from the mechanical tradition*
3:10 – 3:25 pm	**Break**
3:25 – 4:05 pm	**Alexander Blum and Martin Jähnert**, *Substitute Radiators, Virtual Oscillators, and Actual Transitions: Radiation Processes in the Old Quantum Theory and Quantum Mechanics (1913–1927).*
4:05 – 4:45 pm	**Daniel Jon Mitchell**, *"The new conception of the postulates:" Virtual entities and the Bohr-Kramers-Slater reformulation of the (old) quantum theory*
4:45 – 5:00 pm	**Break**
5:00 – 6:00 pm	**Keynote**
	JoAnne Hewett, *Layers of virtuality in particle physics*

Friday March 19

2:00 – 3:00 pm	**Keynote**
	Tarja Knuuttila, *Synthetic biology in between the actual, virtual – and fictional*
3:00 – 3:15 pm	**Break**
3:15 – 3:55 pm	**Mike Buttolph**, *Material and virtual agents of heredity, 1870 to 1930*
3:55 – 4:35 pm	**Sandra Visokolskis and Gonzalo Carrión**, *False Mathematical Entities and Aesthetic Economic Explanations as Virtual Matters*
4:35 – 4:50 pm	**Break**
4:50 – 5:30 pm	**Joseph Wilson**, *The Ghost in the Machine: Emergent Metaphors of 'Virtual' and 'Artificial' in Computer Science in the 1950s*
5:30 – 6:10 pm	**Alexandre Declos**, *What's a virtual entity?*

Friday March 26

2:00 – 2:30 pm	**Poster session 2** Havelok Symes, John Dougherty, Giulia Carini, Genco Guralp
2:30 – 3:10 pm	**Markus Ehberger**, *Getting to know "the language of Dirac's theory of radiation". Narratives and representations of quantum electrodynamics (QED) in the 1930s*
3:10 – 3:25 pm	**Break**
3:25 – 4:05 pm	**Jean-Philippe Martinez**, *Virtuality in nuclear physics (1930s–1940s): the many meanings of an emerging concept*
4:05 – 4:45 pm	**Jean-Marc Lévy-Leblond**, *Have virtual particles any virtue?*
4:45 – 5:00 pm	**Break**
5:00 – 6:00 pm	**General discussion**

Keynote Speakers Abstracts

Arianna Borrelli – March 5, 6:00 pm
JoAnne Hewett – March 12, 6:00 pm
Tarja Knuuttila – March 19, 2:00 pm

Arianna Borrelli – Leuphana University Lüneburg

The eye stays in the picture: The emergence of virtual images in early modern optics

Among the best known virtual entities in physics are the virtual images of geometrical optics. That term describes for example the enlarged image of an object when seen through a magnifying lens. When the same lens is instead used to concentrate sunrays into a point, we speak of a real - and usually quite hot - point-like image of the Sun.

These characterizations appear today as rather straightforward descriptions of natural phenomena whose origin is often traced back to Kepler. In fact, though, they are tied to an abstract view of optics which developed slowly between the Renaissance and the nineteenth century. In order to make explicit the historical and epistemological complexity of the apparently simple notion of virtual image, I will sketch a few steps in its emergence. In doing so, I will underscore the interplay between, on the one hand, the development of the virtual/real image opposition and, on the other, the slow transformation of the methods of diagrammatic image construction which had been used in geometrical optics since ancient times. In particular, I will argue that the eye of the observer initially played a central, explicit role, while since early modern times it slowly became an implicit, yet still necessary element of optical constructions.

JoAnne Hewett – Stanford University

Layers of virtuality in particle physics

TBA

Tarja Knuuttila – Universität Wien

Synthetic biology in between the actual, virtual – and fictional

The notion of virtual as an object of systematic study has yet to arrive in philosophy of science. Fiction, in contrast, has attracted a lot of interest in the recent philosophical discussion of modelling and representation. It has been variously studied in terms of fictional models, fictive elements within models, or non-existent target systems. In this presentation, I will approach fictions as artefactual entities that are dependent on their creators and users, as well as the generative rules and representational modes and material media through which they are produced. Fictions depict/generate entities, systems, or "worlds" that are non-actual. Yet, some of those entities and "worlds" could be actualized, at least partially, as the virtual reality shows.

I will argue that the virtual could fruitfully be distinguished from the fictional in that although intangible, the virtual is able to become actualized while the fictional remains non-actualized or non-actualizable. Such a conceptual division of labour between the notions of fiction and virtual would help us understand one of the most intriguing features of synthetic biology: the modal in-betweenness of synthetic constructs. More often than not, synthetic constructs are only somewhat functional, and so it is not in many cases clear whether they will eventually turn out to be fully actualizable, or are doomed to remain partially actualized and partially fictional. I will use the research on minimal cells and synthetic circuits as examples. Scientific inquiry is often the only way to find out whether, and to what extent, the imagined entities and systems engage in virtual potentialities.

Contributed Talks Abstracts

Alexander Blum and Martin Jähnert – March 12, 3:25 pm
Mike Buttolph – March 19, 3:15 pm
Alexandre Declos – March 19, 5:30 pm
Markus Ehberger – March 26, 2:30 pm
Matthew Gardhouse – March 5, 3:25 pm
Urko Gorriñobeaskoa – March 5, 4:05 pm
Jean-Marc Lévy-Leblond – March 26, 4:05 pm
Jean-Philippe Martinez – March 26, 3:25 pm
Daniel Jon Mitchell – March 12, 4:05 pm
Edward Slowik – March 5, 2:30 pm
Michael Stoeltzner – March 12, 2:30 pm
Sandra Visokolskis and Gonzalo Carrión – March 19, 3:55 pm
Joseph Wilson – March 19, 4:50 pm

Alexander Blum – Max Planck Institut für Wissenschaftsgeschichte
Martin Jähnert – Technische Universität Berlin

Substitute Radiators, Virtual Oscillators, and Actual Transitions: Radiation Processes in the Old Quantum Theory and Quantum Mechanics (1913–1927)

Bohr's atomic model of 1913 famously described the radiation process as a discrete transition between stationary state, rather than as the continuous process of emission of classical electrodynamics. This radically new conception was generally accepted over the course of the 1910s and 1920s, persisting across the transition from the old quantum theory to quantum mechanics. Yet, frequently, this blackbox description of radiation proved insufficient, leading to a re-introduction of the classical, continuous radiation process in the form of "substitute radiators". Building on our previous work, we will trace the development of this method, from Hans Kramers' 1919 dissertation to its hitherto unstudied role in the early development of Schrödinger's wave mechanics and its reception in 1926/27. Further, we will analyze the relation of the "substitute radiator" to the "virtual oscillators" of the Bohr-Kramers-Slater (BKS) theory of 1924, and discuss the concept of the virtual with respect to the ontological notion of potentiality and the methodological notion of the hypothetical.

Mike Buttolph – University College London.

Material and virtual agents of heredity, 1870 to 1930

The concept of a material agent of heredity became generally accepted in the nineteenth century, but there were always contrary views. In particular, as it became possible to estimate molecular sizes many commentators claimed that material entities of sufficient complexity to carry hereditary information could not be fitted into the space available in a cell – the 'numbers objection' of Federico Delpino. This motivated the postulation of various immaterial virtual agents of inheritance such as a life force or memory inherent in all living matter. Then the discovery of the electromagnetic field, radio waves and x-rays suggested that heredity might depend upon processes mediated by entities such as fields or vibrations.
At the end of the century Karl Pearson took up a positivist position, explicitly rejecting any reference to any theory of heredity or materialist explanation. He resisted emerging ideas of a material 'gene' and instead conceived of a virtual force of heredity. Pearson's intellectual development was similar to that of Wilhelm Ostwald, who from a positivist motivation constructed a theoretical framework of Energetics in which energy has precedence over matter and there is no need of a material atom. Whereas Ostwald abandoned these ideas in 1909, Pearson always believed in a virtual force of heredity, the source of a progressive urge to evolve and the foundation of his own theory of evolution in 1930.

Alexandre Declos – Collège de France

What's a virtual entity?

The notion of "virtual reality", as currently used, refers to the technology which enables computer-based simulations of immersive and interactive environments. These environments are populated by, and consist of, virtual entities. The latter, however, seem quite different from their non-virtual counterparts (if any). As such, they raise a number of questions: how do virtual entities differ from non-virtual ones? Are they even real? Do they exist independently of virtual reality users? On what grounds may we speak of two virtual entities being numerically identical or different? What type of change, if any, can a virtual entity survive?

This communication shall be devoted to exploring such ontological issues. After considering the recent debate on whether the virtual is real or fictional (see e.g. Chalmers, 2017), I will address in more detail the nature of virtual entities, and offer an account of their identity, individuation, and persistence conditions.

Markus Ehberger – Technische Universität Berlin

Getting to know "the language of Dirac's theory of radiation." Narratives and representations of quantum electrodynamics (QED) in the 1930s

This presentation is based on some insights from my dissertational research on the historical development of the concept of virtual particles. These particles are deeply connected to a calculational technique and regularly perceived of as "not really" there. Nevertheless, they are the intermediaries in the theoretical description of any interaction in (perturbative) QED. I will argue that a suitable way to study the historical development of such physical-mathematical concepts is to focus on their role in "narratives": exemplary ways in which concepts and their representations are used and organized in the theoretical explanation of physical phenomena. I will reconstruct how P.A.M. Dirac (1927) introduced such a narrative of the light-matter interaction based on the notions of virtual transitions and virtual states (in modern terminology). Through the study of historical examples, I will show how physicists applied, represented and extended Dirac's narrative, how, in this process, they gathered a better understanding of the concepts involved therein and how, from a modern vantage point, they were, at times, led astray.

Matthew Gardhouse – McMaster University

Robert Grosseteste and Roger Bacon on Virtual States in Medium Propagation

By the thirteenth century the term 'virtuality' was being readily used by many authoritative Latin scholars. Here I look at the earliest usages in Robert Grosseteste and Roger Bacon, where virtuality is used to help explain the propagation of light and other 'species', such as heat, through a homogeneous medium. We see that even in this early period, the virtual was used to conceptualize how a material, or 'minor', power is 'energized' into a formal, or 'major' power. In this way corporeal elements are explained to in fact be the relationship and equilibrium between two powers, one dominating (major), the other dominated (minor). However, if a minor power is energized and made major, yet the surrounding environment does not further provide an appropriate minor power for this new major power, as happens in certain homogeneous and transparent mediums like air, then the new major power is left in a virtual state, lacking a new minor power in which to materialize and form an actual element. When in such a virtual state, a major power can instead transfer its major status to a neighboring minor power of the same sort (e.g., major heat to minor heat), after which the major power reverts back to its minor status as material for a different major power. This virtual transfer begins a wavelike propagation of said power through the medium, while leaving the actual state of said medium unchanged, thereby explaining why the air remains transparent, although filled with propagating species like light and heat.

Urko Gorriñobeaskoa – University of the Basque Country

Historizing the virtual: a promising methodology and a study of the ether

When tracing the history of a scientific or epistemic object, most historians of science face a singular problem: the mutability of that object over time. The shape, uses and even the meaning of those scientific objects undergo many changes from their birth to their current configurations. However, this challenge is even more problematic when historizing virtual objects. It is considerably more challenging to identify an epistemic object such as the ether than doing so with a telescope, as the latter is a material, visible and touchable thing.

In this presentation, I shall defend that the recently developed methodology of *semantic layers* (Hentschel, 2018) is a good tool for writing the history of a virtual entity. This methodology, which combines both historiographic and philosophical insights, stresses the properties and the meanings an object takes, holds and rejects throughout its life. That being so, this perspective does not take the object as a given, but rather as an ever-changing entity. This may be useful for virtual entities as most of them go through several semantic and epistemic changes through their history; they are less constant than material objects. As a brief case study, I will propose a number of tentative semantic layers for the ether through the 19th and 20th century. The many different theories and models that used the ether as an heuristic concept seem to indicate its virtual ontological status, and it may be a good example with which to assess the potential benefits of this new methodology.

References

Hentschel, K. (2018). *Photons. The History and Mental Models of Light Quanta*. Springer.

Jean-Marc Lévy-Leblond – Université de la Côte d'Azur

Have virtual particles any virtue?

Without denying its usefulness, the ontological distinction in particle physics between « real particles » and « virtual particles » may be questioned. First, it will be pointed out that it relies on a scheme based on Feynman diagrams, the meaning of which is quite unclear for interactions strong enough that a perturbative expansion is valueless. Second, even if such a perturbative point of view is valid, it may be argued that, in a very concrete sense, any particle is virtual unless it is not subject to any interaction, which is of little physical interest. Finally, some thought will be given to terminological questions; through a comparison with the use of the word « virtual » in other fields, one may wonder if, even though it is admitted that the notion of virtual particles has its phenomenological virtue, a better vocabulary could be proposed.

Jean-Philippe Martinez – RWTH Aachen University

Virtuality in nuclear physics (1930s–1940s): the many meanings of an emerging concept

Now fundamental in QED and QFT through virtual particles, the concept of virtuality began to be used in modern physics after the quantum revolution to qualify intermediate states in quantum electrodynamics. It was then introduced at different stages of the development of nuclear physics in the 1930s. This was the case in connection with Gamow's theory of alpha decay and the Fermi interaction as the theory of beta decay, but also, accordingly, for the problem of neutron scattering with the nucleus and Yukawa's meson theory.
The analysis of these different case studies reveals many meanings for virtually in the 1930s, particularly through its use alternately with other terms (exchange, intermediate states, etc.). Nevertheless, within the framework of meson theory, it also highlights a genuine conceptual effort towards clarifying the notion of virtuality in modern physics, as well as its progressive association with that of particle. Therefore, it helps to better understand the introduction and development of the virtual particle concept and underlines the role of nuclear physics in its emergence.
To sum up, this presentation will address the concept of virtuality in nuclear physics in the 1930s and 1940s, with a view to better understanding the foundations that made it a fundamental concept of QED and particle physics in the postwar period.

Daniel Jon Mitchell – Center for Historical Research Science History Institute

"The new conception of the postulates:" Virtual entities and the Bohr-Kramers-Slater reformulation of the (old) quantum theory

The so-called Bohr-Kramers-Slater theory of 1923–24 ('BKS') contains the earliest (qualitative) invocation of virtual entities in a quantum description of the interaction between light and matter. Despite being widely considered a 'theory of virtual oscillators' (VOs), BKS remains the subject of divergent interpretations. One reason for this is a failure to recognize, as Sandro Petruccioli puts it, "two levels of discourse," namely "that concerning the description of the virtual model and that referring to the real physical situation of quantum systems." Building on this insight, I provide evidence that a binary perspective on BKS better represents how Bohr, Kramers, and Slater themselves perceived and developed the theory. Drawing upon recent scholarship on dispersion theory, I proceed to argue that the physical content of BKS consisted of a reworking of Bohr's postulates of quantum theory. This creates room to clarify the nature and purpose of the virtual model, which introduced an unhelpful ambiguity in the meaning of 'virtual' in this context. Although it is difficult to trace a direct conceptual lineage between BKS and quantum mechanics, at a minimum this episode reveals how the statistical conservation of energy and momentum acted as a catalyst for dissolving previously sharp ontological categories.

Edward Slowik – Winona State University

Virtual Presence in the Early Modern Conception of Immaterial Entities

One of the most contentious debates in seventeenth century metaphysics and theology concerns the presence of immaterial beings in space, an issue that prompted Newton to comment in the /Principia/that God "is omnipresent not only /virtually/but also /substantially/; for action requires substance" (Newton, /Philosophical Writings/, U. of Cambridge Press, 2004, p.90). As Newton's quote reveals, one of the main issues centers on whether a being's substance must be present in space to act in space. Against Newton's assessment, the conceptions developed by Descartes, Leibniz, and the pre-critical Kant contends that immaterial entities (God, souls, monads) are not in space although their actions and effects are spatially situated. In this presentation, the intricacies of the virtual presence concept will be investigated in the Early Modern period. In particular, it will be demonstrated that there are a number of intriguing similarities between the structure and role of virtual presence in Early Modern metaphysics and various contemporary quantum gravity theories that posit an underlying ontology of entities that are not in spacetime.

Michael Stoeltzner – University of South Carolina

How possible is the virtual? Lessons from the mechanical tradition

Feynman diagrams depict virtual particles and processes that enter into the cross section of the overall scattering process but violate energy conservation. While these virtual particles are thus treated as unphysical, they are still entering into quantum field theoretical calculations at higher loop orders and thus into processes that are assigned a probability. Does that eventually render them possible? The aim of my presentation is to show that this question involves different kinds of modality that cannot be assessed independently of the mathematical-physical context. I will approach it by embedding the debate on virtual entities and processes into the classical tradition of analytical mechanics where virtual displacements at the differential level and virtual paths in the context of the principle of least action can only be properly assessed as parts of a global and field theoretical analysis. Such an analysis contains both modal aspects and boundary conditions whose primary rationale stems from the integrity of the mathematical setup and its ability to properly describe a real-world physical scenario. They are thus better described as thought experiments in applied mathematics that – as most advocates of thought experiments would demand – can typically be developed into the description of actual experimental features.

Sandra Visokolskis – National University of Cordoba
Gonzalo Carrión – National University of Villa Maria, Villa Maria, Argentina

False Mathematical Entities and Aesthetic Economic Explanations as Virtual Matters.

The paper proposes to analyse two types of examples from remarkably diverse areas but that, paradoxically, end up serving the same purposes, mathematics, and economics. The aim is to specify why these entities are considered virtual in their respective domains, and how they relate to other entities considered real in their specific contexts. Our hypothesis consists in assuming that the functions of such virtual entities are at least the following two: (F1) to fill explanatory gaps in problems, such that they are not possible to be evacuated through the traditional ways of justification in their respective domains of expertise. And (F2) to allow to obtain consistency in a theory that has unspecified cases, whose incompleteness causes inconsistencies.

The first case study refers to a type of mathematical problems from Old Babylon, solved from about 1800 B.C., such as VAT 8389-8391 (problems #1 to #3) (Høyrup 2002: 77-85). Such problems, which can currently be translated anachronistically in terms of systems of linear equations, resort, for their resolution, to the postulation of "false entities" that offer a first linear approximation to the solving calculus, but that generally provide a false first answer, although later correctable. The fictitious assumption that such an entity solves the problem allows attacking first-degree problems in a not quite straightforward form, under some false assumptions. The underlying idea of the method of false position, which includes virtual entities is to make one or two guesses on the nature of the solution, with the goal of finding the true values by linear interpolation. In the presented case study, the heuristics of this interpolation will be interpreted in such a way as to highlight the fundamental role of the introduction of these virtual entities in solving the mathematical problem. Thus, in relation to assumption (F1), such false entities would offer ontological and explanatory starting points that, otherwise, would have been impossible or difficult to reach.

In relation to assumption (F2), we posit a second case study, now in the field of economics. Indeed, invisible-hand explanations in economy are constructions not only with an "undeniable aesthetic achievement of explaining a lot by a little" (Tieffenbach 2016: 116), but also reduce the philosophical tension between realism and idealism, claiming the role of experience in knowledge, while providing a more consistent explanation of a supposed gap between the two positions, usually considered as opposite. In this sense, the case of Adam Smith's Invisible Hand will be considered from its epistemological assumptions and the importance of the aesthetic element for the creation and acceptance of a theory.

References:

Høyrup, J.: Lengths, Widths, Surfaces: A Portrait of Old Babylonian Algebra and Its Kin. Springer, New York (2002).

Tieffenbach, E.: The Virtual Reality of the Invisible Hand. Social Science Information 55(1): 115-134 (2016).

Joseph Wilson – University of Toronto

The Ghost in the Machine: Emergent Metaphors of 'Virtual' and 'Artificial' in Computer Science in the 1950s

The field of artificial intelligence is built on what Richard Boyd calls a "theory-constitutive metaphor," one that equates computational power with human cognition. The term was first used in 1955 as part of a funding application for the 'Dartmouth Summer Research Project on Artificial Intelligence' by computer scientist John McCarthy. McCarthy gave a name to a nascent field that was grappling with a series of virtual entities: a set of complex behaviours that emerged from a simple set of input variables. This metaphor has since come to influence research conducted in AI labs and shapes the very questions that are asked of these virtual entities. This paper traces the metaphors used in artificial intelligence through an assembled corpus of scientific papers from the 'golden age' of artificial research (1956 to 1976) in parallel with an analysis of the first use of the word 'virtual' in the context of computer science during the same time-frame (1959). I use tools from linguistic anthropology, namely corpus analysis and Critical Metaphor Analysis to track how scientists use metaphors and other figurative language in creative ways to make sense of their work.

Poster Sessions Abstracts

Simon Beyne - March 12, 2:00 pm (Session 1)
Giulia Carini - March 26, 2:00 pm (Session 2)
Brian Francis Conolly - March 12, 2:00 pm (Session 1)
John Dougherty - March 26, 2:00 pm (Session 2)
Stefano Furlan - March 12, 2:00 pm (Session 1)
Genco Guralp - March 26, 2:00 pm (Session 2)
Giora Hon and Bernard R. Goldstein - March 12, 2:00 pm (Session 1)
Havelok Symes - March 26, 2:00 pm (Session 2)

Simon Beyne – Aix-Marseille Université

Is modern cosmology based on virtual entities?

This is how modern physics states the composition of the Universe: there would be only 5% known matter (called ordinary matter), 25% dark matter and 70% would be dark energy. Our ignorance is virtually filled with so-called "dark" entities. This name is also inappropriate since they are not dark but invisible. Dark matter and dark energy have been introduced as auxiliary entities to solve anomalies, and thus, our theoretical models are consistent with the observations. Today, although they have evolved, their ontological status raises questions; no dark matter particle has yet been detected directly.
However, access to "ordinary matter" is also made indirectly through the observation of the effects it produces. Typically, we observe ordinary matter through its electromagnetic effects (the light it emits or reflects) and we would observe dark matter through its gravitational effects. Access to dark matter would be indeed more difficult to us, but does this allow us to place dark matter in a "secondary ontology" or a "virtual ontology"? What types of observation statements would make it possible to define or identify the ontological status of dark matter?

Giulia Carini – Max Planck Institut für Wissenschaftsgeschichte

From "virtual transitions" to neutral particle oscillations

When it first showed up in Gell-Mann's and Pais' paper on the behaviour of neutral kaons, the notion of "virtual transition" was presented as a revolutionary idea, causing the conservation law of strangeness to break down, due to its power of transmuting a K0-meson into its antipartner (endowed with the opposite quantum number). The phenomenon occurred because of the structure of the neutral mesons involved, that could be interpreted as "particle mixtures" of some other "true particles", or "quanta", each characterised by its own unique lifetime and mass. The adjective virtual, nonetheless, did not apply to any of those objects, neither the two poles of the oscillations – namely, the initial and the final state – nor their elementary constituents; instead, it denoted the transition connecting those physical entities, which were still conceived as observable, because subject to some fundamental interaction. Even though this idea does not sound so alien to the definition of "virtual particle" generally accepted nowadays, represented by an internal line in a Feynman diagram, this investigation will put the latter aside in favour of a genuine reconstruction of the former notion, once placed in its original context.
By retracing the development of this notion – first materialised in the realm of neutral mesons, and afterwards extended by Pontecorvo and, independently, by the Nagoya school to neutrino oscillations –, this contribution aims at suspending the *backprojection* of present categories that somehow have evolved into fossilized technical concepts, incapable of preserving the complexity of the idea in the stratification of its meanings.

Brian Francis Conolly – Bard College at Simon's Rock

Virtual Being in Medieval Discussions of the Elements in the Mixed Body

In this paper I consider the notion of "virtual being" in the context of late medieval discussions concerning the ontological status of the classical elements (earth, air, fire, water) in the homeomerous mixed body. The notion of "virtual being" indicates an ontological status in which the substance of a constituting entity is absent yet its powers (or virtues) remain in the constituted entity. "Virtual being" figures in Thomas Aquinas' (13th century CE) solution to a problem introduced by Ibn Rushd (12th century CE), but nowhere considered by Aristotle, namely, how to reconcile the doctrine of the unicity of substantial form – that any material entity is explainable in terms of exactly one substantial form impressed upon prime matter – with Aristotle's theory that any one of the elements can be extracted from any part of the homeomerous mixed body. The latter seems to imply that the elements are present within the mixed body in some manner, which in turn seems to require the presence of more than one substantial form. "Virtual being" is thus a way of accounting for the presence of the elements without compromising the unicity of substantial form of the mixed body. I also consider contemporaneous criticism of Aquinas's notion of virtual being as a solution to this problem.

John Dougherty – Munich Center for Mathematical Philosophy, LMU Munich

I ain't afraid of no ghost

It's widely agreed that virtual particles in quantum field theory don't exist: Feynman diagrams don't depict the interactions of real yet virtual quanta, they only organize the perturbative expansion of expectation values and other such quantities. The virtual particles appearing in quantum gauge theories are said to exist even less than this. In the usual quantization schemes, quantum gauge theories contain 'ghost' quanta, which violate the spin-statistics connection and cannot appear as incoming or outgoing particles. But it is often argued that these ghosts are a computational convenience eliminable in principle— that they are purely a result of our notation. I argue that this is mistaken. Ghosts are indispensable to the quantization of gauge theories, and philosophical work on gauge theories has neglected the role of ghosts to its detriment. In particular, I argue that the standard account of ghosts in the philosophical literature—developed by Robert Weingard and Michael Redhead, among others—isn't adequate to the role that ghosts actually play. I reconstruct and criticize this standard account and give an alternative. I also show that this alternative account can respond to the philosophical literature's two stock arguments against the significance of ghosts as developed by Weingard.

Stefano Furlan – Max Planck Institut für Wissenschaftsgeschichte / Université de Genève

John A. Wheeler as 'geologist of the vacuum': from quantum electrodynamics to pregeometry

Among the phrases and slogans famously coined or adopted by J.A. Wheeler, that of 'quantum foam' is a particularly fascinating one. Its pictorial character in evoking a sort of breaking of spacetime smoothness near Planck length, however, hides a story too, which covers decades of Wheeler's long career. In this paper, I am addressing the ideas and analogies Wheeler drew upon, as well as their intended aims. During the mid-'50s, he was not just pondering about a minimal length, spacetime granularity, quantum fluctuations: he was trying to conceive a Feynman-like quantization of general relativity, an 'omnidimensional geometry' with a sum over all possible dimensions, topologies, metrics, particularly relevant at the smallest scales. In the early '60s, this kind of 'interference' of potentialities was invoked by Wheeler as a mechanism of singularity-avoidance, in his still problematic engagement with gravitational collapse and black holes ante litteram. Later, convinced that he had to embark on a more fundamental quest, he started to push the idea (or 'idea for an idea') of 'pregeometry', a deeper level from which spacetime should somehow emerge – and that is when he built a grand narrative about the 'geology of the vacuum' and its different strata of virtualities, from the Lamb shift he had witnessed during the genesis of quantum electrodynamics to a sort of its gravitational 'analogous', and beyond.

Genco Guralp – San Diego State University

Probing the Ontology of Virtual Particles in QCD: The Case of the Evolution of Parton Distribution Functions

One of the well established predictions of quantum chromodynamics (QCD) is the violation of the phenomenon known as Bjorken scaling. This prediction is obtained from the higher-order correction terms to the leading order Feynman diagrams that contain mass singularities. In QCD, the corrections to Bjorken scaling are understood in terms of the evolution of the Parton distribution functions (PDF), which express the probabilities of finding various constituent particles in the hadron wave-functions. More specifically, the evolution of PDFs are described by certain integral-differential equations known as the Altarelli-Parisi equations, which can be seen as a generalization of the equivalent photon approximation in quantum electrodynamics. In this paper, I aim to show that the PDF evolution phenomena and the interpretation of the Altarelli-Parisi equations contain important lessons for understanding both the ontology of virtual particles in quantum field theory as well as our epistemic access to them. The evolution of PDFs shows that at higher resolution, an electron appears to comprise virtual electrons, virtual electron-positron pairs, and photons. Similarly, a proton probed at short distances (high momentum) is "seen" as composed of a sea of virtual quarks, anti-quarks, and gluons. Hence, a dichotomous ontology of real versus virtual (or virtual particles as "mere" potentialities) appears problematic, as "real" particles seem to be composed of "virtual" ones. I advocate an "interventionist" approach to virtual particles (following Hacking), which stabilizes ontology through epistemic access in experimental contexts. As a result, the demonstration of scaling violation in the modern deep inelastic scattering experiments, following the form predicted by Altarelli-Parisi equations, provides strict epistemic access to virtual particles, similar to any other empirical phenomena in fundamental physics.

Giora Hon – University of Haifa
Bernard R. Goldstein – University of Pittsburgh

Maxwell and Imaginary Physics

James Clerk Maxwell's first contribution to the study of electromagnetism is the most revolutionary, although each of his four contributions is innovative in its own way. In his paper "On Faraday's lines of force" (1856–1858), Maxwell transformed the traditional methodology of analogy, improved by William Thomson, into a powerful new technique which draws a parallel between a set of physical phenomena and an imaginary arrangement, entirely contrived by the physicist. The move was to imagine lines of force as tubes, fill them with an incompressible fluid complete with sources and sinks. Maxwell then developed an imaginary hydrodynamics to turn the geometrical scheme of Michael Faraday into a "physical" one, which now included both the direction of the force and its intensity. This novel imaginary physics served as an analogue which, in turn, facilitated the construction of a new formalism. It was assumed as a vehicle of mathematical reasoning. Faraday's scheme of lines of force had the power to unify electromagnetic phenomena, but only geometrically; Maxwell rendered this scheme physical. This was done by appealing—surprisingly—to imagination; indeed, that was the strength of the new methodology. The use of analogy in scientific discourse goes back to Antiquity, but drawing an analogy between observable phenomena and imaginary physics was something new and unexpected. We call this methodology "contrived analogy", for Maxwell constructed an analogy which worked, as he explicitly put it, in one direction only: from his imaginary physical scheme to the physics of electromagnetism.

Havelok Symes

Reconfiguring the Domain: Meta-empirical Evidence in Support of Realism

The term virtual entity could be defined by its opposition to the kinds of real material particles (e.g., atoms and molecules) which are instrumental in explaining and predicting a range of phenomena observed in nature. However for much of the history of science, atomism remained a doctrine more closely associated with metaphysics than physics. The threat from underdetermination of theory by evidence led many scientists to abstain from ontological commitments altogether. But after Perrin's work on Brownian motion at the start of the twentieth century, the atom became a near universally accepted microphysical entity. Yet a precise understanding of its epistemic status remains a central feature of the scientific realism debate, which aims to explain science in relation to theories' approximate truth. Recent work by Richard Dawid (e.g. Dawid 2020) has sought to understand the epistemic shift which accompanied the confirmation of atomism in relation to the use of meta-empirical assessment – use of evidence from beyond a theory's intended domain to support a belief in a lack of alternatives. This talk will consider the relevance of meta-empirical assessment to supporting realism towards entities, contrasting Dawid's approach with Tautological Scientific Realism (TSR) -- a new form of realism which appeals to meta-empirical evidence, but only in support of coarse-grained features of the natural world. (See Hoefer 2020)

References

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