LMU LUDWIG-MAXIMILIANS-UNIVERSITÄT MÜNCHEN

CAS[LMU] CENTER FOR ADVANCED STUDIES
RESEARCHER IN RESIDENCE

Reasoning in Physics

International Workshop at the Center for Advanced Studies, LMU Munich

Organized by Benjamin Eva, Ph.D. and Prof. Dr. Stephan Hartmann
(CAS Senior Researcher in Residence)

12 and 13 December 2016

Monday, 12 December 2016

10:30–11:00 Coffee and Welcome Address

11:00–11:45 **Jeremy Butterfield** (Cambridge)
Under-determination of theory by data, and selection effects in cosmology

11:45–12:30 **Erik Curiel** (Munich)
Framework confirmation by Newtonian abduction

12:30–13:30 Lunch

13:30–14:15 **Benjamin Eva** (Munich)
A non-numeric representation of the astronomer's prior

14:15–15:00 **Simon Friederich** (Groningen)
Anthropic reasoning, origin oriented reasoning and typicality in cosmology

15:00–15:30 Coffee Break

15:30–16:15 **Casey McCoy** (Edinburgh)
Epistemic justification and methodological luck in inflationary cosmology

16:15–17:00 **Mathias Frisch** (Hannover)
Time a-symmetric reasoning in physics

18:30 Conference Dinner

Tuesday, 13 December 2016

9:30–10:15 **Karim Thebault** (Bristol)
Dumb holes and Bayesian confirmation

10:15–11:00 **Cameron Beebe and Roland Poellinger** (Munich)
Bayesian confirmation from analog models

11:00–11:30 Coffee Break

11:30–12:15 **Peter Mättig** (Wuppertal) and **Michael Stöltzner** (South Carolina)
Model choice and crucial tests: on the epistemology of the Higgs discovery

12:15–13:00 **Radin Dardashti** (Hannover)
Scientific reasoning in theory space

13:00–14:00 Lunch

14:00–14:45 **Sabine Hossenfelder** (Frankfurt)
Naturalness: How religion turned to math

14:45–15:30 **Karen Crowther and Niels Linnemann** (Geneva)
On principles in theory construction and justification of quantum gravity

15:30–16:15 **Michael Krämer** (Aachen)
The art of simplified models

Venue:
Center for Advanced Studies
Ludwig-Maximilians-Universität München
Seestraße 13
80802 München

CAS Researcher in Residence

Abstracts Workshop "Reasoning in Physics"

Cameron Beebe and Roland Poellinger (Munich)
Bayesian confirmation from analog models

Analog models can be employed to investigate aspects of a target system we might not have easy empirical access to. Recently, it has been argued that analog models even provide confirmation of such a target system's theory. We investigate what a formal account of this confirmation might require, and illustrate the details by discussing a water-wave analog system of the quantum Casimir effect. Our finding is that analogical reasoning of this type cannot be sufficiently expressed in traditional Bayesian networks. We therefore sketch an extension of (causal) Bayes nets, where the symmetry of analog reasoning naturally finds expression. This formalization sheds new light onto theoretical pre-unification.

Jeremy Butterfield (Cambridge)
Under-determination of theory by data, and selection effects in cosmology

I discuss two issues about primordial cosmology, i.e. the very early universe, where 'very early' means, roughly, much earlier (logarithmically) than one second after the Big Bang. The first issue concerns the difficulty of ascertaining details of the putative inflationary epoch. The second issue concerns difficulties about confirming a cosmological theory that postulates a multiverse, i.e. a set of domains (universes) each of whose inhabitants (if any) cannot directly observe, or otherwise causally interact with, other domains.

Karen Crowther and Niels Linnemann (Geneva)
On principles in theory construction and justification of quantum gravity

Principles are central to physical reasoning, particularly in quantum gravity (QG) where novel empirical data is lacking. One of the principles in QG is that of UV-completion—the idea that a theory should hold up to arbitrarily high energies. We argue—contra common practice—that UV-completion is poorly-motivated as a guiding principle in theory-construction, and cannot be used as a criterion of theory-justification. For this, we explore the reasons for expecting, or desiring, a UV-complete theory, as well as analyse how UV completion is used, and how it should be used, in different specific approaches to QG.

Erik Curiel (Munich)
Framework confirmation by Newtonian abduction

The analysis of theory-confirmation generally takes the form: show that a theory in conjunction with physical data and auxiliary hypotheses yield a prediction about phenomena; verify the prediction; provide a quantitative measure of the degree of

theory-confirmation this provides. The issue of confirmation for an entire framework (e.g., Newtonian mechanics en bloc, as opposed, say, to Newton's theory of gravitation) either does not arise, or is dismissed in so far as frameworks are thought not to be the kind of thing that admits scientific confirmation. I argue that there is another form of scientific reasoning that has not received much if any philosophical attention, what I call `Newton-Maxwell abduction', that does provide

confirmation for frameworks as a whole. (In particular, Newton-Maxwell abduction is *not* IBE, but rather is much closer to Peirce's original explication of the idea of abduction.) I further argue that it is at least as important a form of reasoning in science as the deductive form sketched above. The form is beautifully summed up by Maxwell: "The true method of physical reasoning is to begin with the phenomena and to deduce the forces from them by a direct application of the equations of motion."

Radin Dardashti (Hannover)
Scientific reasoning in theory space

Physicists use a broad range of methods in scientific inquiry: they test their theories by experiments, they provide thought experiments, they use analogue models if the target system is inaccessible, they simulate on computers, they use non-empirical methods of theory assessment, and many more things. While testing the consequences of a theory by experiments is the gold standard in theory assessment, it has been claimed that these other methods can similarly provide evidence in support of a theory. I will argue that the concept of theory space, as fuzzy a concept it may seem, is useful in assessing and comparing the strength of some of these different claims.

Benjamin Eva (Munich)
A non-numeric representation of the astronomer’s prior

Bayesian confirmation theory relies crucially on the principle of indifference (POP), according to which prior states of ignorance should be represented as uniform distributions on the relevant sample space. POP plays a crucial rule, for example, in Weinberg’s use of anthropic reasoning to obtain new predictions for the value of the cosmological constant, and in the application of Bayesian model selection to cosmological parameter estimation. I consider some arguments against POP and conclude that its use in these cases is illegitimate. I present an alternative approach to representing ignorance in the context of non-numeric probability theory, and show how this non-numeric approach provides a natural representation of prior states of ignorance that (1) overcomes the conceptual problems of POP, (2) poses strict limitations on the validity of anthropic reasoning, and (3) allows us to return to standard numeric probability theory after updating on new evidence.

Simon Friederich (Groningen)
Anthropic reasoning, origin oriented reasoning and typicality in cosmology

Proponents of anthropic reasoning argue that the existence of multiple universes could help explain the apparent fine-tuning of the constants for life in our own universe. Proponents of origin-oriented reasoning dispute this, claiming that the inference from fine-tuning to multiple universes commits what Hacking calls the inverse gambler's fallacy. I suggest that the conflict between these two types of reasoning may not be resolvable by appeals to accepted standards of rationality. I further claim that both types of reasoning are compatible with typicality assumptions as they are commonly used to extract predictions from specific multiverse theories. Typicality assumptions have a respectable motivation but, contrary to claims by Hartle and Srednicki, they are not the kind of hypothesis that is amenable to empirical tests.

Mathias Frisch (Hannover)
Time a-symmetric reasoning in physics

This paper first summarizes how a certain type of time-asymmetric, paradigmatically causal form of inference can be justified even in the context of time-symmetric deterministic dynamical laws. In the second and main part of the paper I then examine a well-known argument by Huw Price, appealing to broadly interventionist considerations, for the claim that time-symmetry in quantum theories in contradistinction to classical theories suggests the presence of bidirectional (and hence partly retrocausal) relations. In showing where Price's argument goes wrong, I distinguish several different principles of time-symmetry and discuss asymmetries between predictive and retrodictive inferences in physics in the context of both deterministic and probabilistic theories.

Sabine Hossenfelder (Frankfurt)
Naturalness: How religion turned to math

Technical naturalness is a supposedly mathematical criterion used in theoretical high energy physics. It has been a guiding principle for much of theory development and the reason for the wide-spread belief that the LHC should deliver evidence for new physics besides the Higgs. In my talk I will briefly lay out the history of arguments from naturalness and then explain why they are philosophical criteria, not mathematical ones.

Michael Krämer (Aachen)
The art of simplified models

Recently, there has been a move in particle physics towards so-called “simplified models” that consciously abstract away from features of the target system. Such models are based on fewer theoretical premises and nevertheless cover a bigger part of the parameter space as compared to traditional, all-encompassing models like supersymmetry. At the same time, the question arises whether simplified models can still be seen as an explanation of what happens in the target system given the amount of idealization involved, or whether they are merely an intermediate step towards an explanation, which would then be provided by a more encompassing theory.

Peter Mättig (Wuppertal) and **Michael Stöltzner** (South Carolina)
Model choice and crucial tests: on the epistemology of the Higgs discovery

On the basis of two questionnaires and interviews with LHC physicists shortly before and shortly after the Higgs discovery, we argue: First, even shortly before the Higgs discovery a significant percentage of physicists were sceptical and expressed preferences for other explanations of the particle masses. Second, our case study suggests that criteria of theory choice should be understood as epistemic and pragmatic values that have to be specified and weighed in actual research practice. Third, the conviction of the particle physics community that the Higgs discovery was indeed a crucial experiment for the Standard Model withstands philosophical scrutiny. For an experiment as complex as LHC is embedded in a tradition of previous precision experiments and reliable experimental strategies that keep theory-ladenness at bay.

Casey McCoy (Edinburgh)
Epistemic justification and methodological luck in inflationary cosmology

I present a recent historical case from cosmology—the story of inflationary cosmology—and on its basis argue that solving explanatory problems can be a reliable method for making progress in science. In particular, I claim that the success of inflationary theory at solving its predecessor's explanatory problems justified the theory (epistemically), even in advance of the development of novel predictions from the theory and the later confirmation of those predictions.

Karim Thebault (Bristol)
Dumb holes and Bayesian confirmation

In 1981 Unruh proposed that fluid mechanical experiments could be used to probe key aspects of the quantum phenomenology of black holes. In particular, he claimed that an analogue to Hawking radiation could be created within a fluid mechanical 'dumb hole', with the event horizon replaced by a sonic horizon. Since then an entire sub-field of 'analogue gravity' has been created. In 2016 Steinhauer reported the experimental observation of quantum Hawking radiation and its entanglement in a Bose-Einstein condensate dumb hole. What can we learn from such analogue experiments? In particular, in what sense can they provide evidence of novel target phenomena such as black hole Hawking radiation? In a recent paper it was argued that there exists circumstances in which confirmation of target phenomena based upon an analogue experiment can obtain. This talk will support and extend these claims via an analysis in terms of Bayesian confirmation theory.