Report on the Institute for Visiting Scholars Grant

The Epistemology of the Higgs Discovery

(Invitation of Dr. Richard Dawid, University of Vienna, Austria)

Amount granted: 23,447.50 $

Effective Duration: September 14th, 2013 - April 29th, 2014.

Awardee/Host: Dr. C. Michael Stoeltzner

Associate Professor, Department of Philosophy
College of Arts and Sciences
Email: stoeltzn@sc.edu; Phone: 71805

Summary

The project was realized in two steps. Dr. Dawid visited USC from September, 14th, 2013 to November 17th, 2013; on April 25th and 26th, the two of us convened an international workshop at USC on “Evidence, Discovery, Proof: Measuring the Higgs particle”. This separation of visit and workshop was necessary because of family reasons and approved by the Provost’s Office. My stay in Europe over the Christmas vacations and weekly Skype sessions allowed us to advance our common research agenda between his visit and the workshop without interruption.

At the beginning of Dr. Dawid’s stay, we discussed in much detail our previous work, finishing two papers on the epistemology of the Higgs particle. Both of them have meanwhile been accepted by international journals. We also started working on our contributions for a special issue, edited by Dr. Dawid, of the philosophical journal Synthese focusing on the Higgs discovery. Several contributors to this special issue took part in the workshop this April, which will significantly increase the volume’s coherence. Final versions, reflecting the discussions on the workshop, are due by the end of May. Dr. Dawid and I have also worked on a joint paper that combines our respective interests in the philosophy of string theory and variational principles in mathematical physics. The working title is “The Existence of the String Action – A Variational Principle Point of View”. We will finish this paper over the summer, continuing our Skype sessions. During the two months of his stay in Fall 2013, Dr. Dawid ran a weekly reading group for faculty and graduate students from physics and philosophy. He repeatedly met with Cristin Chall, a graduate student working in the philosophy of physics.

The grant has led to closer contacts between the Departments of Philosophy and Physics – exemplified by talks of Dr. Dawid and myself within USC’s Physics Colloquium and several extensive discussions with Dr. Ralf Gothe. It revived the close contacts between Philosophy and the Nanocenter; Dr. Thomas Vogt participated in the reading group and the workshop, and the Nanocenter cosponsored it. The participants of the workshop teaching in the U.S. (Beauchemin, Staley, and myself) agreed to establish an interdisciplinary network on the epistemology of the LHC and seek NSF funding for a series of workshops and joint research projects. This research group should become a U.S. counterpart to the Wuppertal-centered “Epistemology of the LHC” (http://www.lhc-epistemologie.uni-wuppertal.de/) that I co-founded in 2006.

The funds were basically spent as outlined in the budget proposal, except for minor shifts in favor of the workshop budget. They became possible because of lower actual travel and health insurance
costs for Dr. Dawid’s visit in Fall 2013. The workshop obtained additional financial and logistical support from the Department of Philosophy and the USC Nanocenter.

**Research projects on the Higgs**

Our research departed from two interrelated themes we had previously worked on. Dr. Dawid developed a Bayesian interpretation of the look-elsewhere effect – i.e., the identification of a new phenomenon by excluding the explanation of a signature in terms of already known physics. I find this a promising approach to understand a key feature of the dramaturgy of the Higgs discovery, to wit, the 5σ-criterion that distinguished previous indications of a Higgs particle from the justified discovery that was announced in 2012. In discussions with Dr. Dawid and particle physicists I came to better understand why such criteria play a major role in the search for new physics the LHC will embark on after obtaining more details on the Higgs particle. I continued to work on the topography and dynamics of the model landscape in the Higgs sector, and have started studying how the increasing amount of data puts constraints on new physics beyond the standard model of elementary particle physics. My hypothesis is that there exists a continuity between such constraints on a dynamically evolving model landscape that limits the parameter space for models of new physics to dwell in, and the statistical employment of bounds in the look-elsewhere effect.

My paper for the projected *Synthese* issue that I presented on the workshop applied both my previous works on the model landscape in the Higgs sector and on the conceptual structure of the Higgs mechanism – which, as the consequence of a two-tiered theoretical argument, yields the Higgs particle – to argue that there exists no universal notion of explanation throughout Higgs physics. Even though, accordingly, realist commitments that are typically based on successful explanations are difficult to pin down, they are nonetheless ubiquitous in particle physics and motivate the physics beyond the standard model. Instrumentalism is not the basic conviction of particle physicists. Nevertheless one can find many of those features that have been brought out by the recent philosophical debates about models that emphasize the irautonomy with respect to high-level theory. In writing the paper I am profiting a lot from the constant exchange with Dr. Dawid and his expertise as a former particle physicist turned philosopher. I am also reading versions of his paper for the volume and have refereed contributions.

**Research project on string theory and variational principles**

Since a couple of years, Dr. Dawid has worked building up the philosophy of string theory as a distinctive research field. His book *String Theory and the Scientific Method* (with Cambridge University Press) provides the first detailed account of the structure of this theory and the peculiar problem of testing a theory that is unreachable by any conceivable experiment. I had already known that string theory is formulated on the basis of a variational principle, a mathematical structure whose philosophical analysis I have been working on since a long time. Over the centuries some distinctive features of variational principles, as compared to differential equations, had sparked controversies in classical physics – from Newtonian mechanics to relativity theory. Discussing Dr. Dawid’s book in the reading group, I realized that some of those features are pivotal in string theory too, especially when making the claim that the theory is already well-formulated, which is often challenged by its critics. Thus we decided to begin a joint paper that shows to what extent the variational principle can be employed in a more general sense than as a vehicle to generate sometimes problematic, sometimes not explicitly expressible dynamical equations. Moreover, string theorists’ intuition to minimize a world sheet corresponds to minimal surfaces
that are typically solved by way of variational principles. We plan to finish this joint paper, of which single chapters already exist, this summer.

*Talks in the Physics Colloquium*

During his stay, Dr. Dawid delivered a talk in the Colloquium of the Department of Physics and Astronomy titled “Beyond Measurement: String Theory and the Scientific Method” based on his book. The talk on October 31st, 2013, was well-attended – also by some philosophers – and enjoyed a long and spirited question period. On April 3rd, 2014, I delivered a Colloquium talk title “Why Philosophers Are Interested in the Higgs Particle” that surveyed present philosophical research on elementary particle physics including the topic of the workshop to be held at the end of the month.

*Workshop*

On April 25th and 26th, 2014, we organized an interdisciplinary workshop “Evidence, Discovery, Proof: Measuring the Higgs particle”. We had four invited speakers and five other regular attendees from the Departments of Physics and Philosophy including two students on site, while four invited speakers joined by a vidyo-connection. We adopted this technology commonly used for CERN collaboration meetings because of scheduling difficulties of some participants. The connection was completely stable, so that we could enjoy very spirited discussions even though participants were taking part from another continent. (Speaking in monetary terms, we enjoyed a 10,000 workshop for half price.) The successful workshop has also convinced Beauchemin, Staley and myself that the intended interdisciplinary network can be established and maintained without extensive travel funds, such that eventual NSF funds could be directed primarily at stimulating research and organizing an annual workshop. It also makes it possible to deepening the ties of the intended network with the Wuppertal group – two of its members gave talks by vidyo – while remaining a separate entity. Even though we did not receive financial support from the Physics Department, Dr. Gothe is very interested in continuing his involvement and, depending on the interest of the students involved, participate in the supervision of a thesis.

*Reading group*

Based on Dr. Dawid’s recently published book, but taking the broader perspective of non-empirical theory confirmation, we organized a reading group that met every week starting on October 4th, 2013 On a regular basis it involved four faculty members (Richard J. Creswick (Physics), Michael Dickson (Philosophy), Tom Vogt (Nanocenter), and myself) and two students. Dr. Dawid met repeatedly with my graduate advisee Christin Chall also outside the reading group, helping him to obtain a broader picture of the present state of the field of philosophy of physics. They also met after the workshop. In March 2014, Cristin had participated in a two-week spring school on philosophy and particle physics organized by the Wuppertal group which perfectly prepared him for the workshop. All these activities come precisely at the right time for him because he is currently in the process of determining a suitable dissertation topic.

*Attachments:*

- Program of the Workshop.
- Flyer of Dr. Dawid’s and my presentations in the Physics Colloquium,
- Emails announcing the reading group.
Announcement of an Interdisciplinary Workshop Dedicated to the Epistemology of the LHC
“Evidence, Discovery, Proof: Measuring the Higgs particle”

USC, 25-26 April 2014, Sumwalt 102 (USC Nanocenter)
Supported by a Provost’s Visiting Scholar Grant, the Department of Philosophy, and the Nanocenter
In collaboration with the Wuppertal-centered research group “Epistemology of the LHC”

Speakers:
2. Richard Dawid (Philosophy, Vienna): “Bayesian Perspectives on the Discovery of the Higgs Particle”
3. Koray Karaca (Philosophy, Wuppertal): “A Study in the Philosophy of Experimental Exploration: The Case of the ATLAS Experiment at CERN’s Large Hadron Collider”
5. Michael Stoeltzner (Philosophy, South Carolina): “Mechanism, model, particle: On the three levels of Higgs epistemology”
7. (per vidyo) Robert Harlander (Theoretical Physics, Wuppertal), “Is the Higgs-mechanism ad hoc?”
8. (per vidyo) Michael Krämer (Theoretical Physics, Aachen), “The Art of simplified models”
9. (per vidyo) James Wells (Theoretical Physics, Michigan): “Naturalness and the Higgs Boson Proliferation Instability Problem”

Schedule: (tentative, V indicates presentation by vidyo, P based on a paper distributed ahead)

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<tr>
<th>Friday, 25 April</th>
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<td>9:00 – 10:15</td>
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<td>Cousins (V,P)</td>
<td>Beauchemin</td>
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<td>Coffee break</td>
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<td>10:30 - 11:45</td>
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<td>Wells (V,P)</td>
<td>Harlander (V)</td>
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<td>Coffee break</td>
<td>Lunch</td>
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<td>12:00 – 1:15</td>
<td>1:15 – 2:30</td>
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<td>Krämer (V)</td>
<td>Dawid</td>
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<td>Lunch</td>
<td>Coffee break</td>
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<td>2:30-3:45</td>
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<td>Staley</td>
<td>Stoeltzner</td>
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<td>Coffee break</td>
<td>Concluding Discussion</td>
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<td>4:00-5:15</td>
<td>Karaca (P)</td>
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For the last thirty years, string theory has played a highly influential role in fundamental physics without having found empirical confirmation. The presentation will analyse reasons for the high degree of trust many physicists have developed in a theory that, according to classical standards of theory assessment, would have to be called an unconfirmed speculation. It will be argued that the case of string theory may suggest a new perspective on our understanding of theory confirmation in general. In the last part of the talk, some implications for the scientific realism debate shall be addressed.
Colloquium

Why Philosophers Are Interested in the Higgs Particle

Speaker
Name
Dr. Michael Stoeltzner
University of South Carolina, College of Arts and Sciences
Department of Philosophy

Abstract
To an increasing extent, philosophers of science are attracted by Higgs physics and the Large Hadron Collider (LHC) because these are exemplary for basic philosophical tenets of 21st century science. Among them are the theory-ladenness of observation that characterizes a modern particle detector, the entirely statistical nature of the evidence for the Higgs particle and the threshold for accepting experimental evidence, the model landscape in the Higgs sector that combines a well-established theory with more speculative physics beyond the standard model, and the quite complex nature of the Higgs mechanism. I present results of an ongoing interdisciplinary collaboration “Epistemology of the LHC”.

www.physics.sc.edu

THURSDAY
April
3

4:15 p.m.

Jones Physical Science Center Room 409

Refreshments served at 4:00 p.m.

Hosted By
Dr. Ralf Gothe

Everyone Invited
Subject: Reading group on philosophy of physics
From: Michael Stoeltzner <stoeltzn@MAILBOX.SC.EDU>
Date: 9/18/2013 11:38 AM
To: <PSTEMCELL@LISTSERV.SC.EDU>

As already mentioned, Dr. Richard Dawid from the University of Vienna is visiting USC as a Provost's Visiting Scholar until mid November. His areas of interest are philosophy of physics and philosophy of science. He offers interested graduate students and faculty to join a reading group on Non-Empirical Theory Confirmation

If you are interested, please write to me and Dr. Dawid stoeltzn@sc.edu richard.dawid@univie.ac.at http://homepage.univie.ac.at/richard.dawid/Homepage-Links.htm

and give some indications about your availability. We will then open some doodle poll if need be.
Ideally we would start next week:

Here is the description:

Non-Empirical Theory Confirmation
RICHARD DAWID

Some of the most influential theories in high energy physics and cosmology today are strongly believed in by their exponents even though those theories have not been empirically confirmed. What is the most plausible way of accounting for this situation at a philosophical level? Can the arguments physicists use to support their empirically unconfirmed theories be understood in terms of an extension of the concept of theory confirmation?

We’ll have a look at string theory, arguably the prime example of a theory trusted by its exponents without empirical confirmation (leaving aside the intricacies of the theory’s mathematical structure, just sketching the main ideas involved). We’ll discuss Lee Smolin’s critical claim that string theory creates its own arbitrary criteria of success. We then contrast this criticism with the idea that the arguments used in establishing trust in string theory do constitute viable scientific reasoning, albeit of a form difficult to grasp based on the canonical understanding of theory confirmation. Finally, we have a more formal look at the issue and discuss a paper that demonstrates that at least one of the main arguments used for supporting empirically unconfirmed theories in fundamental physics does constitute confirmation in a Bayesian sense. We’ll discuss the significance and the limits of that result.

The texts, which will be available online, are taken from:
Subject: Reading group on Non-Empirical Theory Confirmation
From: Richard Dawid <richard.dawid@univie.ac.at>
Date: 9/27/2013 11:48 AM
To: Michael Stoeltzner <stoeltzn@mailbox.sc.edu>, "POSADA-AGUIRRE, CAMILO" <posadaag@email.sc.edu>, <chall@email.sc.edu>, Michael Dickson <mdickson68@gmail.com>, "VOGT, THOMAS" <tvogt@mailbox.sc.edu>
CC: Richard Dawid <richard.dawid@univie.ac.at>

Dear all,

Our reading group on Non-Empirical Theory Confirmation will start next Friday, Oct 4th, 1.15-2.30.

It may be easiest if I just send you the texts to read by email the week before. Next Friday, the idea is to discuss the basic concepts of string theory, the motivation for its development, its conceptual incompleteness and the problem of testing it empirically. Everything on string theory will be very elementary and entirely self-contained. The idea is not to enter the mathematical intricacies of the theory but just to get a general idea of the reasons why string theory is such a good show case for the importance of non-empirical theory confirmation.

The 'textual backbone' of the reading group is going to be my book from this summer "String theory and the scientific method", Cambridge Univ. Press 2013. I send you a pdf of the manuscript before CUP proof reading (not for further distribution).

For next Friday, please look at the Introduction and the introductory Sections 1.1 and 1.2. (pp 7-29).
For those interested in a little more on string theory, the most accessible introductory textbook is Barton Zwiebach's "A first Course on String Theory", Cambridge University Press 2009. A classic and instructive non-technical account of the theory is Brian Greene's "The Elegant Universe", Vintage 2005.

The week after, we'll have a look at Lee Smolin's fundamental criticism of string theory. I'll send you the corresponding text next week.

Looking forward to our first meeting!
Best,
Richard

On Mo, 23.09.2013, 03:24, Michael Stoeltzner wrote:
| Dear All, |
| you have all expressed an interest in the reading group on non-empirical theory confirmation, and two of you suggested Fridays. |
| What about a first meeting on Friday, October 4th, from 1:15-2:30 or around that time? There we could also discuss the further schedule? (It won't work on every Friday because of the Philosophy colloquium, but on most Fridays.) |
| Richard will start with a brief overview of basic (philosophically interesting) questions of string theory. We then move on to Smolin and... |
his own papers.

Best,
Michael

— Attachments: —

String Theory and the Scientific Method - Final Version.pdf 1.4 MB