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The potential for a revolution

Dr Carolin Antos is awarded a Freigeist Fellowship from the Volkswagen Foundation for examining the effects of the forcing technique on the foundations of mathematics

What happens when the foundations of a scientific discipline change without the practitioners being aware of this change? This is the case confronting the mathematician and philosopher Dr Carolin Antos in Konstanz. Her major focus so far has been set theory, and now the Volkswagen Foundation has awarded her a Freigeist Fellowship for her project “Forcing: Conceptual Change in the Foundations of Mathematics.” The fellowship is worth approximately 900,000 euros and represents one of the highest endowments in Germany for the promotion of junior researchers with creative minds. The interdisciplinary project will be investigating the conceptual change that has been taking place in mathematics since the advent of the forcing technique in mathematics in the 1960s. Although the mathematics behind these new foundations has been in constant use since then, the resulting new foundations have not yet been thoroughly explained. But, according to Carolin Antos’ theory, they could bring about a revolutionary paradigm shift in both mathematics and in philosophy. A Bridge Fellowship from the Zukunftskolleg at the University of Konstanz enabled Carolin Antos to complete the application for the Freigeist funding.

For a long time the conviction prevailed in mathematics that it was possible to formulate foundations, or axioms, which describe the whole of mathematics. But the Austrian-American mathematician Kurt Gödel (1906 to 1978) demonstrated with his so-called incompleteness theorems that no axiomatization is capable of solving all questions in mathematics. Every axiomatization will contain questions, or sentences, that are ‘independent’, in other words are neither provable nor disprovable and consequently cannot be decided as true or false. In the 1960s the American mathematician Paul Cohen managed to demonstrate the concrete existence of such independent sentences with the help of the forcing method that he developed. Carolin Antos says: “Up to now, there have been no reflections from outside of mathematics that investigate the effects of this on the foundations of mathematics. This is what our project is designed to do.”

The most prominent of these independent questions is the one concerning the cardinality of the set of real numbers. The forcing technique makes it possible to generate extremely diverse mathematical worlds, i.e. models, which answer this question in highly differing ways. The search for the decision that provides these models with the ‘right’ answer leads directly into the fundamental issues of the philosophy of mathematics.

The project’s approach is unusual. Carolin Antos: “I maintain that the change wasn’t brought about by the introduction of the technique, but by its constant and comprehensive use over a long period

of time. Instead of seeing forcing as the final point of a development, we view the technique as the beginning of a new development that has taken place.” Carolin Antos considers the effect of this development on set theory and the foundations of mathematics to be nothing less than revolutionary. “Since that time set theory has changed immensely. Forcing was a pioneering success that triggered everything else,” says the woman who gained her doctorate in mathematics in 2015, but then opted for the philosophical approach to mathematics.

The project will be addressed by three different disciplines in order to illuminate the development of forcing and its significance: the historical section will illustrate the application and the resulting development and practice of forcing in mathematics up to the present; the mathematical section will show how this instrument has reconfigured set theory and consequently the foundations of mathematics; and the philosophical section will investigate the influence forcing has on philosophical questions and on research programmes. The findings in the three individual disciplines will then be combined to form an interdisciplinary description of the role of forcing which in turn can open up a new interdisciplinary field for foundational research in mathematics.

The Volkswagen Foundation’s Freigeist Fellowship aims to promote junior researchers “who operate between established fields of research and want to engage in high-risk research.” This is not the first time that Carolin Antos has received funding for her research into forcing. In 2014 she and the Konstanz philosopher Dr Daniel Kuby received the Bader Prize for the History of the Natural Sciences from the Austrian Academy of Sciences for the historical aspect. Similarly, she has been receiving support for another part of the project since May 2017 from a Marie Skłodowska-Curie Fellowship provided by the European Commission. With this fellowship she is currently researching in the Department of Philosophy with Professor Wolfgang Spohn. Among other institutions, she studied mathematics at the University of Vienna where she gained her doctorate at the Kurt Gödel Research Center for Mathematical Logic.

Facts:

- Project: Forcing: Conceptual Change in the Foundations of Mathematics.
- Funding of about 900,000 euros from a Freigeist Fellowship awarded by the Volkswagen Foundation.
- Five years of funding with a possible three-year extension.
- Commences in May 2018.
- Since May 2017 funding through a Marie Skłodowska-Curie Fellowship worth 170,000 euros.
- From 2016 to 2017 funding through a Bridge Fellowship awarded by the Zukunftskolleg at the University of Konstanz
- The Zukunftskolleg is an interdisciplinary research institution at the University of Konstanz for the promotion of junior researchers. The aim is to enable junior researchers to pursue self-sufficient and independent research from early on within an interdisciplinary, international environment. The Zukunftskolleg is part of the university’s institutional strategy “Modell Konstanz – Towards a Culture of Creativity“ and has been receiving support since 2007 from the Excellence Initiative organised by the German federal and state governments.

<https://www.uni-konstanz.de/zukunftskolleg/>

Note to editors:

You can download a photo here:

<https://cms.uni-konstanz.de/fileadmin/pi/filesserver/2017/Bilder/Antos-Kuby%2C%20Carolin.jpg>

Caption:

Dr Carolin Antos

Photo credits: Universität Konstanz

Video link: Dr Carolin Antos describes her project “Forcing: Conceptual Change in the Foundations of Mathematics”.

https://www.dropbox.com/s/zklmi6hsw7be8ux/2016-10-10_Conceptual-change-Mathematics_Antos_01.mp4?dl=0

Video credits: KIM/Antos

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