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Per Berglund Professor of Physics travels to Germany

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Professor of Physics -- Germany

The CIE grant provided financial support to travel in May 2013 to Hamburg, Germany to visit DESY, the German Electron Synchrotron, one of the world's leading particle accelerators used to study the fundamental constituents of nature and their interactions. My local expenses were covered by a Collaborative Research Center (SFB) fellowship that I was awarded through SFB's 676 "Particle, Strings and the Early Universe--The Structure of Matter and Space-Time" hosted by DESY and the University of Hamburg. Together these awards facilitated two months of visits and collaborations with theoretical physicists at DESY in 2013.

Professors Berglund (left) and Louis discussing compactifications from eleven dimensions to three, and back up to four, during visit to DESY in Hamburg, Germany in May 2013

During my stay at DESY I worked with colleagues at DESY and the University of Hamburg focusing on new aspects of string compactifications. My main collaborator at the University of Hamburg is Professor Jan Louis, one of the lead investigators for the SFB grant. Professor Louis and I study string theory, a leading candidate for a unifying theory of the basic forces in nature. The main premise behind string theory lies in the notion that fundamental objects are one-dimensional strands, or strings, rather than traditional point-like particles. Compactification, in which extra dimensions are made small and compact, is an important aspect of string theory. Through this process, the ten-dimensional spacetime predicted by string theory can be transcribed to the four (three space and one time) dimensional universe we know. Earlier studies have shown that properties of these extra dimensions, such as the size of the compact dimensions, have physical manifestations in our universe; for example the rapid expansion of the early universe, inflation, and the existence of dark energy, which gives rise to the recently observed accelerated expansion of the universe. New data (spring 2013) from the PLANCK satellite have provided further constraints on models of inflation coming from string theory.

Much of my research effort over the years has focused on the mathematical properties of Calabi-Yau manifolds, which are used when compactifying the extra dimensions required by string theory. Together with Professor Balasubramanian at the University of Pennsylvania, we used this information in a study I carried out when I first came to UNH, building on earlier results by Professor Louis and collaborators, to show how the size of the Calabi-Yau space can be fixed. The effect is due to a correction of how one naively computes the volume, i.e., the size, of the manifold, and exists because the strings are extended objects in space rather than particles. With collaborators at the University of Cambridge, Balasubramanian and I were then able to show that there exists a class of Calabi-Yaus where in fact the overall size can be very large while still having some "holes" that are much smaller, giving rise to the notion of so called "Swiss cheese" manifolds. Work at UNH continues in these topics, now capably championed by Herbie Smith, a rising junior and a UNH McNair scholar, who studies properties of these spaces to learn more about the implications for our four-dimensional universe.

In the ongoing project at DESY, together with Professor Louis and Dr. Alexander Westphal of DESY, we are investigating generalizations of the above string theoretic corrections to the size of Calabi-Yau manifold. One such generalization, involves considering an eleven-dimensional version of string theory, where the strings themselves are replaced by membranes. To obtain a four-dimensional spacetime, the idea is to first compactify on a higher dimensional version of a Calabi-Yau space, which results in a spacetime with three dimensions. However, it is possible to recover the standard four-dimensional universe by taking a particular limit of a doughnut-shaped part of the generalized Calabi-Yau. One then can show how the earlier correction arises from the geometry of the higher dimensional manifold and the string/membrane features of the theory.

Visits like the one in May are essential for exchanging ideas between theorists, leading to new projects. I have known Professor Louis for many years, and as mentioned above, his work was essential for both my earlier research as well as the current project. I met Dr. Westphal at a theoretical physics workshop on Generalized Geometry and Flux Compactifications at DESY in 2007, when he was a researcher at SISSA, Trieste, Italy.

We expect that the results of the work done in May to be finalized during the summer months. A natural extension of our study will be to look at the implications of the generalized corrections for determining the size of the extra dimensional space. We will pursue this in the fall, in particular during my return visit to DESY in November. I have also extended invitations to both Professor Louis and Dr. Westphal to visit UNH during 2013/14 (and beyond). In addition to being important for our collaboration, these stays will be beneficial for my students and the greater UNH community. My collaborators will present research seminars and general physics colloquia, the latter which in the past have been attended by high school teachers and students from throughout New Hampshire.

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