Missouri S&T | Mathematics and Statistics

Ingram Lecture Series

The Geometry of the Phase Retrieval Problem in Coherent Diffraction Imaging

Speaker: Dr. Charles L. Epstein
Thomas A. Scott Professor of Mathematics
University of Pennsylvania

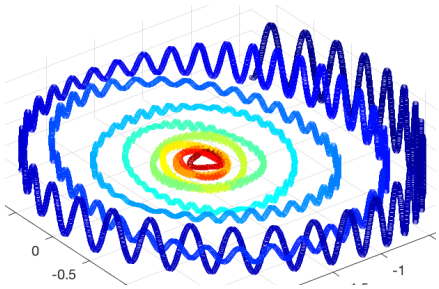
Date: Thursday, March 5, 2020

Location: Toomey Hall, Room 295

Schedule: 3pm: Lecture I (intended for a general audience)
4pm: Light Refreshments
4:30pm: Lecture II

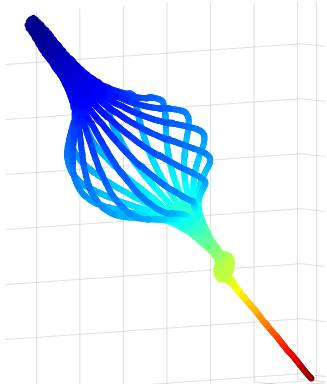
Lecture I (intended for a general audience)

In several high-resolution imaging modalities that use coherent x-rays to illuminate the sample, the measured data can be interpreted as the modulus of the Fourier transform of a function describing the unknown object. The Fourier transform is complex-valued and the phase cannot be measured directly. I will briefly explain the physics that underlies these facts. In order to reconstruct the object from such measurements we must "retrieve" the unmeasured phase of the Fourier transform. To do this requires some auxiliary information about the object, such as its general size and shape. This is a notoriously difficult problem. I will discuss the underlying geometric reasons for these difficulties, algorithms for recovering the phase and approaches to improving their performance.



Lecture II

In the first talk we introduced a geometric formulation of the phase retrieval problem in coherent diffraction imaging (CDI). In that talk we showed how this problem can be formulated as a search for the intersection between two subsets A, B of a very high dimensional space. A is always a torus and B is a subset defined by the auxiliary information, which makes this a non-linear problem. In the second talk we explain why A and B often fail to meet transversely and the effect that this has on the performance of standard algorithms to find the intersections of A and B. This is illustrated with some simple model problems. We then examine the linearization of the maps used to define these algorithms at fixed points, where they display some rather surprising properties. We close our discussion with an entirely different approach to the phase retrieval problem.



About the Speaker:

Dr. Charles L. Epstein is an analyst and applied mathematician with research interests in partial differential equations, medical imaging, mathematical biology, and scientific computation. He received his PhD in Mathematics in 1983 from the Courant Institute, New York University, and completed an NSF Postdoctoral Fellowship at Princeton University in 1986. Since that time, he has been affiliated with the University of Pennsylvania, where he presently holds the positions of Thomas A. Scott Professor of Mathematics and Graduate Group Chair for Applied Mathematics and Computational Science. During his tenure at the University of Pennsylvania, he has also been affiliated with the Department of Radiology in the School of Medicine, as well as the Graduate Groups in Bioengineering and Genomics and Computational Biology. He is the author of over 75 peer-reviewed publications as well as a textbook on the Mathematics of Medical Imaging. His research has been supported by the Sloan Foundation, the NSF, the NIH, and DARPA. In 2014, he became a Fellow of the American Mathematical Society "for contributions to analysis, geometry, and applied mathematics including medical imaging, as well as for service to the profession".

About the Ingram Lecture Series:

After retiring in 2002, Professor W.T. Ingram, who was chair of the Department of Mathematics and Statistics from 1989 until 1998, generously set up an endowed fund in order to bring well-known mathematical scientists to Rolla to give lectures on their work. Visitors brought here under this program typically give one talk suitable for a general audience, along with one talk of a more advanced nature.