In his famous book “A Treatise on Electricity and Magnetism” first published in 1867, J.C. Maxwell made a claim that any configuration of $N$ fixed point charges in $\mathbb{R}^3$ creates no more than $(N-1)^2$ points of equilibrium. He provided this claim with an incomplete proof containing all elements of Morse theory to be created 60 years later. We will discuss what is known at present about his claim which is still open even for 3 charges in $\mathbb{R}^3$. No preliminary knowledge of the subject is necessary.

Professor Shapiro comes to our campus as an INSPIRE scholar. INSPIRE is to establish a transnational partnership alliance between the University of Illinois at Urbana-Champaign (Illinois) and three leading research universities in Stockholm, Sweden.

4:00 p.m.
245 Altgeld Hall
Thursday, February 5, 2015
There is a long standing conjecture on Kaehler Ricci flow in Fano manifolds that the Ricci flow converges sub-sequentially to a Kaehler Ricci solution with at most codimension 4 singularities, with perhaps a different complex structure (so called "Hamilton Tian conjecture"). In this lecture, we will outline a proof for this conjecture. This is a joint work with Bing Wang.

4:00 p.m.
245 Altgeld Hall
Thursday, February 12, 2015
www.math.illinois.edu
The mathematics of geometric clustering

It is often said that "clustering is difficult only when it does not matter." Using tools from convex optimization and non-asymptotic random matrix theory, we aim to make this statement mathematically precise. Our focus will be on the k-means objective, arguably the most popular unsupervised clustering objective; it is NP hard to optimize in the worst case, but implemented heuristically as a pre- and post-processing step a myriad of machine learning algorithms. We will introduce a convex relaxation of the k-means objective, and provide nontrivial geometric conditions on a set of clusters for this convex relaxation is tight. These conditions are then used to derive near-optimal rates for distinguishing clusters in random point cloud models. It is important that in the same regime, heuristic algorithms such as Lloyd's method and kmeans++ will get stuck in local optima. We conclude by discussing open problems suggested by this work related to weighted kernel k-means and spectral clustering. This is joint work with P. Awasthi, A. Bandeira, M. Charikar, R. Krishnaswamy, and S. Villar.
After recalling the classical Schanuel’s conjecture, which encapsulates the transcendence properties of the exponential function, I will describe some functional analogues and their applications to Diophantine problems descending from the Mordell conjecture (theorem of Faltings), as developed by Pila and Zannier. The main tool will be o-minimal geometry. All the notions will be introduced from scratch.
Karen Smith  
University of Michigan

The Magic of Prime Characteristic

Many a calculus student has used the trick $(x+y)^p = x^p + y^p$ to dramatically simplify calculations and sometimes even prove remarkable statements unbelievable to their professors. In this lecture, I hope to show you a context where this trick is valid: the world of "characteristic $p$." This trick has been used to understand complex varieties better—for example, to see that certain cohomology groups vanish or that certain kinds of differential forms exist. It has been used to show that rings of invariants for nice group actions has a particularly nice structure. Most recently, it has been used to show that a natural class of combinatorial algebras called "cluster algebras" arising in many contexts have especially nice properties. The latter work is joint with Angelica Benito, Greg Muller and Jenna Rajchgot.

4:00 p.m.  
245 Altgeld Hall  
Thursday, March 5, 2015
Semirandom methods in combinatorics

The development of the probabilistic method in combinatorics since its inception by papers of P. Erdös has led to groundbreaking results across a broad mathematical landscape. In this talk, I will survey a technique which has come to be known as the semirandom method, starting with the ideas of V. Rödl. Some of the highlights include applications to combinatorial and projective geometry, and most notably the recent proof by Keevash of the existence of combinatorial designs. The main ideas will be discussed, without delving too far into the technical details, and a number of open problems will be presented.
Supercharacters and their superpowers: the graphic nature of exponential sums

The theory of supercharacters was recently developed by P. Diaconis and I.M. Isaacs (based upon earlier work of C. André) to study previously intractable problems in combinatorial representation theory. When this machinery is applied to abelian groups, a wide variety of applications emerge. We develop a “super” version of the discrete Fourier transform and some combinatorial tools. This perspective illuminates several classes of exponential sums that are of interest in number theory while also producing complex-valued functions that display striking patterns of great complexity and subtlety. This talk will be accessible to students and there will be lots of attractive visuals.

(Partially supported by NSF Grant DMS-1265973 and the Fletcher Jones Foundation)

4:00 p.m.
245 Altgeld Hall
Thursday, March 19, 2015
I will discuss ancient solutions in the context of the mean curvature flow, the Ricci flow and the Yamabe flow. I will discuss the classification result in the Ricci flow, construction result of infinitely many ancient solutions in the Yamabe flow. In the last part of the talk I will mention the most recent result about the unique asymptotics of non-collapsed ancient solutions to the mean curvature flow which is a joint work with Daskalopoulos and Angenent.
Every meromorphic function $F$ on a Riemann surface $C$ has a divisor $\text{Div}(F)$ of zeros and poles. When is a divisor on $C$ obtained from a meromorphic function? This question underlies much of the classical study of curves. A modern turn in the subject comes by viewing the answer as a cycle over the moduli space of curves. In 2014, Pixton proposed a complete formula for the class of the associated cycle. I will give an overview of the subject and a sketch of the very recent proof of Pixton’s formula (joint work with Janda, Pixton, and Zvonkine).
Asymptotic dimension (asdim) is the large scale version of the concept of dimension, introduced by Gromov. It applies to metric spaces, and in particular to finitely generated groups. A celebrated theorem of Guoliang Yu implies the Novikov conjecture in manifold theory for groups with finite asdim. In this talk I will discuss some basic examples and explain how hyperbolicity properties of a space can be used to prove finiteness of asdim. If there is time, I will talk about the recent work with Bromberg and Fujiwara that proves that mapping class groups have finite asdim.