Plenary Speakers
Conférences plénières

DAVID ALDOUS, U.C. Berkeley
Scale-invariant random spatial networks

We study the implications of assuming scale-invariance in a mathematical model of road networks. Intuitively, scale-invariance says that the statistics of the network within a window of an online map do not depend on whether the width is 5 miles or 500 miles. Mathematically, scale-invariance forces us to work in the continuum rather than (as in most existing models of spatial networks) on discrete vertex-sets, raising novel foundational issues. One interesting consequence of scale-invariance is a convenient quantification of where a given road section lies on the major road - minor road spectrum. In particular, we introduce a non-obvious numerical statistic $p(1)$ (perhaps very loosely analogous to entropy as a non-obvious statistic of a stationary process?) measuring the density of long-distance routes. This has an intriguing connection with the effectiveness of the route-finding algorithms used by your car's GPS device.

DAVID DONOHO, Stanford
Compressed Sensing: Practical Successes and New Theoretical Frontiers

Compressed sensing can drastically speed up axquisition of signals and images in many applications (eg MRI, radar) by deliberately undersampling and using nonlinear optimization to beat the traditional sampling theory limits. In only a few years it became a popular research area in applied harmonic analysis, information theory, and statistical signal processing, spawning hundreds of papers and some significant applications – for example speeding up pediatric MRIs from 8 minutes to about 1 minute, as shown in pinnacle journals in Radiology.

The most popular mathematical approach, due to Candès, Tao and collaborators, involves asymptotic order bounds; one uses random matrix theory, combinatorics and hard analysis techniques to obtain order bounds how much an object can be undersampled and yet still recovered. A less well-known approach due to myself and Tanner is based on counting faces of random polytopes; it is quantitatively precise. In my talk I will compare these two established approaches and some of their successes and mention other interesting approaches. Then I will discuss a very recent approach which is quantitatively precise, but gives rise to precise information about many topics that previously eluded precise analysis: noise sensitivity, sparsity sensitivity, alternate definitions of sparsity, models of block sparsity, optimal nonconvex optimization. I'll describe some of these new results, which are quite easy to digest as compared to earlier results and formulations. Best of all the new results include a family of algorithms, approximate message passing, which are dramatically faster than the standard 'fast' methods popular today.

SUJATHA RAMDORAI, University of British Columbia,/ Tata Institute of Fundamental Research
Noncommutative Iwasawa theory and Hida families

This talk will be a survey on noncommutative Iwasawa theory. We will present some recent results and discuss the study on noncommutative Iwasawa theory for Hida families, which is joint work with J. Coates.

PETER SARNAK, Princeton University and The Institute for Advanced Study Princeton
The affine sieve and expanders

Many problems concerning the search for prime numbers can be formulated naturally in terms of orbits of a group of affine morphisms of n-space. We will explain this set up as well as the theory of the affine linear sieve, which thanks to a number of striking recent developments connected with "expanders", is now an effective theory. We highlight applications to classical Diophantine problems such as integral Apollonian packings.

CARL WIEMAN, University of British Columbia
Math Education in the 21st Century: Using the methods of science to improve learning

Postsecondary math and science teaching have remained largely true to their medieval roots, while the disciplines themselves have advanced enormously. Modern society needs higher levels of general competence and specialized expertise in these fields. Research on how people develop expertise is providing new insights on how to provide more effective teaching. A number of teaching methods based on these insights have been tested in university classrooms. They have shown substantial improvements over the traditional lecture methods even as practiced by very good lecturers, particularly on measures that explicitly probe how well students are learning to reason like experts. I will discuss recent research on learning and these experiments demonstrating effective teaching methods.

TAMAR ZIEGLER, Technion
Patterns in primes and nilpotent groups

A classical theorem of Dirichlet establishes the existence of infinitely many primes in arithmetic progressions, so long as there are no local obstructions. In 2006 Green and Tao set up a programme for proving a vast generalization of this theorem (falling just short of proving the twin prime conjecture). They conjectured a relation between the existence of linear patterns in primes and dynamics on nilmanifolds. In recent joint work with Green and Tao we completed the final step of this programme.