JOHN BALDWIN, University of Illinois at Chicago
Categoricity Proofs

Over 40 years ago, Morley proved that a first order theory which is categorical (has only one model) in one uncountable cardinality is categorical in all uncountable cardinalities. The theory of the complex field is the prototypical example of this situation. Morley's theorem spawned modern model theory; applications have included results in arithmetic algebraic geometry. Zilber now conjectures an analogous, but no longer first order, categorical axiomatization for the complex field with exponentiation; a first order approach is impossible. There are now several approaches to proving categoricity theorems. Some focus on the existence of a dimension governing the models just as in the case of algebraically closed fields. Others focus on the transfer of 'saturation'. Some have an 'upwards transfer' and a 'downwards transfer' component; others have only one step. We will compare and contrast several of the proofs (for both first order and analogous results in infinitary logic). Such an analysis of proof techniques may shed light both the nature of connections with geometry/algebra and on the distinctions between different logics.

KRISTIN BENNETT, Rensselaer Polytechnic Institute
Optimization Challenges in Machine Learning

In this talk, we examine model selection problems in machine learning and the optimization challenges that they represent. Great progress has been made in machine learning by cleverly reducing machine learning problems to convex optimization problems with one or more hyper-parameters. For example, in support vector machines, highly non-linear classifiers are constructed by solving a convex quadratic program with at least two hyper-parameters specified by the users.

While cross validation is a commonly employed and widely accepted method for selecting these parameters, its implementation by a grid-search procedure in the parameter space effectively limits the desirable number of hyper-parameters in a model, due to the combinatorial explosion of grid points in high-dimensions. Explicitly tackling model selection by cross validation as a bilevel optimization problem allows for efficient systematic search of large numbers of hyper-parameters. We discuss recent progress in solution of the resulting bilevel problems, and the many interesting optimization challenges that remain. Finally, we investigate the intriguing possibility of novel machine learning models enabled by multilevel programming.

RICHARD CLEVE, University of Waterloo and Perimeter Institute
Efficient quantum algorithms for simulating sparse Hamiltonians

A "quantum computer" is a computing device that can exist in a quantum mechanical superposition of several states simultaneously and whose computation paths can interfere with each other. Such computers can perform some remarkable feats, such as efficient integer factorization, which appear to go beyond the capabilities of "classical computers". Another natural and important application area of quantum computers is the efficient simulation of quantum mechanical systems. After some preliminary remarks about quantum computing, we describe some general frameworks in which these simulation problems can be cast and explain how some efficient simulation algorithms work.

This is joint work with Graeme Ahokas, Dominic Berry, and Barry Sanders.

RICHARD KENYON, UBC, Vancouver, BC
Dimers and Limit shapes

We study a natural family of smooth surfaces in R^3 arising as limits of random discrete "stepped" surfaces. For fixed boundary conditions, the law of large numbers for stepped surfaces leads to a PDE for the limit surfaces (when the lattice spacing tends to zero). This PDE is a variant of the complex Burgers equation and can be solved analytically via holomorphic functions. This is surprising since the surfaces generically have both smooth parts and facets. The interplay between analytic (even algebraic) functions and facet formation in the surfaces leads to some interesting questions in real algebraic geometry.

CHARLES READ, University of Leeds, UK
The hypercyclicity problem

We will discuss the recent solution to the hypercyclicity problem, with some new developments.

An operator T on a Banach space X is *hypercyclic* if there is a vector x whose translates $T^r x$ are dense. For the translates thus to take a walk through the whole space is regarded as chaotic behaviour, so this definition is related to the general area of mathematical chaos. There is a well known sufficient condition for T to be hypercyclic, known as the hypercyclicity criterion.

The hypercyclicity problem is the long standing problem of whether the hypercyclicity criterion is also necessary—in fact, it is not, not even on the Hilbert space.

ARNOLD ROSENBERG, University of Massachusetts Amherst, Amherst, MA, 01003, USA
IC-Scheduling Theory: A New Scheduling Paradigm for Internet-Based Computing

Technological and economic developments have made the Internet a viable platform for a new, "collaborative" modality of *Internet-based computing* (*IC*, for short). Within this modality, the owner of a large, typically compute-intensive, computation enlists remote clients to "collaborate" in performing the computation. When the computation's tasks have interdependencies that prioritize their execution, then the *temporal unpredictability* of IC—communication is over the Internet; computing is by clients who arrive at unpredictable times and who are typically not dedicated to the computation—can confute attempts to benefit from "parallel" execution of tasks and can cause a computation to stall for lack of tasks that are eligible for allocation.

In recent papers, we have proposed a new scheduling paradigm that aims to respond to the new challenges of IC. Faced with the impossibility (due to temporal unpredictability) of scheduling to accommodate "critical paths" in a computation, we seek to schedule in a way that always renders as many tasks as possible *eligible for allocation* (to remote clients). This has the dual goal of maximizing the utilization of available clients and minimizing the likelihood of a computation's stalling for lack of eligible tasks. We have formalized this scheduling problem and, under idealized assumptions, have developed the rudiments of an algorithmic theory of how to schedule complex computations for IC.

We begin this talk with the concepts underlying the theory and the algorithms that emerge from them. We then describe several familiar computations and computational paradigms that the nascent theory can schedule optimally. We finally describe simulation experiments whose results suggest that the theory's schedules have a measurable benign effect on "real" Internet-based computing.

DROR VAROLIN, Stony Brook
Extension Theorems in Complex Analysis and Geometry

Since the early 1960s with the work of J. J. Kohn and L. Hörmander, Hilbert space methods have played a central in role in several complex variables. In 1970 E. Bombieri introduced such methods to establish important results in number theory. Shortly after that, H. Skoda used L^2 methods to establish, among many things, central results in commutative algebra. Y.-T. Siu established many deep results in complex geometry, and in the late 1980s T. Ohsawa and K. Takegoshi made a breakthrough in L^2 methods in proving their celebrated extension theorem.

Two major developments came in the 1990s. Around 1992, K. Seip initiated a movement, later joined by R. Wallsten, B. Berndtsson, and J. Ortega Cerdà, to extend Beurling's results about interpolation and sampling sequences from Hardy

spaces to so-called Generalized Bergman spaces. Some of these results were extended to higher dimensions by Forgacs, Ortega Cerdà, Schuster and myself. On the other side of the spectrum, Y.-T. Siu and J.-P. Demailly blew open many very sturdily fortified paths and the area of analytic methods in algebraic geometry has since then grown at an amazing rate. The crowning jewel was Siu's work on the Fujita conjecture and his proof of the deformation invariance of plurigenera, and it looks as though the Fujita and Plurigenera methods will be strong enough to complete many deep and interesting programs in algebraic geometry.

In this talk we will try to give an idea of the nature of the methods behind these results. We will start with the basic Hörmander solution of the dbar equation with L^2 estimates, and some of its applications. We will then review the new twist (literally) introduced by Ohsawa and Takegoshi, and how it relates to interpolation and sampling problems, as well as some extension problems in algebraic geometry.