Plenary Speakers
Conférences plénières

GRACIELA CHICHILNISKY, Columbia University
"The Foundations of Probability and Statistics with Black Swans"

Classical mechanics, probability and statistics neglect rare events. The associated stochastic systems represent smooth transition while real systems exhibit jumps as well as continuous evolution. The universe is bumpy as well as continuous and so are most of natural systems, such as earth shifts, as well as social systems such as the economy and financial markets. We present a new axiomatic treatment of probability and statistics with black swans, which are rare events with momentous consequences. The new axioms differ from traditional axioms of probability and statistics in that we require 'sensitivity to rare events'. A representation theorem identifies a new type of measures on R that has both countably additive and purely finitely additive parts. This leads to distributions with heavy tails, and to stochastic systems that result in jump - diffusion processes through time. The new axioms are compared with the standard axioms of mathematics and probability theory and are shown to differ in a crucial axiom ("Monotone Continuity, S.P.4.") that is generally invoked and is restrictive enough to eliminate heavy tails and to underestimate rare events. The new theory is able to integrate ambiguous features of mathematics and includes aspects of Godel's Incompleteness Theorem as well as the Independence of the Continuum Hypothesis and the Axiom of Choice, and is applied to practical examples of measure theory, probability and stochastic systems in natural systems as well as in financial markets.

TED HSU, Member of Parliament for Kingston and the Islands
Reflections of a new scientist-parliamentarian

How can we communicate the importance of fundamental research? How can we muster a democratic will to take action on climate change? What could be missing in the education of Canadians? What difference could a scientist-politician make in parliament?

Ted Hsu, a former theoretical physicist, and now MP for Kingston and the Islands and the Liberal Party critic for science and technology and economic development in Ontario will share some thoughts about these questions and propose practical suggestions for those who wish they could have a bigger influence on government.

MARTIN NOWAK, Harvard University
Evolution of Cooperation

Natural selection is based on competition between individuals. Cooperation means that individuals help one another. Why competitors should cooperate is a conundrum. Yet cooperation is abundant in nature and can even be seen as the master architect of evolution. Without cooperation there is no construction. The emergence of cells, multi-cellular organisms, animal societies and human language all require cooperation. I present five mechanisms for the evolution of cooperation: kin selection, direct reciprocity, indirect reciprocity, spatial selection and group selection. Direct and indirect reciprocity are the key mechanisms for understanding pro-social behavior among humans and are needed for the survival of intelligent life on earth.

Further Reading:

Nowak MA (2006). Five rules for the evolution of cooperation. Science 314: 1560-1563

Nowak MA, CE Tarnita, EO Wilson (2010). The evolution of eusociality. Nature 466: 1057-1062.

Nowak MA & Highfield R (2011) SuperCooperators. Simon & Schuster.

DUONG H. PHONG, Columbia University
Green's functions and complex Monge-Ampere equations

The classical Green's function plays an important role in function theory of one complex variable or two real variables. In higher dimensions, from the point of view of complex analysis, its proper generalization is as the pluricomplex Green's function, which is a solution of a complex Monge-Ampere equation with a Dirac mass. We discuss the geometric properties of pluricomplex Green's functions, as well as methods for solving such Monge-Ampere equations, with emphasis on a priori estimates, geometric constructions, and the differences with real Monge-Ampere equations.

CATHERINE SULEM, University of Toronto

The Dynamics of Ocean Waves

The theory of ocean waves has been an active topic of research for more than 150 years due to the significance of the sea in human history. The motion of waves is a very complex phenomenon and its study has applications in every aspect of our lives.

I will show how methods of mathematical analysis combined with asymptotic theory and numerical simulations can contribute to a better understanding of propagation and interaction of large amplitude ocean waves, both at the surface of the ocean and in its interior, in regular situations as well as in extreme events.

In particular, I will discuss the influence of bottom topography on wave dynamics. This is an important topic because of its relevance to coastal engineering, sediment transport, and global-scale propagation of tsunamis. The horizontal length scales of tsunamis are so large that even in the deep oceans, their impact depends on the particular topography of the coastline and inshore bathymetry. Uneven topography is also responsible for the generation of internal waves in the oceans. They are commonly observed in regions of sharp changes in temperature or salinity. Local measurements and photographs taken from orbital spacecraft show that their presence has a significant effect on the surface of the sea.