Plenary Lectures
Conférences plénières

STEVE RAYAN, University of Saskatchewan
A Snapshot of Mathematics in the Second Quantum Revolution

We are in the midst of an exciting revolution in quantum science and technology, comparable in ways to the first one that occurred about 100 years ago. One of the most tantalizing and potentially disruptive innovations to emerge from this second revolution is the prospect of quantum computing. Serious attempts in both academia and industry to design practical quantum computers are pushing physical materials to their extremes. The rise of quantum materials, influenced in part by these attempts, has involved new perspectives and tools not only from physics, chemistry, and material science, but also from mathematics — and not only applied mathematics, but also pure mathematics. I will discuss my work over the past half decade in using ideas from pure mathematics — especially from complex algebraic geometry and Riemann surfaces — to anticipate new models of quantum materials as well as new paradigms for programming quantum devices that would result from these materials. I will explain, with lots of pictures, not only the mathematical and scientific ideas here, but also how the path to fabrication and actualization has led to exciting interdisciplinary collaborations between mathematics and other sciences and between academia and industry.

TREVOR WOOLEY, Purdue University
Waring's problem and its relatives

In 1770, E. Waring made an assertion these days interpreted as conjecturing that when k is a natural number, all positive integers may be written as the sum of a number g(k) of positive integral k-th powers, with g(k) finite. This conjecture generalises the familiar theorem of Lagrange showing that all positive integers are the sum of four squares. Since the work of Hardy and Littlewood a century ago, attention has largely shifted to the problem of bounding G(k), the least number s having the property that all sufficiently large integers can be written as the sum of s positive integral k-th powers. The principal tool for investigations associated with Waring's problem, namely the Hardy-Littlewood (circle) method, is Fourier-analytic in flavour. In this talk we survey progress on Waring's problem that has emerged in the past 15 years, its connection with numbers having only small prime divisors as well as recent progress on discrete harmonic analysis, and implications of these recent ideas for cognate problems. Emerging developments, for example, touch on the topic of representing prime numbers as sums of powers, and impact the apparently mundane topic of controlling small solutions of congruences.