Student Research Presentations
Présentations de recherche des étudiants
(Org: **Muhammad Khan** (Calgary) and/et **Kyle MacDonald** (McMaster))

CHIMAOBI AMADI, Brock University
Generation of 7x7 Calcrostic Puzzles and Rational Solution of Highly Underdetermined Polynomial Systems

This talk is on the generation of new types of mathematical 'calcrostic' puzzles. In these puzzles the task is to determine for each letter the corresponding digit that the letter represents such that a number of conditions arranged in the form of a crossword problem are satisfied. Earlier versions of these puzzles were used in Caribou Mathematics Contests with large Canadian and international participation.

Through our work we are able to generate larger calcrostics, now of size 5x5 and 7x7 instead of 3x3, more complicated ones, now involving rational numbers rather than integers, and puzzles that require many more conditions to be satisfied through extra diagonal relations.

Apart from many new procedures that had to be written for handling these new types of puzzles, the key problem was that much larger systems of under-determined polynomial equations needed to be solved with computer algebra. We developed a method of computing special solutions of highly under-determined and highly non-linear, polynomial equations. The new technique was implemented and merged into the computer algebra package CRACK. It was successfully used for the generation of all types of new calcrostic puzzles.

HATEF DASTOUR, The University of Calgary
A computational method for solving an inverse heat conduction problem

In this study, a one-dimensional inverse heat conduction problem with unknown nonlinear boundary conditions is investigated. Nonlinear boundary conditions are imposed involving both the flux and the temperature. The heat transfer coefficient depends on the boundary temperature and the dependence has a complicated or unknown structure. A numerical algorithm is generated, based on a space marching scheme and the mollification method, and its stability and convergence are analyzed. Two numerical examples are tested to illustrate the efficiency of the proposed algorithm.

ARAM DERMENJIAN, University of Quebec at Montreal
Facial Weak Order for finite Coxeter groups

We will discuss a poset structure that extends the weak order on a finite Coxeter group W to the set of all faces of the permutahedron of W. We call this order the facial weak order. We first provide two characterizations of this poset: a local one, which was first studied by Krob, Latapy, Novelli, Phan, and Schwer in the case of symmetric groups, and a global one, that generalizes the notion of inversion sets of roots. These characterizations are the keys to show that the facial weak order is a lattice, generalizing a well-known result of A. Björner for the classical weak order. This is joint work with Christophe Hohlweg and Vincent Pilaud.

RAED MARA'BEH, University of Saskatchewan
Localized Spot Patterns for the Brusselator Reaction-Diffusion System

The Brusselator reaction-diffusion model characterizes dynamical processes of some reaction-diffusion systems in chemistry, physics, biology, and geology. On the sphere, the solutions of the Brusselator system center on a discrete set of points. In this talk, we study the system of differential-algebraic equations (DAEs) that describes the slow dynamics of localized spot patterns for the Brusselator model on the surface of a unit sphere. The DAE system is solved numerically using Matlab's ode15s function. The relationship between the equilibria of the DAE system and the set of elliptic Fekete points is studied.

Precisely, solutions of the DAE system are obtained from solving the elliptic Fekete optimization problem. The optimization problem is solved using the particle swarm optimization method. It is verified that for N = 2, 3,. . . ,8 spots, the equilibrium spot configurations of the DAE system starting from a set of random initial points are elliptic Fekete points.

ZIJIA WANG, University of Calgary

Modelling of Variance and Volatility Swaps with Stochastic Volatility and Jumps

In this presentation, we will introduce the financial derivatives variance and volatility swaps. A general analytic approach for pricing discretely sampled variance and volatility swaps under Heston stochastic volatility model will be presented. We investigate the effect of asset price jumps on fair swaps strikes. The closed form pricing formula for variance swap under exponential Lévy Process will also be discussed.

LIRONG YANG, University of Waterloo

Generalization of two notions in group theory-associativity and order

In this talk, we generalize two group-theoretic ideas as follows.

i) We formalize and prove "the most general setting" to define associativity of a binary function and generalized associativity, i.e. "inserting parentheses in any manner".

ii) By definition, the order of an element is either a positive integer or infinite. Using transfinite recursion, we generalize the notion to the class of ordinals for topological groups. Arithmetical and group-theoretic properties of such generalization are studied. We also discuss examples that lead to further questions.