Monday, 3 July, 2017
9:30 – 10:30

Dispersive Quantization of Linear and Nonlinear Waves

Peter J. Olver
U. Minnesota, USA

Abstract: The evolution, through spatially periodic linear dispersion, of rough initial data leads to surprising quantized structures at rational times, and fractal, non-differentiable profiles at irrational times. Similar phenomena have been observed in optics and quantum mechanics, and lead to intriguing connections with exponential sums arising in number theory. Ramifications and recent progress on the analysis, numerics, and extensions to nonlinear wave models will be discussed

---

Monday, 3 July, 2017
11:30 – 12:00

A Lagrangian variational formulation for nonequilibrium thermodynamics

François Gay-Balmaz
IENS Paris, France

Abstract: We present a Lagrangian variational formulation for nonequilibrium thermodynamics. This formulation extends the Hamilton principle of classical mechanics to include irreversible processes in both discrete and continuum systems. The irreversibility is encoded into a nonlinear nonholonomic constraint given by the expression of entropy production associated to the irreversible processes involved. The introduction of the concept of thermodynamic displacement allows the definition of a corresponding variational constraint. We show that the evolution equations for nonequilibrium thermodynamics admit an intrinsic formulation in terms of Dirac structures. Finally, we illustrate our theory with both finite and infinite dimensional examples, including mechanical systems with friction, chemical reactions, electric circuits, reacting fluids, and moist atmospheric modelling. This is a joint work with Hiroaki Yoshimura.

Monday, 3 July, 2017
14:00 – 15:00

Covariant brackets in Field Theories and Particle Dynamics
Alberto Ibort
UC3M/ICMAT Madrid, Spain

Abstract: The search for covariant formulations of Poisson brackets in field theories has a long history beginning with Peierls' 1952 pioneering work. In this talk we will succinctly review the history of the subject and we establish the ground for a geometrical theory of covariant brackets based on the multisymplectic formulation of Hamiltonian field theories. Recent contributions to the subject describing a covariant Jacobi bracket for relativistic particle dynamics will be also discussed.

Monday, 3 July, 2017
16:00 – 17:00

Hamiltonian and the zeros of the Riemann zeta function
Dorje Brody
Brunel University London, UK

Abstract: The Riemann hypothesis asserts that the nontrivial zeros of the Riemann zeta function should be of the form $1/2 + iE_n$, where the set of numbers $\{E_n\}$ are real. The so-called Hilbert-Pólya conjecture assumes that $\{E_n\}$ should correspond to the eigenvalues of an operator that is Hermitian. The discovery of such an operator, if it exists, thus amounts to providing a proof of the Riemann hypothesis. In 1999 Berry and Keating conjectured that such an operator should correspond to a quantisation of the classical Hamiltonian $H = xp$. Since then, the Berry-Keating conjecture has been investigated intensely in the literature, but its validity has remained elusive up to now. In this talk I will derive a "Hamiltonian" (a differential operator), whose classical counterpart is $H = xp$, having the property that with a suitable boundary condition on its eigenstates, the eigenvalues $\{E_n\}$ correspond to the nontrivial zeros of the Riemann zeta function. This Hamiltonian is not Hermitian, but is symmetric under space-time reflection (PT symmetric) in a special way. A formal argument will be given for the construction of the metric operator to define an inner-product for the eigenstates such that the Hamiltonian is symmetric. The talk is based on the work carried out in collaboration with Carl M. Bender (Washington University) and Markus P. Müller (University of Western Ontario).

Tuesday, 4 July, 2017
9:30 – 10:30

Monge-Ampère geometry and the Navier-Stokes equations

I. Roulstone
U. of Surrey, UK

Abstract: The Monge-Ampère equation plays a key role in an important class of models describing large-scale atmosphere-ocean dynamics, and the geometries associated with its transformation properties symplectic, contact and Khlerian facilitate a classification of flows, including singularities.

In this talk, Monge Ampère structures arising in the incompressible Euler and Navier-Stokes equations in two and three dimensions will be described. A one-parameter family of metrics (with time as the parameter) is associated with such structures, and the evolution of these metrics is governed by the structure of the pressure hessian, and by the geometric invariants of the fluid flow.

Tuesday, 4 July, 2017
11:30 – 12:30

Minimal time splines on the sphere

Jair Koiller
Brazil

Abstract: Robotics and space science motivate the problem of finding a smooth time-parametrized curve, controlled by a bounded acceleration, connecting in minimum time two prescribed tangent vectors of a Riemannian manifold Q. Applying Pontryagin's principle one gets a Hamiltonian system in $T^*(TQ)$. Here we take $Q = S^2(r)$. The $SO(3)$ symmetry allows reducing to five variables (a, v, M_1, M_2, M_3), where v is the scalar velocity, conjugated to a costate variable a and (M_1, M_2, M_3) are costate variables that satisfy $\{M_i, M_j\} = \epsilon_{ijk} M_k$. We derive the Hamiltonian reduced equations and find special analytical solutions, that are organizing centers for the dynamics. Reconstruction of the curve $\gamma(t)$ is achieved by a time dependent linear system of ODEs for the orthogonal matrix R whose first column is the unit tangent vector of the curve and whose last column is the unit normal vector to the sphere. The infinite dimensional version of the time minimal spline problem may be useful in computational anatomy. For this project, some technical issues arising from work by Darryl Holm and his associates will be discussed briefly.
(Joint work with T. Stuchi, P. Balseiro and A.Cabrera)

Tuesday, 4 July, 2017
14:00 – 15:00

Boxes and Loops in Circles and Ovals, Billiards and Ballyards, Squircles and Squovals

Peter Lynch
UC Dublin, Ireland

Abstract: The familiar phase portrait of a simple pendulum shows how a separatrix divides the phase plane into to regions, corresponding to libration and rotation. In many dynamical systems there is a similar separation into orbits known as boxes and loops. This is seen in elliptical billiards, rigid body mechanics, astrodynamics and elsewhere. We will discuss this phenomenon and illustrate it with a variety of examples.

Tuesday, 4 July, 2017
16:00 – 17:00

Title: TBA

Laurent Younès
Johns Hopkins, USA

Abstract: TBA

Wednesday, 5 July, 2017
9:30 – 10:30

Flocks and Form

P. S. Krishnaprasad
University of Maryland, USA

Abstract: Collective behavior in nature has attracted attention across a broad spectrum of observers, ranging from artists, biologists, and ecologists, to engineers, mathematicians and physicists. As our ability to gather data in this arena grows, so does the need for refined tools to analyze it with the aim of uncovering the principles and mechanisms of collective motion. In this talk, we present a new construction of a fiber bundle and connection in the sense of Ehresmann, to study such questions. Taken together with the classical notion of principal bundle structure of configuration space over shape space, the results yield ways to decompose collective motion into kinematic modes and to examine associated energy partitions. This is joint work with Matteo Mischiati.

Wednesday, 5 July, 2017
11:30 – 12:30

A new a affine formulation of Hamiltonian Classical Field Theories of first order

Juan Carlos Marrero
U. de la Laguna, Spain

Abstract: In this talk, I will present a new affine geometric formulation of the Hamilton-de Donder-Weyl equations for a Hamiltonian Classical Field theory of rst order. This formulation may be also used in order to describe the Hamilton-Poincaré field equations associated with a symmetric Hamiltonian Classical Field theory. In order to do this, we will introduce the phase bundle associated with an affine bundle $\tau : A \to P$ and a fibration $\pi : P \to M$. The another important ingredient is a suitable Lie algebroid structure on a vector subbundle of the extended multimomentum bundle associated with the fibration $\pi \circ \nu_0 : \mathcal{M}_0\pi = V^* \to M$. Here, V is the vector bundle associated with the affine bundle A.

Wednesday, 5 July, 2017
14:00 – 15:00

Tailoring the tails in Taylor dispersion
Roberto Camassa
U. North Carolina, USA

Abstract: The interplay between fluid flow and diffusion of a solute in the fluid is a primary mechanism for transport and mixing of substances, and one of the most ubiquitous phenomena in nature. Since the seminal investigation by G.I. Taylor in 1953, it has also been the focus of much mathematical efforts to model it. Taylor's counterintuitive result – that at long times the effective diffusivity determined by the flow scales like the inverse of the tracer's molecular diffusivity – is a classical illustration of mathematical analysis' predictive power and arguably one of the most remarkable effects demonstrated in this context. This talk will report results that focus on the interaction of advection and diffusion with fluid boundaries, such as pipes or ducts, at early and intermediate time scales in the transport process. This can have direct applications to microfluidics. Many microfluidic systems including chemical reaction, sample analysis, separation, chemotaxis, and drug development and injection require precision and control of solute transport. Although concentration levels are easily specified at injection, pressure- driven transport through channels is known to spread the initial distribution, resulting in reduced concentrations downstream. By monitoring the skewness (centered, normalized third moment) of the tracer distribution in laminar, pressure driven flows an unexpected phenomenon can be revealed: The channel's cross-sectional aspect ratio alone can control the shape of the concentration profile along the channel length. Thin channels (aspect ratio << 1) deliver solutes arriving with sharp fronts and tapering tails, whereas thick channels (aspect ratio ˜1) produce the opposite effect. Thus, it is possible to deliver solute with prescribed distributions, ranging from gradual buildup to sudden delivery, based only on the channel dimensions.

Wednesday, 5 July, 2017
16:00 – 17:00

Bi-hamiltonian systems from cluster algebras
Andrew NW Hone
U. Kent, UK

Abstract: Cluster algebras are a new class of commutative algebras whose generators are defined recursively by a process called mutation. Since they were introduced by Fomin and Zelevinsky, they have cropped up in many different

areas of mathematics and physics, ranging from Lie theory and Teichmuller theory to discrete integrable systems and dimer models. An important feature of cluster algebras is that they are equipped with a natural presymplectic structure of log-canonical type. This can be used to construct a large class of symplectic maps, some of which are integrable in the Liouville sense. Here it is shown how a bi-Hamiltonian structure for reductions of Hirota's discrete KdV equation arises naturally from two different bilinear equations associated with cluster algebras.

Thursday, 6 July, 2017
9:30 – 10:30

Gas Dynamics Beyond the Navier-Stokes Approximation
Dave Levermore
U. Maryland, USA

Abstract: Abstract: Corrections to the classical Navier-Stokes system of gas dynamics can be derived from kinetic equations. Traditionally this is done using either a Hilbert or Chapman-Enskog expansion in small Knudsen number, however direct applications of those approaches lead to ill-posed systems beyond the Navier-Stokes approximation. Here we take a different approach based upon balances that preserve an entropy structure. The resulting systems are formally well-posed. The first correction to the Navier-Stokes system is dispersive. It includes earlier approximations by Maxwell, Kogan, Sone, and others.

Thursday, 6 July, 2017
11:30 – 12:30

Time-delay reservoir computers: nonlinear stability of functional differential systems and optimal nonlinear information processing capacity. Applications to stochastic nonlinear time series forecasting
Juan-Pablo Ortega
U. St. Gallen, Switzerland

Abstract: Reservoir computing is a recently introduced brain-inspired machine learning paradigm capable of excellent performances in the processing of empirical data. We focus on a particular kind of time-delay based reservoir computers that have been physically implemented using optical and electronic systems and have shown unprecedented data processing rates. Reservoir computing is well-known for the ease of the associated training scheme but also for the problematic

sensitivity of its performance to architecture parameters. This talk addresses the reservoir design problem, which remains the biggest challenge in the applicability of this information processing scheme. More specifically, we use the information available regarding the optimal reservoir working regimes to construct a functional link between the reservoir parameters and its performance. This function is used to explore various properties of the device and to choose the optimal reservoir architecture, thus replacing the tedious and time consuming parameter scanning used so far in the literature.

Thursday, 6 July, 2017
14:00 – 15:00

A review of mathematical regularization as a model representing small-scale turbulence

Bernard Geurts
U. of Twente, Netherlands

Abstract: Turbulent flow arises in a wide variety of natural and technological situations. While the full richness of turbulence is appreciated qualitatively, a quantitatively accurate prediction is often outside the scope of direct numerical computations. As an alternative, filtered flow descriptions, such as large-eddy simulation (LES), have been proposed and studied intensively, promising a combination of accuracy and computational feasibility. Many heuristic closure models for small-scale turbulence have been put forward to represent their dynamic effects on the large-scale characteristics of the flow. While these models are often effective in reducing the dynamic complexity of the LES approach, accuracy limitations of LES are a matter of ongoing discussion. In this presentation, the alternative offered by mathematical regularization, pioneered already by Leray in the 1930s, is explored. Following the regularization approach for the nonlinear convective terms, the closure model is uniquely connected to the underlying regularization principle, thereby by-passing the heuristic closure modeling that is characteristic of the filtering approach to LES. A number of regularization models will be reviewed and their performance in homogeneous isotropic turbulence and in turbulent mixing will be discussed with particular emphasis to flow at high Reynolds numbers. It will be shown that regularization methods that account for effective dissipation can be accurate at strongly reduced computational costs.

Thursday, 6 July, 2017
16:00 – 17:00

Infinite dimensional integrals and PDEs,and their connections with stochastic and quantum phenomena
Sergio Albeverio
AM and HCM, U. Bonn, Germany

Abstract: A unified picure of infinite dimensional integrals with phase functions motivated by classical mechanics is presented.Relations to quantum and stochastic phenomena are discusssed, stressing asymptotic expansions.Applications including the study of formation of regular structures will be mentioned.

Friday, 7 July, 2017
9:30 – 10:30

Hamiltonian equations of motion and the 'extra' conserved quantity for the Lanchester-Joukowski glider
Charles Doering
U. Michigan, USA

Abstract: Phugoid motion of a self-propelled or gliding aircraft or underwater seacraft is one of the basic modes of flight dynamics. The phugoid has a constant angle of attack with varying pitch caused by a repeated exchange of airspeed and altitude: the vehicle periodically pitches up and climbs and subsequently pitches down and descends. In 1908 Frederick William Lanchester (1868–1946) published a simple mechanical model [1] of phugoid motion that contains two conserved quantities, the usual total (kinetic plus potential) energy and another somewhat mysterious 'extra' one that parameterizes classes of motion including steady level flight, wavy paths and loops, and a singular trajectory. In this talk we consider Hamiltonian descriptions of the equations motion for the variables whose dynamics are contained in the extra conserved quantity. These considerations have been in consultation and collaboration with quite a collection of co-conspirators including Jane Wang, Tony Bloch, Vakhtang Poutkaradze, Melvin Leok, Dmitry Zenkov, Phil Morrison and Darryl Holm himself.

[1] F. W. Lanchester, Aerial Flight: Aerodonetics, London: Constable, 1908.

Friday, 7 July, 2017
11:30 – 12:30

Exact geometric approach to the fluid-structure interactions: dynamics, variational integrators and the role of friction
Vakhtang Putkaradze
U. Alberta, Canada

Abstract: While the theory of variational integrators for mechanical systems is well developed, there applications of these integrators to systems involving fluid-structure interactions have proven difficult. The main difficulty lies in expressing the fluid-structure interactions in the variational form. In this talk, we consider variational approach for a particular type of fluid-structure interactions, namely, the dynamics of a tube conveying fluid. We shall primarily consider the ideal fluid in a tube that can change its cross-section (collapsible tube) and derive a fully three-dimensional, geometrically exact theory for such systems. Our approach is based on the symmetry-reduced, exact geometric description for elastic rods, coupled with the fluid transport and subject to the volume conservation constraint for the fluid. Based on this theory, we derive a variational discretization of the dynamics based on the appropriate discretization of the fluid's back-to-labels map, coupled with a variational discretization of elastic part of the Lagrangian. Time permitting, we shall also present results illuminating the role of friction, and its relationship with constraints in fluid-structure systems, both holonomic and non-holonomic.

The work was partially supported by NSERC and the University of Alberta Centennial Fund.

Friday, 7 July, 2017
14:00 – 15:00

From unbalanced optimal transport to the Camassa-Holm equation
François-Xavier Vialard
U. Paris-Dauphine, France

Abstract: The group of diffeomorphisms of a compact manifold endowed with the Lˆ2 metric acting on the space of probability densities gives a unifying framework for the incompressible Euler equation and the theory of optimal mass transport. Recently, several authors including ourselves, have extended optimal transport to the space of positive Radon measures where the Wasserstein-Fisher-Rao distance is a natural extension of the classical L^2-Wasserstein distance. In this talk, our goal is to show a similar relation between this unbalanced optimal

transport problem which will be presented in details and the Hdiv right-invariant metric on the group of diffeomorphisms, which corresponds to the Camassa-Holm (CH) equation in one dimension. Among others, a surprising application of this geometric point of view is the following: Solutions to the standard CH equation give particular solutions of the incompressible Euler equation on a group of homeomorphisms of $\mathbb{R}^2$ which preserve a radial density that has a singularity at zero.

Friday, 7 July, 2017
16:00 – 17:00

Making gauge symmetries into Casimirs in non-holonomic systems
James Montaldi
University of Manchester, UK

Abstract: In Hamiltonian systems, conserved quantities arising from symmetries give rise to Casimirs on the orbit space, a fact at the heart of symplectic reduction. In non-holonomic systems, even when symmetries do give rise to conserved quantities, these often do not give rise to Casimirs in the same way, at least not for the standard "non-holonomic Poisson bracket" (due to Maschke and van der Schaft). In this talk I will describe a way to modify this (non-)Poisson structure so that the conserved quantities do become Casimirs, and this can in particular be useful for studying stability of relative equilibria via the energy-Casimir method. This is joint work with Luis García-Naranjo.
