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Geometry and Symmetry based Mathematical and Computational Methods

with Applications in Engineering, Science and Education

August 28 - 30, 2015 – SUNY Poly, Department of Mathematics & Physics, Utica, NY

	Friday	Saturday	Sunday
9 am Student Center Theatre	**Cristina Stoica,** Wilfrid Laurier, CA I will review notions of geometric mechanics on finite-dimensional spaces with emphasis on Lie symmetric systems. Specifically, I will touch upon elements of classical mechanics and the theory of Lie group actions on manifolds, co-adjoint orbits, Euler-Poincaré) reduction, momentum maps, Poisson reduction, Casimirs. I will use as case studies the Euler (free) rigid body and the three body problem and point out analogous systems in infinite-dimensional (functional) spaces.	**Holger Heumann,** INRIA, France I can talk about my work with Ralf Hiptmaier on discretisation of advection for differential forms, in particular about the stabilised Galerkin methods. The application in mind is magnetohydrodynamics (MHD) but the focus is rigorous convergence analysis, so besides structure preserving discretisation there is also the aspect of "structure preserving numerical analysis".	**Werner Bauer,** LMD, France Covariant shallow-water equations and their structure preserving discretization: I will give an introductory talk about the stuff that I am currently working on. It is a real world problem in the sense that it allows to actually implement the formulations of the covariant shallow-water equations.
10 am Student Center Theatre	**Tanya Schmah,** Univ. of Ottawa, CA Geodesic motion in diffeomorphism groups appears in many problems in fluid mechanics and image registration. I will introduce Euler-Poincaré) reduction in this setting (EPDiff), momentum, and singular solutions such as pulsons. I will also survey some applications and computational methods, with a focus on medical image registration.	**Mamdouh Mohamed,** KAUST, SA In this talk, the discretization of Navier-Stokes equations using discrete exterior calculus (DEC) is presented. The conservation properties and the numerical convergence of the developed discretization are demonstrated through various incompressible flow test cases on planar and curved surfaces.	**Arzhang Angosthari,** Georgia Tech Hilbert Complexes & Mixed Finite Element Methods for Nonlinear Elasticity: In this talk, a Hilbert complex for nonlinear elasticity together with some of its applications are discussed. The applications include studying arrangements of different phases in solid-solid phase transformations and developing new mixed finite element methods for nonlinear elasticity.
11 am Student Center Theatre	**Michael Karow,** TU Berlin, Germany Numerical projects from Fluids and Elasticity for undergraduates: I report on my experience with an introductory numerical analysis course in project form. The intention is to stimulate discussion how recent developments in numerical analysis can be included in such a course.	**Robert Lowry,** SUNY Suffolk In this talk I will survey Arthur E. Fischer & Jerrold E. Marsden's general approach to the initial value problem, canonical formalism, and the space of gravitational degrees of freedom of general relativity. We will focus on the dynamical structures (Lagrangian, Hamiltonian, and Poisson) of geometric mechanics present in their work. We'll also discuss the role of reduction in these structures and their application in understanding the foundations of specific systems coupled to gravity such as fluids, elasticity, plasmas.	**Carlo Cafaro,** SUNY Poly An Information Geometric Approach to Complexity: In this talk, we will explain our own point of view on the mathematical modeling of natural complex phenomena in terms of information geometry and entropic inference.
12 pm	**Lunch break**	**Lunch break**	**Lunch break**
1:30 pm C012 or Library Lanigan	**Edmond Rusjan,** SUNY Poly Session A.I: Exterior calculus is a generalization of calculus to manifolds. It allows the definitions of differential operators in a coordinate invariant manner, which can then be discretized by intrinsic computation of quantities in the triangles approximating the manifolds. We review exterior derivative, Hodge star, and Lie derivative with examples.	**Anil Hirani,** University of Illinois, IL Session B.I: Introduction to PyDEC Boundary and coboundary for simplicial meshes (finding and highlighting boundaries) Abstract simplicial complexes (examples of graphs, Moebius strip, projective plane, maybe ranking on graphs) Vietoris-Rips complex Computing DEC and FEEC Hodge stars	**Kaushik Kalyanaraman,** U Illinois Session B.II: Using PyDEC for Poisson's equation DEC/FEEC mixed formulation 0 and 2 (scalar) Poisson on square 1 (vector) Poisson on annulus Computing harmonic forms
3 pm	**Coffee break**	**Coffee break**	**Coffee break**
3:30 pm C012 or Library Lanigan	**Andrea Dziubek,** SUNY Poly Session A.II: The minimum of tools neccessary to introduce numerical solution of differential equations into the classroom. Minimalistic introduction to Python Meshing (Gmsh) Visualization (matplotlib, Mayavi) Introduction to FEniCS	**Open Discussion Session**	**Francis Valiquette,** SUNY Paltz The method of equivariant moving frames is a powerful tool for studying geometric properties of submanifolds under the action of a group of transformations. Moving frames are used to construct discrete invariants and invariant numerical schemes, differential invariants, and more. In my presentation, I will introduce the basic algorithms behind the method of equivariant moving frames. As an application, I will explain how to use moving frames to solve differential equations that admit a symmetry group.
5:30 pm	**Dinner time**	**Dinner time**	**Dinner time**

Afternoons will be very informal. The goal will be to foster possible future collaborations. Participants will be able to choose between open discussions and tutorial sessions. Some of these afternoon sessions may run in parallel and if needs and interests arise additional tutorials will be offered on the fly.

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