**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

**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 symmetries. 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.

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**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 as puzzles. I will also survey some applications and computational methods, with a focus on medical image registration.

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**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 about recent developments in numerical analysis that can be included in such a course.

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**12 pm**

- **Lunch break**

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**1:30 pm**

**CH 2 or Library Lounigan**

- **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.

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**3 pm**

- **Coffee break**

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**3:30 pm**

**CH 2 or Library Lounigan**

- **Andrea Dziubek**, SUNY Poly

  Session A.II: The minimum of tools necessary to introduce numerical solution of differential equations into the classroom: Minimalistic introduction to Python, Meshing (Gmsh), Visualization (matplotlib, Mayavi), Introduction to FEniCS

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**5:30 pm**

- **Dinner time**

### Saturday

**9 am**

**Library or C012**

- **Holger Heumann**, INRIA, France

  I can talk about my work with Ralf Hiptmair 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”.

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**11 am**

**Library or C012**

- **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 is demonstrated through various incompressible flow test cases on planar and curved surfaces.

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**1 pm**

**Library or C012**

- **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.

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**3 pm**

- **Coffee break**

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**3:30 pm**

**Library or C012**

- **Open Discussion Session**

### Sunday

**9 am**

**Library or C012**

- **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.

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**11 am**

**Library or C012**

- **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.

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**1 pm**

**Library or C012**

- **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.

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**3 pm**

- **Coffee break**

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**3:30 pm**

**Library or C012**

- **Kaushik Kalyanaraman**, U Illinois

  Session B.II: Using PyDEC for Poisson’s equation: Boundary and coboundary for simplicial meshes (finding and highlighting boundaries) Abstract simplicial complexes (examples of graphs, Moebius strip, projective plane, maybe ranking on graphs) Victoria-Rips complex Computing DEC and FEEC Hodge stars

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**5:30 pm**

- **Dinner time**

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*Aftemoons 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.*

*The workshop is supported by the President Opportunity Fund and the Provost office.*