Nonlocal School on Fractional Equations
NSFE 2022
School Booklet

Department of Mathematics
Iowa State University

June 9–11, 2022

IOWA STATE UNIVERSITY
Department of Mathematics

Nonlocal School on Fractional Equations

NSFE 2022 - June 9 -11, 2022

MINI-COURSES LECTURERS

- **Ovidiu Savin** (Columbia)
- **Mahamadi Warma** (George Mason)

INVITED SPEAKERS

- **Olena Burkovska** (Oak Ridge)
- **Christian Glusa** (Sandia)
- **Robert Lipton** (Louisiana State)
- **Petronela Radu** (Nebraska-Lincoln)
- **Armin Schikorra** (Pittsburgh)
- **Mary Vaughan** (UT Austin)

ORGANIZING COMMITTEE

- **Harbir Antil** (George Mason)
- **Paul Sacks** (Iowa State)
- **Pablo Raúl Stinga** (Iowa State)

REGISTRATION

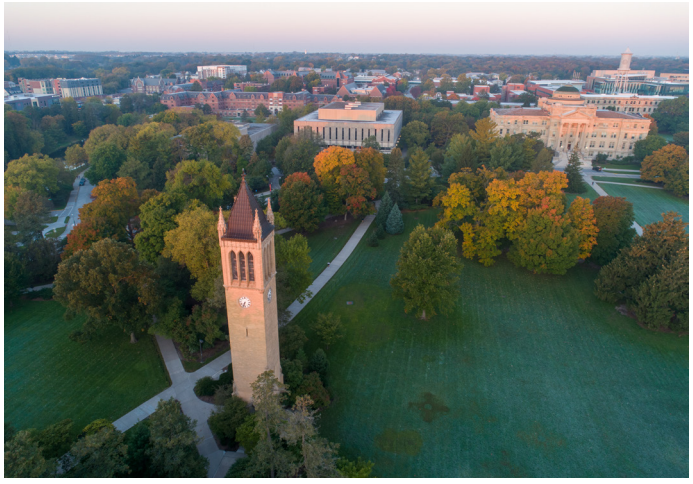
There is no registration fee.

Registration Deadline: May 1, 2022.

CONFERENCE WEBSITE

https://pabloraulstinga.github.io/NSFE2022.html

contact: nsfe@iastate.edu



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Mini-courses

Nonlocal minimal surfaces

Ovidiu Savin

Columbia University

In these lectures I will introduce nonlocal minimal surfaces and present their regularity theory. Nonlocal minimal surfaces appear naturally in the limit of phase field models when long space correlations are present, or in the minimization of the H^s norm for the characteristic function of a set.

The lectures will focus on the tools needed in the blow-up analysis such as density estimates, compactness, monotonicity formula and the improvement of flatness result. In the second part I intend to discuss the regularity of stable cones in 2 dimensions and the uniform BV estimate of stable nonlocal minimal surfaces.

Preliminary material. Some familiarity with the tools in the theory of classical minimal surfaces [E. Giusti, *Minimal Surfaces and Functions of Bounded Variation*, Monographs in Mathematics **80**, Birkhäuser Verlag, Basel, 1984] could be useful but not necessary.

General control theory of linear and semilinear nonlocal (fractional) PDEs

Mahamadi Warma

George Mason University

In the series of the three lectures we will first make a connection between controllability, optimal control, and optimization of general PDEs with state and/or control constraints. Secondly, we will apply this theory to nonlocal (fractional) control problems with state and/or control constraints. Linear and semilinear state constraints will be discussed in detail. I refer to the notes that will be posted in the web site for more details. The lectures will be accessible to a large audience, avoiding unnecessary technicalities.

Invited Conferences

Scalable methods for nonlocal models

Christian Glusa

Sandia National Laboratories

The naive discretization of nonlocal operators leads to matrices with significant density, as compared to classical PDEs. This makes the efficient solution of nonlocal models a challenging task. In this presentation, we will discuss ongoing research into assembly and multilevel solution techniques that are suitable for nonlocal models.

Quasistatic evolution with unstable nonlocal forces

Robert Lipton

Louisiana State University

We consider load controlled quasistatic evolution. Well-posedness results for the nonlocal continuum model related to peridynamics are established. We show local existence and uniqueness of quasistatic evolution for load paths originating at critical points associated with energy minima. These are local minima among the convex set of deformations belonging to the strength domain of the material. The evolution of the displacements however is not constrained to lie inside the strength domain of the material. The load-controlled evolution is shown to exhibit energy balance.

Nonlocal frameworks in physical phenomena and applications

Petronela Radu

University of Nebraska-Lincoln

The emergence of nonlocality as a successful framework for capturing a variety of different physical phenomena has catalyzed research in many directions at the applied, computational, as well as at the theoretical levels. While models formulated with the classical continuum mechanics theory have brought huge developments in technology and science over the last century, the new frontier requires tackling discontinuous, singular, or irregular behavior encountered in many applications such as deformations and damage of solid bodies, phase transitions and image processing. To this end, the study of systems that allow low-regularity (possibly discontinuous) solutions becomes the critical center-piece. In this talk I will present basic nonlocal formulations for elasticity, diffusion, conservation laws, as well as some geometric aspects for studying curvature for boundaries that lack (classical) C^2 regularity. For the corresponding nonlocal systems of equations we will discuss recent results (most of them belonging to the nonlinear realm) that we have obtained with our students and collaborators, as well as ongoing problems and future directions.

On Calderón–Zygmund type estimates for nonlocal PDEs

Armin Schikorra

University of Pittsburgh

I will report on progress obtained for the $W^{s,p}$-regularity theory for nonlocal/fractional equations of differential order $2s$ with bounded measurable kernel. Namely, under (not yet optimal) assumptions on the kernel we obtain $W^{t,p}$-estimates for suitable right-hand sides, where $s < t < 2s$. Technically we compare such equations via a commutator estimate to a simpler fractional equation. Based on joint works with M. Fall, T. Mengesha and S. Yeepo.

Crystal dislocation dynamics in higher dimensions

Mary Vaughan
The University of Texas at Austin

In this talk we will discuss the homogenization of a fractional reaction-diffusion equation which arises naturally in crystallography. First, we will review the Peierls–Nabarro model for straight edge dislocations in crystals. For the corresponding evolutionary problem, a phase parameter is used to describe the ratio between the microscopic and mesoscopic scales, where the dislocations dynamics are characterized by a system of one-dimensional ODEs. We will then present our recent progress on the homogenization problem and the dislocation dynamics in higher dimensions. At the mesoscopic scale, we will exhibit dislocation curves moving by mean curvature. This is joint work with Stefania Patrizi (UT Austin).

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Participants

	Last name	First name	Institution
1	Antil	Harbir	George Mason University
2	Argus	Robert	University of Wisconsin-Madison
3	Banerjee	Aniket	Iowa State University
4	Biswas	Animesh	University of Nebraska-Lincoln
5	Black	McKenzie	University of South Carolina
6	Blanco Drago	Clara	University of Puerto Rico-Mayagüez
7	Buczkowski	Nicole	University of Nebraska-Lincoln
8	Caicedo Torres	Luis	Florida International University
9	Camrud	Evan	Iowa State University
10	Ceretani	Andrea	Universidad de Buenos Aires and CONICET
11	Charro	Fernando	Wayne State University
12	Cueto	Javier	Universidad de Castilla-La Mancha
13	Fallon	Kean	Iowa State University
14	Foss	Mikil	University of Nebraska-Lincoln
15	Glusa	Christian	Sandia National Laboratories
16	Green	Kiefer	George Mason University
17	Guerrero Laos	Marilin Nathalya	University of Puerto Rico-Mayagüez
18	Haeuser	Mitch	Iowa State University
19	Horton	Madeline	George Mason University
20	Huber	Jake	Iowa State University
21	Jing	Tian	University of Pittsburgh
22	Kim	Ju heung	Iowa State University
23	Li	Yulong	University of Nevada Reno
24	Lipton	Robert	Louisiana State University
25	Meraz	Cristian	University of Houston
26	Mesino Espinosa	Efren	University of Puerto Rico-Mayagüez
27	Nguyen	Xuan Hien	Iowa State University
28	Parshad	Rana	Iowa State University
29	Pieper	Michael	University of Nebraska-Lincoln
30	Radu	Petronela	University of Nebraska-Lincoln
31	Raihen	Nurul	Wayne State University
32	Reyes Farina	Silvino	University of Pittsburgh
33	Sacks	Paul	Iowa State University
34	Savin	Ovidiu	Columbia University
35	Sawyer	Shane	University of Tennessee-Knoxville
36	Schikorra	Armin	University of Pittsburgh
37	Scott	James	Columbia University
38	Siktar	Joshua	University of Tennessee-Knoxville
39	Srivastava	Vaibhava	Iowa State University

40	Stinga	Pablo Raúl	Iowa State University
41	Stokols	Logan	Duke University
42	Torres	Céline	University of Maryland-College Park
43	Vaughan	Mary	The University of Texas at Austin
44	Velez-Santiago	Alejandro	University of Puerto Rico-Mayagüez
45	Vincent	Akshara	University of Pittsburgh
46	Warma	Mahamadi	George Mason University
47	Wu	Yaqi	University of Maryland-College Park
48	Yan	Jue	Iowa State University
49	Yastrzhembskiy	Timur	Brown University
50	Zhou	Shiping	Missouri University of Science and Technology

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NSFE 2022 Schedule

Time	**June 9**	**June 10**	**June 11**
8:00-9:00am	registration+breakfast welcome (8:45am)	breakfast	breakfast
9:00-10:00am	Savin	Savin	Savin
10:00-10:30am	coffee break	coffee break	coffee break
10:30-11:30am	Warma	Warma	Warma
11:30-1:30pm	lunch break (your own)	lunch break (your own)	End of the school
1:30-2:30pm	Lipton	Glusa	
2:30-3:30pm	Schikorra	Vaughan	
3:30-4:00pm	coffee break	coffee break	
4:00-5:00pm	Radu	Panel discussion	