Research Interaction Team Plan

Team Name. Numerical Methods for PDE: Analysis and Computation

Team Directors. Georg Dolzmann, Bo Li, Jian-Guo Liu, Ricardo H. Nochetto, John Osborn, and Tobias von Petersdorff.

Research Focus. The numerical analysis group offers a variety of areas of research including basic theory, implementation, and application of finite element methods, finite difference methods, boundary element methods and wavelets. Topics of interest are: multiscale methods and adaptivity, fast algorithms, eigenvalue problems, and applications to materials science, fluid and solid mechanics, and finance. Initial efforts will focus on the following areas:

(1) adaptive finite element and wavelet methods for multiscale PDE: design of algorithms, implementation and experimentation, algorithms for nonconvex minimization;
(2) free boundary problems in materials science, fluid and solid mechanics, approximation of interfaces;
(3) numerical methods for eigenvalue problems in PDE and applications to solid-fluid interactions;
(4) special finite element methods for multiscale problems, connections with homogenization.

The group has a long standing collaboration with CS and links with CSCAMM, NRL, and NIST, which offer additional research and employment opportunities.

Graduate Prerequisites. Introductory PDE (MATH 462) and numerical computation (AMSC 460 or 466). Concurrent enrollment in advanced PDE (MATH 673-674) and numerical analysis and/or scientific computing (AMSC 666 and/or 660). Preference will be given to students who have passed the qualifyng exam in numerical analysis or equivalent number of courses in the area of scientific computation of AMSC.

Undergraduate Prerequisites. Several variable calculus (MATH 241) and differential equations (MATH 246). Concurrent enrollment in scientific computing (AMSC 460) or numerical analysis (AMSC 466).

Graduate Program and Activities. In addition to personal contacts and interaction, the activities of the team are centered around the *numerical analysis seminar* and an *informal seminar*. The former is the traditional forum for discussion, which we have successfully run for more than 30 years now. Most numerical analysts, and to a lesser degree computational scientists, of the US and abroad have spoken in this seminar (check the website `www.math.umd.edu/dept/seminars/nas/`). The informal seminar, instead, offers a relaxed and friendly ambiance for faculty, graduate students and postdocs to communicate their current research or explain seminal papers. For the graduate students and postdocs this informal presentation is a crucial learning and teaching experience, which forces them to focus on essentials and describe main ideas and fundamental concepts. We have experienced over the last 3 or 4 years how important, effective, an enriching this experience is for graduate students, postdocs and faculty alike. We will insist on this format and topics will reflect the areas of Research Focus. Graduate students and postdocs are expected to serve as consultants on undergraduate projects as opportunity allows. Undergraduate students in the team will be encouraged to attend the informal seminar, and will present their own results once completed.

Undergraduate Program. We aim at recruiting undergraduates from AMSC 460 and AMSC 466, not only among bright math majors, but also among bright students in computer science, physics and engineering. Research opportunities include a number of computational activities using Matlab (mainly in 1d), such as implementation of and experimentation with adaptive multiscale algorithms, numerical eigenvalue problems, iterative methods (Krylov and multigrid), preconditioners for model PDE, and wavelets.

Virtual Numerics Lab. This is long term project to be developed by undergraduates, and consists of a high level, user friendly simulator of several (nonlinear) ODE and PDE on the web which would allow for on-line experimentation by changing parameters and visualizing results. Examples include the nonlinear pendulum, population dynamic models, LU and QR decompositions, eigenvalue approximation, and basic PDE in 1d. This site will then be used for teaching within the pilot project of the Dept in courses such as MATH 246 (Elementary ODE), MATH 461 (Linear Algebra), MATH 462 (Elementary PDE), AMSC 466 (Numerical Analysis), and AMSC 460 (Scientific Computing). Undergraduates will work under the direct supervision of graduate students and postdocs, and to a lesser extent faculty, and will disseminate their results in the department and campus-wide seminars.