Population Balance Equations with Applications

A short course organized by IIT Roorkee,

through the GIAN Scheme under MHRD, Government of India

Overview

Engineers, natural scientists and, increasingly, researchers and practitioners working in economics and other social sciences, use mathematical modelling to solve problems arising in their disciplines. Mathematical modelling may lead to many mathematical objects describing the real world. However, most often, the laws of physics and, increasingly, also those of other sciences are expressed in terms of differential or integro-differential equations. If one models systems evolving with time, then the variable describing time plays a special role, as the equations are built by balancing the change of the system in time against its `state space' behavior. Such equations are called *evolution equations.*

There are two main types of conservative laws: those balancing the change of the numbers of interacting objects and those that balance the energy in the process. In these lectures we shall focus on equations of the first type. Here the modelling leads to the so-called kinetic models (similar to Master Equations in the theory of Markov processes), where one considers the loss and gain of objects at a particular state through motion in the physical state as well as through interactions, both with each other and with the environment. A prototype for such equations is the Boltzmann equation describing the dynamics rarefied gases, derived in the XIX century but the argument leading to that equation, over the years has been extended to a range of problems in epidemiology, genetics, learning, chemical engineering and in many other fields. During these lectures, we will introduce

- transport models and their generalizations, including network transport and McKendric population equation
- Smoluchowski- Müller fragmentation-coagulation processes, whose applications range from polymerisation processes of chemical engineering, through rock crushing and planetesimal formation, to algae dynamics and animal groupings, and we will discuss a selection of them. Models of that type are known to practitioners in science and engineering and many of them have well established explicit solutions (that will be mentioned in the course). However, in some case these solutions have properties that are pathological from the applications point of view.

Objective

The primary objectives of the course are as follows:

- Exposing participants to the fundamentals of building kinetic type models in various areas of natural sciences and engineering – in particular, the transport models, and the Smoluchowski- Müller coagulation-fragmentation equation.
- Providing participants with tools for constructing explicit solutions to selected models and determining whether they are physical or unphysical.
- Making the participants conversant with basic tools of functional analysis, dynamical systems theory and numerical analysis.

- Exposing the participants to the methods of qualitative analysis of selected models with identification of pathological ranges of parameters and investigations of the break-down of well-posedness.
- Discussion on convergence analysis of various numerical methods for solving population balance equations.

Course participants will learn the topics through lectures and tutorials. Also case studies and assignments will be shared to stimulate research motivation of participants

Dates	**26th November to 30th November, 2018**
Host Institute	**IIT Roorkee**
You Should Attend If…	➢ PhD students/ postdocs, faculties and young researchers in applied sciences/ engineering interested in learning and mastering mathematical techniques for analyzing quantitative problems in their fields ➢ Students at from Senior Undergraduate to Postgraduate levels (BTech/MSc/MTech) interested in mathematical methods in applied sciences **Number of participants for the course module will be limited.**
Course Registration Fees	➢ **Students (BTech/MTech/MSc/PhD):** Rs.2500. ➢ **Participants from academic/technical/R&D institutions/industry:** Rs. 5000 . ➢ **Participants from abroad:** US $ 250. The above fee includes all instructional materials, computer use for tutorials and assignments, free internet facility. The participants will be provided with accommodation on payment basis. Hotel accommodation may also be arranged on payment basis at nearby places, if required.

The Faculty

Prof. Jacek Banasiak

Email: Jacek.Banasiak@up.ac.za

Jacek Banasiak is a Professor at University of Pretoria from January 2015. He is also serving as DST/NRF SARCHI Chair in Mathematical Models and Methods in Biosciences and Bioengineering. He obtained his MSc (Engineering) from the Technical University of Łódź in 1981 and PhD from the Strathclyde University in Glasgow in 1989 on elliptic and parabolic problems in irregular domains. Later, his Habilitation (DSc) conferred by the University of Warsaw in 1999 and the State title of Professor conferred by the President of the Republic of Poland in 2007. In 1992, he joined the Department of Mathematics and Applied Mathematics at the University of Natal and was there as a Senior Professor since 2008-2015 and a Research Professor 2011-2015.

Prof. Banasiak has authored/co-authored 5 research monographs including: *Methods of Small Parameter in Mathematical Biology*, Birkhäuser, 2014, (with M. Lachowicz), *Difference and Differential Equations in Mathematical Modelling*, Cambridge University Press, *2013*, *Perturbations of positive semigroups with applications*, Springer, 2006, (with L. Arlotti), and *Singularly Perturbed Evolution Equations with Application to Kinetic Theory*, World Scientific, 1995 (with J.R. Mika). *He has* published over 100 refereed research papers. He is also a Visiting Professor at the University of Strathclyde, UK since 2010.

Fields of interest: Functional analysis and semigroup theory with applications to models in natural and physical sciences, dynamical systems, asymptotic analysis and methods of small parameter, network dynamics.

Research interests: Nonlocal integro-differential models in kinetic theory, mathematical biology and fragmentation-coagulation theory, asymptotic analysis of multiple scale problems, asymptotics of dynamical systems of networks, structured population dynamics

Prof. Ankik Kumar Giri

Email: ankikgiri.fma@iitr.ac.in

Ankik Kumar Giri is an Assistant Professor in Mathematics at IIT Roorkee, Roorkee, India since June 2014. He received his PhD in Mathematics from International Max-Planck Research School at Otto-von-Guericke University, Magdeburg, Germany in 2010. After completing his PhD, he worked as a Postdoctoral Fellow at Montan University Leoben, Austria since 2010-2012. Later, he served as a Research Scientist at Radon Institute for Computational and Applied Mathematics (RICAM), Austrian Academy of Sciences, Linz, Austria since 2012-2014. He has authored one monograph on *Mathematical and Numerical Analysis for Coagulation-Fragmentation Equations* in 2011. Dr. Giri has published several research papers in the international refereed journals.

Research interests: Partial-integro differential equations, Coagulation and fragmentation processes, Stochastic PDEs and regularization theory for Inverse problems.

Important Dates

Registration Deadline: October 15, 2018

Classes start: November 26, 2018

Classes end : November 30, 2018

Venue

Department of Mathematics
Indian Institute of Technology
Roorkee, Roorkee-247667
www.iitr.ac.in

Course Co-ordinator

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For registration visit:
http://www.gian.iitkgp.ac.in/GREGN

REGISTRATION AND ACCOMODATION REQUEST FORM

(to reach electronically by 5th October, 2018)

POPULATION BALANCE EQUATIONS WITH APPLICATIONS

November 26-November 30, 2018

Department of Mathematics

Indian Institute of Technology Roorkee

Roorkee, Uttarakhand

After Completion, please mail to: **Dr. Ankik Kumar Giri** **Department of Mathematics** **Indian Institute of Technology Roorkee** **Roorkee, Uttarakhand-247667, India** **Phone: +91-1332-284818(O)** **Mobile no: +91-8439188828** **Email: ankikgirifma@iitr.ac.in,** **ankik.math@gmail.com**	**Affix passport size photograph**

- Name of Applicant(in block letters):
  Ms./Mr./Dr……
- Status (Mark anyone): Student…….. Not a student……..
  (a) If a Student:
  Academic program under which registered currently…… …
  Date since when registered…… …
  Name of Academic/ Research Institution……
  (b) If not a Student
  Nature of employment (Teaching, Research, Govt. service, NGO, Industry)……..
  Organization where employed……
  Employed since…… Designation……..
  Academic qualifications……..
- Full Postal Address for Communication:
- Email id:
- Phone numbers: Mobile…….. Landline……..

Date: Signature of applicant

(i) Scanned copy must be sent by an e-mail to ankikgirifma@iitr.ac.in by 5th October, 2018.
(ii) The seats are limited and will be filled generally on the first come first serve basis. Decision of the course coordinator will be final in this regard.
(iii) Please start your travel to Roorkee to attend the course only if you have received a formal confirmation.