研究集会「異常拡散の数理とシミュレーション手法ならびに関連する課題」
(Conference on Diffusion in Heterogeneous Media and Related Topics)

数理科学研究科棟
Room 002

6 March (Thursday) 2014

10:00-10:10: Opening

10:10-11:00:
J. Cheng (Fudan Univ.)
"The Mathematical Model for the Contamination Problems and Related Inverse Problems"

11:10-12:00
W. Rundell (Texas A&M Univ.)
"Inverse problems with fractional derivatives in the space variable".

13:30-14:20
T. Kumagai (Kyoto Univ.)
"Simple random walk on the two-dimensional uniform spanning tree and its scaling limits"

14:30-15:20
Y. Luchko (Beuth Technical University of Applied Sciences):
"Neutral-fractional diffusion-wave equation and some properties of its fundamental solution"

15:20-16:10
S. Hirano (Univ. Tsukuba)
“An integral representation and numerical simulation of dynamic earthquake faulting occurring in a two-layered medium”

16:20-17:10
M. Cristofol (Aix-Marseille Univ.)
“New kind of observations in an inverse parabolic problem”

18:00-: Group discussions

7 March (Friday)

10:00-10:50
L. Ling (Hong Kong Baptist Univ.)
"Numerical Caputo differentiation by radial basis functions"

11:00-11:50
Benny Hon (City Univ. of Hong Kong)
"Kernel-based approximation method for backward time-fractional diffusion problem"

13:30-14:20
Yasumasa Miyazawa (JAMSTEC)
"Dispersion of materials in ocean: observation and modeling"

14:20-15:10
Y. Hatano (Tsukuba Univ.)
TBA

15:10-16:00
T. Aoyama (Tsukuba Univ.)
"Diffusion of radioactive Suspended Particulate Matter (SPM) in the atmosphere"

16:10-16:40
Z. Li (The Univ. of Tokyo)
“Initial-boundary value problem for multi-time-fractional diffusion equation and its inverse problems”

16:40-17:10
Y. Liu (The Univ. of Tokyo)
“Well-posedness and numerical simulation for multi-term time-fractional diffusion equations with positive constant coefficients”

17:10-17:50
T. Li (Southeast Univ.)
“ On the efficient computations for transmission eigenvalue problems arising in wave scatterings”

8 March (Saturday)

10:00-10:50
R. Guglielmi (Bayreuth University)
"Null controllability of degenerate/singular parabolic equation"

10:50-11:40
J. Liu (Southeast Univ.)
“Total variation regularization for backward time-fractional diffusion problem”

11:40-12:30
Daijun Jiang (Central China Normal University)
“Convergence Rates of Tikhonov Regularizations for Parameter Identification in a Parabolic-Elliptic System”

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ABSTRACT

J. Cheng (Fudan Univ.)
"The Mathematical Model for the Contamination Problems and Related Inverse Problems"
In this talk, we discuss the motivation for the study of the abnormal diffusion models for the contamination problems. From the practical point of view, several inverse problems proposed and studied Theoretic results, for example, the uniqueness and stability are shown. The possibility of the application of these studies is mentioned.

W. Rundell (Texas A&M Univ.)
"Inverse problems with fractional derivatives in the space variable".
This talk will look at some classical inverse problems where the highest order term in the spatial direction is replaced by a fractional derivative. There are again some surprising results over what is known in the usual case of integer order derivatives but also quite different from the case of fractional diffusion in the time variable.
The talk will give some answers, but pose many more open problems.

T. Kumagai (Kyoto Univ.)
"Simple random walk on the two-dimensional uniform spanning tree and its scaling limits"
In this talk, we will first discuss anomalous asymptotic behavior of simple random walk on the two-dimensional uniform spanning tree. We then show the existence of subsequential scaling limits for the random walks, and describe the limits as diffusions on the limiting random real trees. Anomalous heat transfer on the random real trees will be derived by estimating heat kernels of the diffusions. This is an on-going joint project with M.T. Barlow (UBC) and D. Croydon (Warwick).

Y. Luchko (Beuth Technical University of Applied Sciences)
"Neutral-fractional diffusion-wave equation and some properties of its fundamental solution"
Recently, the so called neutral-fractional diffusion-wave equation was introduced and analysed in the case of one spatial variable. In contrast to the fractional diffusion of diffusion-wave equations, the neutral-fractional diffusion-wave equation contains fractional derivatives of the same order both in space and in time. The fundamental solution of the neutral-fractional diffusion-wave equation was shown to exhibit properties of both the solutions of the diffusion equation and those of the wave equation.
In the one-dimensional case, the fundamental solution of the neutral-fractional diffusion-wave equation can be interpreted as a spatial probability density function evolving in time. At the same time, it can be treated as a damped wave whose amplitude maximum and the gravity and mass centres propagate with the constant velocities that depend just on the equation order.
In this talk, the problems mentioned above are considered for the multi-dimensional neutral-fractional diffusion-wave equation. To illustrate analytical findings, some results of numerical calculations and plots are presented.

Shiro Hirano（Univ. of Tsukuba）
“An integral representation and numerical simulation of dynamic earthquake faulting occurring in a two-layered medium”
Earthquakes are dynamic rupture and slip along cracks embedded in rocks.
Wave field due to dynamic rupture is represented as an integral transform of slip along an expanding crack, so that bounded integration kernels for the transform are required depending on surrounding media to simulate earthquakes numerically.
Although the kernel for an infinite homogeneous medium have been obtained, actual rocks surrounding faults are inhomogeneous and often modeled as a layered medium.
Hence we here derive the kernels for a two-layered medium and simulate dynamic rupture propagation intersecting with a material interface.

M. Cristofol (Aix-Marseille Univ.)
“New Kind of Observations in an Inverse Parabolic Problem”
In this talk, I analyze the inverse problem of determining the reaction term f(x,u) in reaction-diffusion equations of the form ¥partial_t u-D¥partial_{xx}u = f(x,u), where f is assumed to be periodic with respect to x in R. Starting from a family of exponentially decaying initial conditions u_{0,¥lambda}, I will show that the solutions u_¥lambda of this equation propagate with constant asymptotic spreading speeds w_¥lambda. The main result shows that the linearizationof f around the steady state 0,¥partial_u f(x,0), is uniquely determined (up to a symmetry) among a subset of piecewise linear functions, by the observation of the asymptotic spreading speeds w_¥lambda.

L. Ling (Hong Kong Baptist Univ.)
"Numerical Caputo differentiation by radial basis functions"
Previously, based on the method of (radial powers) radial basis functions, we proposed a procedure for approximating derivative values from one-dimensional scattered noisy data. In this talk, we show that the same approach also allows us to approximate the values of (Caputo) fractional derivatives (for orders between 0 and 1). With either an a priori or a posteriori strategy of choosing the regularization parameter, our convergence analysis shows that the approximated fractional derivative values converge at the same rate as in the case of integer order 1.

Yasumasa Miyazawa (JAMSTEC)
"Dispersion of materials in ocean: observation and modeling"
This talk provides a brief introduction to a view of materials dispersion in physical oceanography. A classical theory has been developed partly motivated by necessity of tracking artificial radionuclides emitted into the ocean. The turbulence viscosity/diffusion coefficients involved in the theory, which could be basically isotropic and stationary, have been frequently adopted for the analyses in the literature. Recent severe marine accidents including the Deep Water Horizon oil rig in Mexico Bay (2010) and Fukushima Dai-ichi Nuclear Plant (2011) have revealed quite un-isotropic and un-stationary features of materials dispersion in ocean through utilization of the advanced measurement and simulation techniques. A Lagrangian-type concept originating from the classical continuum mechanics has been recently proposed for understanding of the complex features of materials dispersion in ocean.

T. Aoyama (Tsukuba Univ.)
"Diffusion of radioactive Suspended Particulate Matter (SPM) in the atmosphere"
Meteorological approach of non-reactive matters in the atmosphere Practical puff model of Japan Atomic Energy Agency Gaussian extensions to include chemical reactions Equation of motion of Gaussian puff Decay and gamma-ray flux of fission products; Interaction with human body Simulation for radioactive SPM in the Fukushima accident; comparison with observations.

Z. Li (The Univ. of Tokyo)
"Initial-boundary value problem for multi-time-fractional diffusion equation and its inverse problems"
We investigate the initial-boundary value problem for multi-term time-fractional diffusion equation. By means of the Mittag-Leffler function and the eigenfunction expansion, the problem is reduced to an integral equation for a solution. The fixed-point theorem is then applied to prove the unique existence. For the case of the homogeneous equation, the solution can be analytically extended to a sector in the complex plane. Moreover, the decay rate of the solution is shown to be determined by the lowest order of fractional time-derivative.
For the inverse problem, we focus on the determination of the fractional orders in the diffusion model by interior observation or Dirichlet-to-Neumann map, which is important for experimentally evaluating the anomaly of the diffusion in heterogeneous medium.

Y. Liu (The Univ. of Tokyo)
"Well-posedness and numerical simulation for multi-term time-fractional diffusion equations with positive constant coefficients"
We investigate the initial-boundary value problem for time-fractional diffusion equations, where the time differentiation consists of a finite summation of Caputo derivatives with decreasing orders and positive constant coefficients. Based on several new properties of multinomial Mittag-Leffler functions, we establish the uniqueness and stability of the solution with respect to initial value and source term, from which the continuous dependency of Lipschitz type upon various coefficients is also verified. Concerning the numerical simulation, we develop a standard Galerkin finite element method and a fully discrete scheme, and give error estimates. This is a joint work with Dr. Bangti Jin (UC Riverside), Prof. Raytcho Lazarov and Mr. Zhi Zhou (Texas A&M Univ.).

T. Li (Southeast Univ.)
" On the efficient computations for transmission eigenvalue problems arising in wave scatterings"
Abstract: Transmission eigenvalue problems arise in many applied areas such as wave scatterings. It was found in resent years that such problems are related to some reconstruction schemes for inverse scattering problems. However, the efficient computations for the transmission states are very difficult due to some extra complex eigenvalues for the discrete system which are not physical meaningful. In this talk, we will introduce our recent works for the efficient computations of transmission eigenvalues for our discrete system which is of the size of 100 thousands. Moreover, out scheme can yield the real eigenvalues automatically.

R. Guglielmi (Bayreuth University)
"Null controllability of degenerate/singular parabolic equation"
We study the controllability properties of a class of generalized Grushin operator of parabolic type, when the degeneracy occurs in the interior of the space domain. We show that the null controllability holds true only when the degeneracy of the operator is weak, and possibly under minimum time assumptions. The positive results lies on suitable Carleman estimates. Moreover, in connection with the study of the Laplace-Beltrami operator on manifold with almost Riemannian metrics, we analyze the case of a Grushin operator with a inverse square singular potential, and we show partial positive result on the null controllability of this operator.

J. Liu (Southeast Univ.)
"Total variation regularization for backward time-fractional diffusion problem"
Consider a 2-dimensional backward problem for time-fractional diffusion process, which can be considered as image de-blurring where the blurring process is assumed to be slow diffusion. In order to avoid the over-smoothing effect for object image with edges and to construct a fast reconstruction scheme, the total variation regularizing term and the data residual error in the frequency domain are coupled to construct the cost functional. The well-posedness of this optimization problem is studied. The minimizer is sought approximately using the iteration process for a series of optimization problems with Bregman distance as penalty term.
This iteration reconstruction scheme is essentially a new regularizing scheme with coupling parameter in the cost functional and the iteration stopping times as two regularizing parameters. We give the choice strategy for the regularizing parameters in terms of the noise level of measurement data, which yields the optimal error estimate on the iterative solution. The series optimization problems are solved by alternative iteration with explicit exact solution and therefore the amount of computation is much weakened. Numerical implementations are given to support our theoretical analysis on the convergence rate and to show the significant reconstruction improvements.

Daijun Jiang (Central China Normal University)
"Convergence Rates of Tikhonov Regularizations for Parameter Identification in a Parabolic-Elliptic System"
We shall study the convergence rates of the Tikhonov regularizations for the identification of the diffusivity $q(¥x)$ in a parabolic-elliptic system. The H^1 regularization and a mixed L^p-H^1 regularization are considered. For the H^1 regularization, we present a simple and easily interpretable source condition, under which the regularized solutions will be shown to converge in the standard rate in terms of the noise level of the data. The convergence is analyzed
in three different approaches, which result in the same convergence rate but require quite different conditions on the measurement time and the identifying parameters. For the mixed L^p-H^1 regularization, we will achieve some desired convergence rate by using the Bregman distance and some new source condition and nonlinearity condition.