PDE Model and Nonlinear Waves for Fluids and Plasma Workshop

Sanya, Hainan, China

December 25-29, 2017

Contents

1 Schedule

PDE Model and Nonlinear Waves for Fluids and Plasma Workshop
December 25-29, 2017

Talks: All talks are forty-five minutes (ideally, it is designed to be forty-minute talk plus five-minute questions and answers)
There is a five-minute short break between talks.
There are thirty-minute coffee breaks in the morning and afternoon sessions.
Banquet: Evening of December 26, Tuesday
Tourism: Afternoon of December 26, Tuesday

Time&Date	Monday (December 25)	Tuesday (December 26)	Wednesday (December 27)	Thursday (December 28)	Friday (December 29)
7:30-8:30	*Breakfast (60 minutes)*				
Chair	Yue Liu	Wen-An Yong	*Zheng-An Yao*	Huijiang Zhao	
8:30-8:35	Opening Ceremony & Group Photo	———	———	———	———
8:35-9:20	Boling Guo	Chongchun Zeng	Zhiwu Lin	Yi Zhu	
9:20-10:05	Shuming Sun	Guilon Gui	Zhaohui Huo	Juan-Ming Yuan	
10:05-10:30	*Coffee Break(25 minutes)*				
Chair	Ronghua Pan	Daiwan Huang	Shijin Ding	Yongsheng Li	
10:30-11:15	Shu Wang	Jian Zhang	Huijiang Zhao	Chunyou Sun	
11:15-12:00	Zhaoyang Yin	Ming Chen	Jingjun Zhang	Ting Luo	
12:00-13:30	*Lunch (90 minutes)*				
Chair	Shouchuan Hu	Free Discussion 13:30-17:00	Chongchun Zeng	Shu Wang	
14:00-14:45	Ronghua Pan		Baoxiang Wang	Xueke Pu	
14:45-15:30	Linghai Zhang		Hao Zhu	Shihui Zhu	
15:30-16:00	*Coffee Break(30 minutes)*		*Coffer Break(30 minutes)*		
Chair	Shuming Sun		Baoxiang Wang	Zhiwu Lin	
16:00-16:45	Yao Yao		Geng Chen	Zhouping Xin	
16:45-17:30	Daiwen Huang		Nan Liu	Hui Yu	
17:30	*Dinner*	Banquet 18:00-20:00	*Dinner*		

2 Program

Rogue waves and turbulence in integrable systems

Boling Guo, Institute of Applied Physics and Computational Mathematics

Abstract: In this talk, we review some development of the study in the rogue waves, the integrable turbulence and the formation of rogue waves.

Mathematical theory of solitary or multi-solitary water waves

Shuming Sun, Virginia Polytechnic Institute and State University

Abstract: The talk will discuss recent development on the existence and stability of two- and three-dimensional solitary or multi-solitary surface waves on the water of finite depth with or without surface tension using the exact governing equations (called Euler equations). The fluid is assumed to be incompressible and inviscid with a constant density (one common example is water) and the flow is irrotational. The surface wave is propagating with a constant speed on the free surface under gravity and small surface tension. It will be shown that when the non-dimensional wave-speed and surface tension are in various regions, the Euler equations possess several different kinds of two- or three-dimensional solitary or multi-solitary wave solutions. Moreover, some stability results for these waves will be addressed, such as transverse instability, spectral stability, asymptotic linear stability or conditional stability.

流体力学中的若干数学问题的最新进展

王术，北京工业大学应用数理学院

摘要: 将讨论粒子输运过程中一些耦合外势场的流体动力学方程中的若干问题，包括三维不可压轴对称 Euler/Navier-Stokes 方程解的整体正则性、不可压磁流体动力学方程的边界层理论、电磁流体动力学模型的适定性与渐近极限、漂流扩散模型的拟中性极限等问题，主要综述这些问题并介绍我与合作者在这些问题研究中所取得的最新进展。

The Liouville theorem and the L^2 decay for the FENE dumbbell model of polymeric fluids

Zhaoyang Yin, School of Mathematics, Sun Yat-sen University

Abstract: In this talk, we mainly investigate the finite extensible nonlinear elastic (FENE) dumbbell model with dimension $d \geq 2$ in the whole space. We first prove that there is only the trivial solution for the steady-state FENE model under some integrable condition. The obtained results generalize and cover the classical results for the stationary Navier-Stokes equations. We then obtain the L^2 decay rate of the velocity of the co-rotation FENE model is $(1+t)^{-\frac{d}{4}}$ when dimension $d \geq 3$. We finally obtain the L^2 decay rate of the velocity of the 2D co-rotation FENE model is $(1+t)^{-\frac{1}{2}}$. Our obtained results are sharp and improve considerably the recent result of Schonbek in SIAM J. Math. Anal. in 2009.

Incompressible MHD Without Resistivity on Periodic Boxes

Ronghua Pan, Georiga Institute of Technology, USA

Abstract: We study the global existence of classical solutions to the 3D incompressible viscous MHD system without magnetic diffusion on periodic boxes. In Eulerian coordinate, we employ a specially designed time-weighted energy estimates to show that if the initial data is close enough to a non-trivial magnetic equilibrium along with some symmetries over the periodic boxes, then the initial value problem admits a unique global classical solution. This is a joint work with Yi Zhou and Yi Zhu.

Several properties of the global smooth solutions of a nonlinear singular system of differential equations arising from geostrophics

Linghai Zhang, Lehigh University, USA

Abstract: We study the Cauchy problems for a nonlinear singular system of differential equations arising from geostrophics. Recently, we found that there exist a few very important special structures in the system. By making complete use of the special structures, we derive several new energy estimates. The main results include the existence, the decay estimates with sharp rates, the exact limits and various stability estimates of the global smooth solutions of the Cauchy problems for the nonlinear singular system of differential equations.

Finite time singularity of a vortex patch model in the half plane

Yao Yao, Georgia Institute of Technology, USA

Abstract: The question of global regularity v.s. finite time blow-up remains open for many fluid equations. In this talk, I will discuss a family of equations which interpolate between the 2D Euler equation and the surface quasi-geostrophic (SQG) equation. We focus on the patch dynamics for this family of equation in the half-plane, and obtain the following results: For the 2D Euler patch model, the patches remain globally regular even if they initially touch the boundary of the half-plane; whereas for the family of equations that are slightly more singular than the 2D Euler equation, the patches can develop a finite-time singularity. This talk is based on a joint work with A. Kiselev, L. Ryzhik and A. Zlatos.

On ergodicity of 2D stochastic primitive equations of the large-scale ocean

Daiwen Huang, Institute of Applied Physics and Computational Mathematics

Abstract: In this talk, we give some results on stochastic primitive equations of the large-scale ocean. Firstly, we recall the global well-posedness and long-time dynamics for the viscous primitive equations describing the large-scale oceanic motion with white noise. Secondly, we introduce some results on ergodicity of the stochastic primitive equations driven by degenerate noise.

Instability and Center Manifolds of Traveling Waves of the Gross-Pitaevskii Equation

Chongchun Zeng, Georgia Institute of Technology and Nankai University

Abstract:: The 3-dim Gross-Pitaevskii (G-P) equation has been proved to possess traveling wave solutions. Each traveling wave generates a 3-dim manifold of traveling waves via translation in spatial variables. This talk is concerned with the local dynamics near the manifolds of traveling waves. We first prove an instability criterion where the symplectic operator of the G-P equation is not a bounded operator. In the unstable case, we also construct the local stable, unstable, and center manifolds of the whole traveling manifolds. In the proof, a space-time estimate and a bundle coordinate system are used.

On the Camassa-Holm-KP model arising in shallow water theory

Guilong Gui, Northwest University, China

Abstract: In the talk we describe the asymptotic perturbation method to derive a two-dimensional Camassa-Holm-Kadomtsev-Petviashvili-type (CH-KP) equation in the context of full water waves. Starting from the incompressible and irrotational governing equations in the three-dimensional water waves, we show that such a equation arises in the modeling of the propagation of shallow water waves over a at bed. The resulting equation is a two dimensional Camassa-Holm equation with weakly transverse e ect for the horizontal velocity component. The equation captures stronger nonlinear e ects than the classical dispersive integrable equations like the Korteweg-de Vries and Kadomtsev-Petviashvili equations. We also address some properties of the this model equation and how it relates to the surface wave. Finally, we establish the local well-posedness of this model in a suitable Sobolev space.

Dynamics Characteristic of Solitons for Davey-Stewartson System

Jian Zhang, University of Electronic Science and Technology of China

Abstract: We study the Cauchy problem of the Davey-Stewartson system:

$$iu_t + \Delta u + |u|^{p-1}u + E(|u|^2)u = 0; t \in [0; T); x \in R^N \qquad \text{(GDS)}$$

where $1 < p < \frac{N+2}{(N-2)^+}$, which appears as mathematical models for the evolution of shallow-water waves having predominant direction of travel. We shall investigate the variational characteristic of various solitons to (GDS) and use them to study the dynamical properties the Cauchy problem of (GDS). First, when $N = 2; 3$, by constructing a type of cross-constrained variational problem and establishing so called cross-constraint manifolds of the evolution ow, we derive a sharp thresholds for blow-up and global existence of the solutions to the Cauchy problem for (GDS) provided $1 + \frac{4}{N} < p < \frac{N+2}{(N-2)^+}$. Especially, for $N = 2$ and $N = 3$, by using the profile decomposition of the bounded sequences in H^1, we get the generalized Gagliardo-Nirenberg inequalities and the sharp thresholds of the existence of blow-up solutions of (GDS) for $3 < p < +\infty$ and $1 + \frac{4}{3} \leq p < 5$, respectively. Then, we study the dynamical properties of

blow-up solutions. We obtain the concentration of blow-up solutions of (GDS) for $1 < p \leq 3$ and the limiting profile of blow-up solutions of (GDS) for $N = 2$ and $p = 3$. Finally, we study the stability of standing waves of (GDS). This is a joint work with Xiaoguang Li and Shihui Zhu etc.

Energy conservation for inhomogeneous Euler equations

Ming Chen, University of Pittsburgh

Abstract: We consider the problem of energy conservation for the density-dependent Euler equations. In particular, we provide two types of sufficient conditions on the regularity of solutions that ensure the conservation of the total kinetic energy on the entire time interval including the initial time. The first type of data assumes integrability on the spatial gradient of the density and hence allows velocity to be rough in time. The second type imposes extra time regularity on the velocity and the result covers a wide range of rough density profiles. This is a joint work with Cheng Yu.

Instability of relativistic, self-gravitating matter distributions

Zhiwu Lin, Georgia Institute of Technology

Abstract: We consider steady state solutions of the massive, asymptotically flat Einstein-Vlasov system, i.e., relativistic models of galaxies or globular clusters, and steady state solutions of the Einstein-Euler system, i.e., relativistic models of stars. We prove that such steady states are linearly exponentially unstable when their central redshift is sufficiently large, i.e., when they are strongly relativistic. Our work confirms the scenario of dynamic instability proposed by Zeldovich & Podurets in the 1960s, and our results are in sharp contrast to the corresponding non-relativistic, Newtonian setting. We will also discuss the turning point principle for the stability of these models. This is a joint work with Mahir Hadzic and Gerhard Rein.

Well-posedness for the 2D generalized Zakharov-Kuznetsov equation

Zhaohui Huo, University of Chinese Academy of Sciences

Abstract: The Cauchy problem of the generalized 2D Zakharov-Kuznetsov equation

$$\partial_t u + \partial_x(\partial_{xx} + \partial_{yy})u + u^l u_x = 0; l \geq 1;$$

is considered. It is shown that the 2D Z-K equation ($l = 1$) is locally well-posed in the anisotropic Sobolev space $H^{\frac{1}{2}+,0}$ ($B^{\frac{1}{2}}_{2,1}L^2_y$), where the norm $H^{s,r}$ and $B^s_{2,1}H^r_y$ are defined by

$$\|f\|_{H^{s,r}_{(x,y)}} = \|\langle\xi\rangle^s\langle\zeta\rangle^r\widehat{f}\|_{L^2_{(\xi,\zeta)}}, \ \ \|f\|_{B^s_{2,1}H^r_y} = \left\|\|\langle\xi\rangle^s\langle\zeta\rangle^r\widehat{f}\|_{B^0_{2,1}(\xi)}\right\|_{L^2_\zeta}.$$

Moreover, the modified 2D Z-K equation ($l = 2$) is locally well-posed in the anisotropic Sobolev space $H^{s,0}$ with $s > 1/4$ ($B^{\frac{1}{4}}_{2,1}L^2_y$) with small initial.

Moreover, the generalized 2D Z-K equation ($l \geq 3$) is locally well-posed in the Sobolev space H^s with $s > s_l$ ($B^{s_l}_{2,1}$) with small initial, where the norm H^s and $B^s_{2,1}$ are defined by

$$\|f\|_{H^s_{(x,y)}} = \|\langle(\xi,\zeta)\rangle^s \widehat{f}\|_{L^2_{(\xi,\zeta)}}, \ \ \|f\|_{B^s_{2,1}} = \|\langle(\xi,\zeta)\rangle^s \widehat{f}\|_{B^0_{2,1}(\xi,\zeta)}, \ \ s_l = 1 - \frac{3}{2l}.$$

Spherically Symmetric Flow for a Viscous Radiative and Reactive Gas in an Exterior Domain with Large Initial Data

Huijiang Zhao, Wuhan University

Abstract: This talk is concerned with the global existence, uniqueness and large-time behavior of spherically symmetric solution of a viscous radiative and reactive gas in an unbounded domain exterior to the unit sphere in $\mathbb{R}^n$ for $n \geq 2$. The key point in the analysis is to deduce certain uniform estimates on the solutions, especially on the uniform positive lower and upper bounds on the specific volume and the temperature. It is based on a recent work joint with Dr. Yongkai Liao and Dr. Tao Wang.

Global solutions for the magnetic Zakharov system

Zhang Jingjun, Jiaxing University

Abstract: In this talk, we consider a type of magnetic Zakharov system in plasmas. Local existence of solutions and global solutions with small initial data are shown for this system.

Global Well-Posedness for NLS with a Class of H^s-Supercritical Data

Baoxiang Wang, Peking University

Abstract: We conside the focusing NLS

$$\mathrm{i}u_t + \Delta u + |u|^{2\kappa}u = 0, \quad u(0) = u_0.$$

It is known that it may have a blowup solution in finite time if the initial energy is negative. In this paper we obtain that the focusing NLS is globally well-posed for a class of initial data u_0 satisfying

$$\|u_0\|_2 \ll 1, \ \ \|u_0\|_\infty \ = \infty, \ \ \|u_0\|_{H^{s(\kappa)}} = \infty$$

where $\kappa \geq 2/d, \ \kappa \in \mathbb{N}, \ s(\kappa) := d/2 - 1/\kappa$. Our result contains the energy super-critical case $\kappa > 2/(d-2)$. This is a joint work with Dr. Han Jinsheng.

Lipschitz metric for a nonlinear wave equation

Geng Chen, University of Kansas, USA

Abstract: The nonlinear wave equation: $u_{tt} - c(u)[c(u)u_x]_x = 0$ is a natural generalization of the linear wave equation. In this talk, we will discuss a recent breakthrough addressing the Lipschitz continuous dependence of solutions on initial data for this quasi-linear wave equation. Our earlier results showed that this equation determines a unique flow of conservative solution within the natural energy space $H^1(R)$. However, this flow is not Lipschitz continuous with respect to the H^1 distance, due to the formation of singularity. To prove the desired Lipschitz continuous property, we constructed a new Finsler type metric, where the norm of tangent vectors is defined in terms of an optimal transportation problem. For paths of piecewise smooth solutions, we carefully estimated how the distance grows in time. To complete the construction, we proved that the family of piecewise smooth solutions is dense, following by an application of Thom's transversality theorem. This is a collaboration work with Alberto Bressan.

Initial-boundary value problem and long-time asymptotics for the Kundu–Eckhaus equation on the half-line

Boling Guo, Nan Liu, Institute of Applied Physics and Computational Mathematics

Abstract: In this talk, we will study the initial-boundary value problem for the Kundu–Eckhaus equation on the half-line by using the Fokas method. We will show that the solution $u(x,t)$ can be expressed in terms of the solution of a matrix Riemann–Hilbert problem formulated in the complex k-plane. Furthermore, based on a nonlinear steepest descent analysis of the associated Riemann–Hilbert problem, we can give the precise asymptotic formulas for the solution of the Kundu–Eckhaus equation on the half-line.

Analysis of Topological Edge States in Photonic Graphene

Yi Zhu, Tsinghua University

Abstract: Topological materials have been very popular research topics in different fields. Their novel and subtle properties have attracted a lot of theoretical and experimental studies. They also bring opportunities and challenges to applied and computational mathematics. In this talk, I will introduce our recent results on the topological edge states in photonic graphene, which is an easily realizable topological material and has wide applications. Specifically, we study the propagation of electromagnetic waves governed by the two-dimensional Maxwell equations in honeycomb media. Thanks to the symmetries of the media, existence of Dirac points and corresponding Dirac dynamics are rigorously analyzed. Moreover, the introduction through small and slow variations of a domain wall across a line-defect gives rise to the bifurcation from Dirac points of highly robust (topologically protected) edge states. Via a rigorous multi-scale analysis, we give an explicit description (to leading order) of the edge states. This talk is mainly based on the joint work with Michael I. Weinstein at Columbia University and James Lee-Thorp at Courant Institute.

A new solution representation for the fifth-order BBM equation in a quarter plane and the eventual periodicity

Juan-Ming Yuan, Providence University

Abstract: The initial-boundary-value problem for the fifth-order Benjamin-Bona-Mahony (BBM) equation is studied in this paper. The goal is to understand the periodic behavior (termed as eventual periodicity) of its solutions corresponding to periodic boundary condition or periodic forcing. To this aim, we derive a new formula representing solutions of this initial- and boundary-value problem by inverting the operator $\partial_t + \alpha\partial_x - \gamma_1\partial_{xxt} + \delta_1\partial_{xxxxt}$ defined in the space-time quarter plane. The eventual periodicity of the linearized fifth-order BBM equation with periodic boundary data and forcing term is established by combining this new representation formula and the method of stationary phase.

无穷维动力系统吸引子相关问题

孙春友, 兰州大学

摘要: 吸引子是无穷维动力系统研究的主要对象之一。这个报告将主要介绍我们研究吸引子的动机, 以及部分相关理论和应用的进展和问题。

Asymptotic analysis on the modelling of the shallow-water waves with the Coriolis effect

Ting Luo, Institute of Applied Physics and Computational Mathematics

Abstract: In this talk, we introduce some simplified phenomenological models of long-crested shallow-water waves propagating in the equatorial ocean regions with the Coriolis effect due to the Earth's rotation. These new model equations are analogous to the Green-Naghdi equations, the first-order approximations of the KdV-, or BBM-type, respectively. We then justify rigorously that in the long-wave limit, unidirectional solutions of a class of KdV- or BBM-type are well approximated by the solutions of the Camassa-Holm equation with the Coriolis effect. The modeling and analysis of those mathematical models then illustrate that the Coriolis forcing in the propagation of shallow-water waves can not be neglected. Indeed, the CH-approximation with the Coriolis effect captures stronger nonlinear effects than the nonlinear dispersive rotational KdV-type. Furthermore, we demonstrate nonexistence of the Camassa-Holm-type peaked solution and classify various localized traveling-wave solutions to the rotation-Camassa-Holm equation depending on the range of the rotation parameter. This is a joint work with Prof. Guilong Gui and Prof. Yue Liu.

Incompressible inviscid resistive MHD surface waves in 2D

Zhouping Xin, The Chinese University of Hong Kong

Abstract: In this talk, I will present some studies on the effects of the magnetic diffusions on the motions of an ideal free surface wave for 2-dimensional incompressible electrically conducting fluids. ăSuch a problem is governed by the inviscid and resistive MHD system, and the effects of the surface tension on the free boundary is considered.ă We find a strong dissipation for the fluid vorticity due to the traversed magnetic field and thus are able to establish the global well-posedness of the free surface wave motion around an equilibrium. ăSome of the key ideas of analysis will be presented.This is a joint work with Professor Yanjin Wang.

Self-Organized Hydrodynamic models for nematic alignment and the application to myxobacteria

Hui Yu, Tsinghua University

Abstract: A continuum model for a population of self-propelled particles interacting through nematic alignment is derived from an individual-based model. The methodology consists of introducing a hydrodynamic scaling of the corresponding mean field kinetic equation. The resulting perturbation problem is solved thanks to the concept of generalized collision invariants. It yields a hyperbolic but non-conservative system of equations for the nematic mean direction of the flow and the densities of particles flowing parallel or antiparallel to this mean direction. An application to myxobacteria is presented.

3 Participants

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