China-Czech Mini Workshop on Mathematical Fluid Mechanics

2021.12.15 (Zoom meeting ID: 817 0102 4044; Password: 852921)	
8:20-8:30 15:20-15:30	Opening (Song Jiang, Eduard Feireisl)
8:30-9:10 15:30-16:10 Chair: Song Jiang	Miroslav Bulicek (Mathematical Institute, Faculty of Mathematics and Physics, Charles University) ***Incompressible heat conducting viscoelastic fluids with stress diffusion - existence analysis***
9:10-9:50 16:10-16:50 Chair: Song Jiang	Qiangchang Ju (Institute of Applied Physics and Computational Mathematics, Beijing, China) ***Diffusion limit of the compressible Euler-P1 approximation model arising from radiation hydrodynamics***
9:50-10:00 16:50-17:00	Break
10:00-10:40 17:00-17:40 Chair: Eduard Feireisl	Martina Hofmanova (TU Bielefeld, Germany) ***Convex integration in SPDEs***
11:00-13:00 18:00-20:00	Lunch break (dinner break)
13:00-13:40 20:00-20:40 Chair: Feimin Huang	Yi Wang(The Academy of Mathematics and Systems Science, CAS, China) ***Time-asymptotic stability of composite wave of viscous shock and rarefaction for barotropic Navier-Stokes equations***
13:40-14:20 20:40-21:20 Chair: Feimin Huang	Ondrej Kreml (Institute of Mathematics, Czech Academy of Sciences, Prague) ***Measure-valued solutions for the incompressible inviscid fluid-rigid body interaction***

2021.12.16 (Zoom meeting ID: 884 0807 7098; Password: 129332)	
8:30-9:10 15:30-16:10 Chair: Josef Malek	Weixi Li(Wuhan University, Wuhan, China) ***Wellposedness of hyperbolic Prandtl equations***
9:10-9:50 16:10-16:50 Chair: Josef Malek	Vaclav Macha (Institute of Mathematics, Czech Academy of Sciences, Prague) ***The dynamics of a body containing a compressible fluid***
9:50-10:00 16:50-17:00	Break

10:00–10:40 17:00–17:40 Chair: Shu Wang	Huanyao Wen (South China University of Technology, Guangzhou, China) *Vanishing viscosity limit for compressible Navier-Stokes equations with cylindrical symmetry*
11:00–13:00 18:00–20:00	Lunch break (dinner break)
13:00–13:40 20:00–20:40 Chair: Hailiang Li	Milan Pokorny (Mathematical Institute, Faculty of Mathematics and Physics, Charles University) *Steady compressible Navier–Stokes–Fourier equations with Dirichlet boundary condition for the temperature*
13:40–14:20 20:40–21:20 Chair: Hailiang Li	Chao Wang (Peking University, Beijing, China) *The inviscid limit of the compressible Navier-Stokes equations in the analytic setting*
14:20–14:30 21:20–21:30	Closing

Black: Czech time. Red: Chinese time.

Titles and Abstracts

Incompressible heat conducting viscoelastic fluids with stress diffusion--existence analysis

Miroslav Bulíček
(Mathematical Institute, Faculty of Mathematics and Physics, Charles University)

We present a thermodynamically compatible model for flows of heat-conducting viscoelastic incompressible fluid with stress diffusion and prove that there exists a~large-data and global-in-time weak solution to the corresponding system of PDEs. The model is a modifiaction of the diffusive Oldroyd-B model in 3D and we assume that the fluid admits a~strengthened dissipation mechanism, at least for excessive elastic deformations. All the relevant material coefficients are allowed to depend continuously on the temperature, whose evolution is captured by a thermodynamically consistent equation. In fact, the studied model is derived from scratch using only the balance equations and thermodynamical laws. The only real simplification of the model, apart from the incompressibility, homogeneity and isotropicity of the fluid, is that we assume a linear relation between the temperature and the internal energy. The concept of our weak solution is considerably general as the thermal evolution of the system is governed only by the entropy inequality and the global conservation of energy. Still, this is sufficient for the weak-strong compatibility of our solution and we also specify additional conditions on the material coefficients under which the balances of the total and internal energy hold locally.

Convex integration in SPDEs

Martina Hofmanova
(TU Bielefeld, Germany)

I will report on several recent results which employed convex integration to answer some open questions in stochastic fluid dynamics. It was believed/hoped that a certain stochastic perturbation could possibly help with the uniqueness issue for the Navier-Stokes equations. Namely, uniqueness in law may be easier to prove. Yamada-Watanabe-Engelbert's theorem then suggests to combine it with existence of probabilistically strong solutions to obtain pathwise uniqueness. This was proven wrong: in a class of weak solutions, convex integration led to non-uniqueness in law as well as existence of infinitely many probabilistically strong solutions. Additionally also existence of non-unique Markov selections was established. The talk is based on joint works with Rongchan and Xiangchan Zhu.

Diffusion limit of the compressible Euler-P1 approximation model arising from radiation hydrodynamics

Qiangchang JU
(Institute of Applied Physics and Computational Mathematics, Beijing, China)

We first show the nonequilibrium-diffusion limit of the compressible Euler-P1 approximation model arising in radiation hydrodynamics as the Mach number tends to zero when the initial data is well-prepared. In particular, the effect of the large temperature variation upon the limit is taken into account. The model leads to a singular problem which fails to fall into the category of the classical theory of singular limits for quasilinear hyperbolic equations. By introducing an appropriate normed space of solutions and exploiting the structure of the system, we establish the uniform local existence of smooth solutions and the convergence of the model to the incompressible nonhomogeneous Euler system coupled with a diffusion equation. Moreover, we also prove the nonequilibrium-diffusion limit of the compressible Euler-P1 approximation model when the Mach number is fixed.

Measure-valued solutions for the incompressible inviscid fluid-rigid body interaction

Ondrej Kreml
(Institute of Mathematics, Czech Academy of Sciences, Prague)

We consider a coupled system of partial and ordinary differential equations describing the interaction between an incompressible inviscid fluid and a rigid body moving freely inside the fluid. We prove the existence of measure-valued solutions which is generated by the vanishing viscosity limit of incompressible fluid-rigid body interaction system under some physically constitutive relations. Moreover, we show that the measure-valued solution coincides with strong solution on the interval of its existence. This relies on the weak-strong uniqueness analysis. This is the first result of an existence of measure-valued solution and weak-strong uniqueness in measure-valued sense in

the case of inviscid fluid-structure interaction. This is a joint work with Matteo Caggio, Sarka Necasova, Arnab Roy and Tong Tang.

Wellposedness of hyperbolic Prandtl equations

Weixi LI
(Wuhan University, Wuhan, China)

We study the wellposedness of hyperbolic Prandtl equation in the Gevrey space. Compared with the classical parabolic Prandtl equations, new difficulties arise from the hyperbolic type. The main tool is the straightforward energy method as well as the abstract Cauchy-Kovalevskaya Theorem in the Gevrey setting, in particular the argument will not invove any cancellation mechansim developed for parabolic counterpart.

The dynamics of a body containing a compressible fluid

Vaclav Macha
(Institute of Mathematics, Czech Academy of Sciences, Prague)

The presence of the fluid in a freely moving body has a tremendous effect on the dynamics of the whole system. The original conjunction in this direction (which is due to Zhukovski) has been proven quite recently for the case of an incompressible fluid. During the talk, we present several results concerning the compressible fluid inside a freely moving body and inside a pendulum. The talk is based on papers written in collaboration with G. P. Galdi, Š. Nečasová, and B. She.

Steady compressible Navier-Stokes-Fourier equations with Dirichlet boundary condition for the temperature

Milan Pokorny
(Mathematical Institute, Faculty of Mathematics and Physics, Charles University)

Based on the recent result by Chaudhuri and Feireisl for the evolutionary compressible Navier-Stokes-Fourier equations we present the proof of existence of a weak solution for the steady system with Dirichlet boundary condition for the temperature without any restriction on the size of the data. The weak formulation of the equations for the temperature is based on the total energy balance and entropy inequality with compactly supported test functions and a steady version of the ballistic energy inequality which allows to obtain estimates of the temperature. We aim to include the values of the exponent γ (the pressure $p(\varrho,\vartheta) \sim \varrho^\gamma$ for very small temperature) close to one.

The inviscid limit of the compressible Navier-Stokes equations in the analytic setting

Chao WANG

(Peking University, Beijing, China)

In this talk, we talk about the compressible Navier-Stokes equation in a half space with non-slip boundary condition. When the initial data are analytical, we use the energy method to justify the zero-viscosity limit. This work is joint with Yuxi Wang and Zhifei Zhang.

Time-asymptotic stability of composite wave of viscous shock and rarefaction for barotropic Navier-Stokes equations

Yi WANG

(The Academy of Mathematics and Systems Science, CAS, China)

We talk about our recent result on the time-asymptotic stability of composite waves consisting of the superposition of a viscous shock and a rarefaction for the one-dimensional compressible isentropic Navier-Stokes equation. Our result solves a long-standing problem first mentioned in 1986 by Matsumura and Nishihara in [Japan J. Appl. Math., 1986]. The same authors introduced it officially as an open problem in 1992 in [Comm. Math. Phys., 1992] and it was again described as a very challenging open problem in 2018 in the survey paper [A. Matsumura, Handbook of mathematical analysis in mechanics of viscous fluids, Springer, 2018]. The main difficulty is due to the incompatibility of the standard anti-derivative method, used to study the stability of viscous shocks, and the energy method used for the stability of rarefactions. Instead of the anti-derivative method, our proof uses the a-contraction with the time-dependent shifts to control the compressibility of viscous shocks in the original perturbation framework for the stability of rarefactions. This method is energy based, and can seamlessly handle the superposition of waves of different kinds. Finally, I will talk about our recent developments on the stability of planar viscous shock wave to the multi-dimensional baratropic Navier-Stokes equations.

Vanishing viscosity limit for compressible Navier-Stokes equations with cylindrical symmetry

Huanyao WEN

(South China University of Technology, Guangzhou, China)

We consider the vanishing shear viscosity limit of the initial boundary value problem for the isentropic compressible Navier-Stokes equations with cylindrical symmetry. By using the matched asymptotic expansion, we derive explicit Prandtl type boundary layer equations. Moreover, we prove the global-in-time stability of the boundary layer profile together with the optimal convergence rate of the vanishing shear viscosity limit without any smallness assumption on the initial and boundary data. This talk is based on a recent work joint with Prof. Tong Yang, Dr. Xinhua Zhao, and Prof. Changjiang Zhu.