# Titles and Abstracts

1. Rémi Abgrall, University of Zurich, Switzerland

   **Title:** High order method for systems of conservation laws using continuous approximation of data.

   **Abstract:** When dealing with hyperbolic systems of conservation laws, popular methods, like finite volumes, WENO or DG method, use a discontinuous approximation of data. The rational is that, since the solutions we are looking for are a priori discontinuous, it is safer to look for discontinuous approximations.

   Concerning continuous approximation, a potential candidate, among others, is the SUPG method, or the stream line diffusion method. However it is often said that such methods are not locally conservative.

   In this talk I will show/explain that:

   (a) one can construct a class of methods, using a globally continuous approximation of data, that are able to compute very good approximations;

   (b) This type of approximation, and the continuous finite element methods (with artificial viscosity) are locally conservative: one can exhibit flux;

   (c) There is a systematic procedure that can make them entropy stable, and then one can control the amount of dissipation;

   (d) They can be arbitrary high order, with the same stencil as discontinuous Galerkin methods.

   This is a joint work with M. Ricchiuto (Inria, France), P. Bacigaluppi (Zurich) and S. Tokareva (Los Alamos)

2. Mejdi Azaïez, Bordeaux INP, France

   **Title:** Constraint oriented spectral element method

   **Abstract:** An original polynomial approximation to solve partial differential equations is presented. This spectral element version takes into account of the underlying nature of the corresponding physical problem. For different types of operators, this approach allows to all terms in a variational form to be represented by the same functional dependence and by the same regularity, thus eliminating regularity constraints imposed by standard numerical methods. This method satisfies automatically different type of constraints, such as occur for the **grad**(div) and **curl**(curl) operators, and for any geometry. It can be applied to a wide range of physical problems, including fluid flows, electromagnetism, material sciences, ideal linear magnetohydrodynamic stability analysis, and Alfvèn wave heating of fusion plasmas.

3. Sebastiano Boscarino, University of Catania, Italy

   **Title:** All-Mach number high order semi-implicit IMEX schemes for the Euler equations of gas dynamics

   **Abstract:** We present two approaches for the numerical solution of Euler equations of gas dynamics. We consider high order schemes in space and time where the material waves are treated explicitly, while acoustic waves are treated implicitly, thus avoiding severe CFL restrictions for low Mach flows. The first approach is an all Mach number finite volume shock capturing method on staggered cartesian grid. Both isentropic and full Euler equations are considered. The staggered grid simplifies flux computation and guarantees a natural central discretization in the low Mach limit, thus dramatically reducing the excessive numerical diffusion of upwind discretizations. Furthermore, second order accuracy in space is automatically guaranteed. For the time discretization we adopt an Semi-IMplicit/EXplicit (S-IMEX) method which means, at each step, the solution of a linear elliptic problem for the pressure (isentropic case) or the energy (full Euler). In the second approach we consider all Mach number high-order finite difference shock capturing methods. High order accuracy in space is obtained by WENO reconstruction for the explicit terms and high order central discretization for the acoustic terms, so that no excessive numerical diffusion is introduced. High order in time is obtained by IMEX methods. In both approaches the schemes are proven to be Asymptotic Preserving (AP) and Asymptotic Accurate (AA) as the Mach number vanishes. Numerical tests are displayed in one and two dimensions to demonstrate the performance of our schemes in both compressible and incompressible regimes.

4. Guoxian Chen, Wuhan University, China

   **Title:**The subcell hydrostatic reconstruction method for Euler equations under gravitational fields with vacuum front

   **Abstract:** This talk solves the Euler equations under gravitational fields based on the subcell hydrostatic reconstruction framework. Different from other existing schemes, in this present one can deal with the vacuum front which can be connected with a polytropic steady state. The method defines the nonconservative product by reconstructing the states on singular layers at every cell interface using the subcell hydrostatic reconstruction method. The reconstruction can maintain the polytropic hydrostatic equilibria even when it is connected with the vacuum front. The scheme's robustness and stability properties, including well-balancing, positivity, and entropy inequality with a positive and bounded production term, are proved. Several numerical experiments illustrate the performance of our method.

5. Yibing Chen, Institute of Applied Physics and Computational Mathematics, China

   **Title:** Recent developments of HFVS: High order approach based on flux vector splitting

   **Abstract:** In this report, recent developments of HFVS, a new scheme of high order accuracy in both space and time, are introduced. The basic idea in the construction is that, based on the idea of the flux vector splitting (FVS), we split all the spatial and time derivatives in the Taylor expansion of the numerical flux into two parts: one part with positive eigenvalues, another with negative eigenvalues. According to a Lax-Wendroff procedure, all the time derivatives are then replaced by spatial derivatives, which are evaluated by using high order reconstruction polynomials. One of the most significant advantages of the current scheme is very easy to implement. In addition, it is found that the higher spatial and time derivatives produced in the construction of the numerical flux can be regarded as a building block, in the sense that they can be coupled with any exact/approximate Riemann solvers to extend a first-order scheme to very high order accuracy in both space and time. The original HFVS uses WENO technique to construct the high order reconstruction polynomials. Later, to design a compact high order scheme, Hermite WENO method is utilized. Numerous numerical results for the hyperbolic systems demonstrate that HFVS scheme is robust and can be of high order accuracy.

6. Juan Cheng, Institute of Applied Physics and Computational Mathematics, China

   **Title:** High order positivity-preserving and conservative DG schemes for radiation transfer equations

**Abstract:** Numerical simulation of radiation transfer equations arises in many applications, including astrophysics, inertial confinement fusion, optical molecular imaging, shielding, and so on. The positivity-preserving and conservation-preserving properties are two important and challenging issues for the numerical solution of this kind of equations. In this talk, I will introduce our recent work on high order positivity-preserving and conservative discontinuous Galerkin (DG) schemes solving steady and unsteady radiation transfer equations. The properties such as positivity-preserving and high order accuracy are proven rigorously. One- and two-dimensional numerical results are provided to verify the designed characteristics of our schemes.

7. Wai Sun Don, Ocean University of China, China

   **Title:** High order positivity- and bound-preserving hybrid Compact-WENO finite difference scheme for the compressible reactive Euler equations

   **Abstract:** We constructed a hybrid conservative upwind compact (Compact) finite difference scheme and characteristic-wise weighted essentially non-oscillatory (WENO) finite difference scheme (Hybrid) for the compressible reactive Euler system simulations. The Hybrid scheme employs the nonlinear fifth order WENO-Z scheme to capture high gradients and discontinuities in an essentially non-oscillatory manner and the linear conservative upwind fifth-order Compact scheme to resolve the fine scales structures in the smooth regions of the solution in an efficient and accurate manner. Unlike our previous work, which the central form compact scheme is used and the numerical oscillations generated by the Compact scheme is mitigated by the high order filtering, this new Hybrid scheme will limit the numerical oscillations by the upwind Compact scheme by itself because of the dissipation properties and at the same time will obtain a better resolution than the previous one. On the other hand, based on this new Hybrid scheme we can easily extend the positivity-preserving limiter for some extreme problems and bounded-preserving limiters to ensure the mass fractions to be bounded between zero and one in reactive cases. If time allows, we will also discuss the applications of the high order alternative WENO finite difference scheme in simulating strong shock flows and multi-components flows in the quasi-conservative formulation that maintains equilibrium of the pressure, velocity and temperature at the material interfaces and contact discontinuities.

8. Francis Filbet, Paul Satatier University - Toulouse III, France

   **Title:** Convergence analysis of asymptotic preserving schemes for strongly magnetized plasmas

   **Abstract:** This talk is devoted to the convergence analysis of a class of asymptotic preserving particles schemes [Filbet & Rodrigues, SIAM J. Numer. Anal., 54(2) (2016):1120-1146] for the Vlasov-Poisson system with a strong external magnetic field. In this regime, classical Particle-In-Cell (PIC) methods are subject to quite restrictive stability constraints on the time and space steps related to the small Larmor radius and plasma frequency. Our asymptotic preserving discretization allows to remove such a constraint, and our analysis allows to choose an optimal time step to get a uniform error bound for various regimes.

9. Shi Jin, Shanghai Jiao Tong University, China

   **Title:** Semiclassical computational methods for quantum dynamics with band-crossing and uncertainty

   **Abstract:** Band-crossing is a quantum dynamical behavior that contributes to important physical and chemistry phenomena such as quantum tunneling, Berry connection, chemical reaction etc. In this talk, we will discuss some recent works in developing semiclassical methods for band-crossing in surface hopping. For such systems we will also introduce an "asymptotic-preserving" method that is accurate uniformly for all wave numbers, including the problem with random uncertain band gaps. The method allows one to simulation highly oscillatory uncertain problem with a uniform (in frequency) spectral accuracy in the random space.

10. Christian Klingenberg, Würzburg University, Germany

    **Title:** The compressible Euler equations with gravity: well-balanced schemes and all Mach number solvers

    **Abstract:** In this project we aim to develop a new numerical method for stellar astrophysical applications. To this end the compressible Euler equations with gravity need to be solved numerically such that hydrostatic equilibria are maintained to machine precision and at the same time the scheme can be used for all Mach numbers. We present various methods to this end, and give an outlook for ideal magnetohydrodynamics with gravity.

11. Dmitriy Leykekhman, University of Connecticut, USA

    **Title:** Discrete maximal parabolic regularity for discontinuous Galerkin time discretizations with applications to symmetric error estimates

    **Abstract:** Maximal parabolic regularity is an important analytical tool and has a number of applications, especially to nonlinear problems and/or optimal control problems when sharp regularity results are required. Recently, there have been a lot of interest in establishing similar results for various time discretization methods. In my talk, I will describe our results for discontinuous Galerkin time schemes and show how such results can be used, for example, in establishing pointwise best approximation estimates for fully discrete Galerkin solutions without any coupling between the spatial mesh size and the time steps. If time permits I will also mention non-autonomous case.

12. Alexander Ostermann, University of Innsbruck, Austria

    **Title:** Low regularity integrators for dispersive problems

    **Abstract:** Nonlinear Schrödinger equations are usually solved by pseudo-spectral methods, where the time integration is performed by splitting schemes or exponential integrators. Notwithstanding the benefits of this approach, its successful application requires additional regularity of the solution. For instance, second-order Strang splitting requires four additional derivatives for the solution of the cubic nonlinear Schrödinger equation. Similar statements can be made about other dispersive equations like the Korteweg–de Vries or the Boussinesq equation.

    In this talk, we introduce an alternative low regularity Fourier integrators. They are obtained from Duhamel's formula in the following way: first, a Lawson-type transformation eliminates the leading linear term and second, the dominant nonlinear terms are integrated exactly in Fourier space. For nonlinear Schrödinger equations, first order convergence of such methods only requires the boundedness of one additional derivative of the solution, and second-order convergence the boundedness of two derivatives. This allows us to impose lower regularity assumptions on the data. Numerical experiments underline the favorable error behavior of the newly introduced integrators for low regularity solutions compared to classical splitting and exponential integration schemes.

This is joint work with Chunmei Su (TU Munich), Marvin Knöller and Katharina Schratz (KIT, Karlsruhe).

13. Jianxian Qiu, Xiamen University, China

    **Title:** A moving mesh discontinuous Galerkin method for hyperbolic conservation laws

    **Abstract:** In this presentation, a moving mesh discontinuous Galerkin (DG) method is developed for the numerical solution of hyperbolic conservation laws. The method combines the DG method and the mesh movement strategy which is based on the moving mesh partial differential equation approach and moves the mesh continuously in time using a system of mesh partial differential equations. The mesh is a nonuniform mesh that is sparse in the regions where the solution is smooth and more concentrated near discontinuities. The method can not only achieve the high order in the smooth region, but also capture the shock well in the discontinuous region. For the same number of grid points, the numerical solution with the moving mesh method is much better than ones with the uniform mesh method. Numerical examples are presented to show the accuracy and shock-capturing of the method.

14. Jie Shen, Purdue University, USA and Xiamen University, China

    **Title:** Structure preserving schemes for a class of nonlinear problems

    **Abstract:** I will present the scalar auxiliary variable (SAV) approach to deal with nonlinear terms in a large class of gradient flows and Hamiltonian systems. The technique is not restricted to specific forms of the nonlinear part of the free energy. It leads to linear and unconditionally energy stable schemes which only require solving decoupled linear equations with constant coefficients. Hence, these schemes are extremely efficient and very accurate when combined with higher-order BDF schemes.

15. Chi-Wang Shu, Brown University, USA

    **Title:** Optimal energy-conserving discontinuous Galerkin methods for wave equations

    **Abstract:** Energy conservation is an important property for many time dependent PDEs, such as linear hyperbolic systems, linear and nonlinear dispersive wave equations including KdV equations, etc. Discontinuous Galerkin (DG) methods are often used to solve such problems, especially when adaptivity is desired. However, it is difficult to design energy conserving DG methods for such problems with optimal convergence in the $L^2$-norm. In this talk we will describe our recent work in designing such DG schemes, which involves the technique of possible doubling of unknowns. Optimal a priori error estimates of order $k+1$ are obtained for the semi-discrete scheme in one dimension, and in multi-dimensions on Cartesian meshes when tensor-product polynomials of degree $k$ are used, for linear hyperbolic and dispersive wave equations. Computational results for linear and nonlinear problems including those in aeroacoustics, Maxwell equations and KdV equations, on both structured and unstructured meshes, demonstrate the excellent performance of these energy conserving schemes. This is joint work with Guosheng Fu.

16. Yajuan Sun, Academy of Mathematics and Systems Science, China

    **Title:** Particle in cell method for Vlasov-Poisson-Fokker-Planck system

    **Abstract:** In the plasma physics, it is important to study the problem on the effect of small-angle collisions on longitudinal plasma oscillations. To deal with the problem, it is required to solve the Vlasov-Poisson-Fokker-Planck (VPFP) system. In this talk, we study the corresponding Langevin equations in the framework of stochastic equivalence, and investigate its ergodicity. Combining particle-in-cell (PIC) technique, we verify the numerical ergodicity of numerical discretizations, and simulate the Landau damping and distribution function.

17. Huazhong Tang, Peking University and Xiangtan University, China

    **Title:** Physical-constraints-preserving schemes for special relativistic magnetohydrodynamic equations

    **Abstract:** We first study the admissible state set G of special relativistic magnetohydrodynamics (RMHD). It paves a way for developing physical-constraints-preserving (PCP) schemes for the special RMHD equations with the solutions in G. To overcome the difficulties arising from the extremely strong nonlinearities and no explicit formulas of the primitive variables and the flux vectors with respect to the conservative vector, two equivalent forms of G with explicit constraints on the conservative vector are skillfully discovered. The first is derived by analyzing roots of several polynomials and transferring successively them, and further used to prove the convexity of G with the aid of semi-positive definiteness of the second fundamental form of a hypersurface. While the second is derived based on the convexity, and then used to show the orthogonal invariance of G. The LxF splitting property does not hold generally for the nonzero magnetic field, but by a constructive inequality and pivotal techniques, we discover the generalized LxF splitting properties, combining the convex combination of some LxF splitting terms with a discrete divergence-free condition of the magnetic field. Based on the above analyses, several 1D and 2D PCP schemes are then studied. In the 1D case, a first-order accurate LxF-type scheme is first proved to be PCP under the CFL condition, and then the high-order accurate PCP schemes are proposed via a PCP limiter. In the 2D case, the discrete divergence-free condition and PCP property are analyzed for a first-order accurate LxF-type scheme, and two sufficient conditions are derived for high-order accurate PCP schemes. Our analysis reveals in theory for the first time that the discrete divergence-free condition is closely connected with the PCP property. Several numerical examples demonstrate the theoretical findings and the performance of numerical schemes.

18. Jaap J.W. van der Vegt, University of Twente, The Netherlands

    **Title:** Positivity preserving limiters for time-implicit higher order discontinuous Galerkin discretizations

    **Abstract:** In the numerical solution of partial differential equations it is frequently necessary to ensure that certain variables, e.g. density, pressure, or probability density distributions, remain within strict bounds. Strict observation of these bounds is crucial otherwise unphysical or unrealistic solutions will be obtained that might result in the failure of the numerical algorithm. Bounds on certain variables are generally ensured using positivity preserving limiters, which locally modify the solution to ensure that the constraints are satisfied. For discontinuous Galerkin methods, in combination with explicit time integration methods, this approach works well and many accurate positivity preserving limiters are available. The combination of (positivity preserving) limiters and implicit time integration methods results, however, in serious problems. Many limiters have a complicated, non-smooth formulation that is difficult to linearize, therefore seriously hamper the use of standard Newton methods to solve the nonlinear algebraic equations of the implicit time discretization.

    In this presentation, we will discuss a different approach to ensure that a higher order accurate numerical solution satisfies the positivity constraints. Instead of using a limiter, we impose the positivity constraints directly on the algebraic equations resulting from a higher order accurate time implicit discontinuous Galerkin discretization by reformulating the DG equations with constraints using techniques from mathematical optimization theory. The resulting algebraic equations are then solved using a semi-smooth Newton method that is well suited to deal with the resulting nonlinear complementarity problem. This approach allows the direct imposition of constraints in higher order accurate discontinuous Galerkin discretizations combined with Diagonally Implicit Runge-Kutta methods. It does not require the construction of complicated limiters, and results in more efficient solvers for the implicit discretization. We will demonstrate the novel algorithm on a number of model problems, namely the advection, Burgers, Allen-Cahn, Barenblatt, and Buckley- Leverett equations, both in 1D and 2D, using time-implicit DG-DIRK discretizations with order of accuracy ranging between 2 and 5.

19. Lian-Ping Wang, Southern University of Science and Technology, China, and University of Delaware, USA

    **Title:** On the accuracy and implementation of discrete unified gas kinetic scheme when simulating immiscible two-phase turbulent flows

    **Abstract:** Immiscible two-phase turbulent flows contain fluid-fluid interfaces involving extensive topological changes that are coupled with turbulent fluctuations at different scales. Their detailed flow features are difficult to be treated experimentally and theoretically. In recent years, numerical methods have served as a vital research tool for probing flow structures and nonlinear dynamics in these complex flows. Most of these simulations were performed based on the continuum (or macroscopic) Navier-Stokes equations. Since the 1990s, mesoscopic methods based on the Boltzmann equation, such as the lattice Boltzmann method and gas kinetic schemes, have also been developed and applied to simulate these complex flows, with various degrees of success. In this talk, we consider a relatively new gas kinetic scheme known as the discrete unified gas kinetic scheme (DUGKS). In DUGKS a model Boltzmann equation is solved using an accurate finite-volume formulation coupling tightly kinetic particle transport and particle collisions. Compared to the lattice Boltzmann scheme, DUGKS can incorporate irregular meshes and different kinetic particle velocity models. The scheme has been applied to simulate single-phase homogeneous isotropic turbulence and wall-bounded turbulent flows. Here we further explore the capabilities of DUGKS by incorporating non-ideal molecular interaction forces using the diffuse interface formulation, so that the dynamics of fluid-fluid interfaces in a turbulent flow can be simulated. The focus here is on the accuracy of DUGKS. First, the DUGKS scheme will be examined to reveal its leading-order truncation errors under specific treatments of cell interface fluxes. Second, for a solid boundary, the usual bounce-back scheme will be re-examined through the Chapman-Enskog analysis to reveal potential issues with a moving solid boundary. Third, when treating a fluid-fluid interface, additional issues in processing local interaction forces and their effects on spurious currents and the overall accuracy will be described. These analyses will be supported by some simulation results of wall-bounded turbulent flow, the Rayleigh-Taylor instability, and three-dimensional immiscible two-phase homogeneous isotropic turbulence.

20. Yinhua Xia, University of Science and Technology of China, China

    **Title:** Discontinuous Galerkin methods for short pulse type equations via hodograph transformations

    **Abstract:** In this talk, we consider the energy and Hamiltonian conservative discontinuous Galerkin (DG) methods for short pulse type equations. The short pulse equation has been shown to be completely integrable, which admit the loop-soliton, cuspon and breather solition

solutions as well as smooth-soliton solutions. Through hodograph transformations, these non-classical solutions can be profiled as the smooth solutions of the coupled dispersionless (CD) system or sine-Gordon equations. Thus, the DG methods are developed for the CD system or sine-Gordon which link the short pulse type equations through hodograph transformations. These DG schemes are proved to be energy or Hamiltonian conservation, and the a-priori error estimate has been provided for some DG scheme. Numerical examples are provided to illustrate the accuracy and capability of the proposed DG schemes.

21. Feng Xiao, Tokyo Institute of Technology, Japan

    **Title:** A new paradigm to design high-fidelity Godunov schemes for both smooth and discontinuous solutions in complex flow simulations

    **Abstract:** One of the hard nuts to crack in computational fluid dynamics is how to simultaneously resolve both smooth (vortex, acoustic wave) and discontinuous (shock, contact jump, material interface) flow structures with high fidelity in numerical simulations of complex flows which involve strong discontinuities and flow structures of wide-range scales. The mainstream Godunov finite volume framework, which combines polynomial-based reconstruction and nonlinear limiting projection to compromise between spurious oscillation and numerical dissipation, has been proven to be a great success in many applications. However, it is also found that the existing methods of this sort can hardly provide adequate solution quality for some applications due to excessive numerical dissipation.

    In this talk, we present a novel paradigm, so-called Boundary Variation Diminishing (BVD) principle, to design high-fidelity finite volume schemes to capture both smooth and non-smooth flow structures with high-fidelity solution quality. The BVD principle minimizes the jumps of the reconstructed physical variables at cell boundaries, and thus effectively reduces the dissipation errors in Godunov finite volume method. More profoundly, the BVD principle provides a completely new alternative to the conventional limiting-projection approach to eliminate numerical oscillation. The resulting schemes are able to retrieve the unlimited very- high-order polynomials for smooth solution while eliminating numerical oscillations around discontinuities. With proper BVD-admissible functions and BVD algorithms, we have developed a new class of numerical schemes of great practical significance for compressible and interfacial multiphase flows.

    The numerical schemes have been extensively verified with various benchmark tests of single and multiphase compressible flows involving strong discontinuities and complex flow structure of broad-band scales.

22. Yulong Xing, Ohio State University, USA

    **Title:** Arbitrary order discontinuous Galerkin methods for hyperbolic balance laws

    **Abstract:** Shallow water equations with a non-flat bottom topography, and Euler equations under gravitational fields, are two prototype hyperbolic balance laws, with various applications in many fields. In this presentation, we will talk about arbitrary order well-balanced discontinuous Galerkin finite element methods which can exactly capture the non-trivial steady state solutions of these models. Some numerical tests are provided to verify the well-balanced property, high-order accuracy, and good resolution for both smooth and discontinuous solutions.

23. Tao Xiong, Xiamen University, China

    **Title:** A hybrid discontinuous Galerkin method for multi-scale kinetic equations

**Abstract:** Kinetic equations which arise from dilute gas dynamics or plasma physics has a great challenge for numerical simulations.It is mainly due to its multiscale structure and high dimensionality. Asymptotic preserving schemes have been proposed for the multiscale structure. In our work, in order to save computational cost due to high dimensionality, we propose a hybrid method, namely we solve the kinetic or CNS equations in regions where their corresponding models are appropriate. The discontinuous Galerkin method is used in space discretization due to its compactness. The numerical solvers for different regimes are coupled by suitable interface conditions. Numerical experiments demonstrate the efficiency and effectiveness of our proposed approach.

24. Chuanju Xu, Xiamen University, China

    **Title:** Muntz spectral methods for some problems having singular solutions

    **Abstract:** In this talk we will present a fractional spectral method for a class of equations with non-smooth solutions. The proposed method makes new use of the classical fractional polynomials, also known as Muntz polynomials. We will show how to construct efficient fractional spectral methods for some integro-differential equations which can achieve spectral accuracy for solutions with limited regularity. A detailed convergence analysis will be provided. The potential application of this method covers a large number of problems, including classical elliptic equations, integro-differential equations with weakly singular kernels, fractional differential equations, and so on.

25. Liwei Xu, University of Electronic Science and Technology of China, China

    **Title:** Discontinuous Galerkin methods for elastic waves

    **Abstract:** In this talk, we consider numerical solutions for two kinds of elastic waves. One is the elastic wave in homogeneous media, and the other is in orthotropic poroelastic media. We design corresponding discontinuous Galerkin (DG) methods for their numerical solutions for which essential analysis is presented as well. Numerical results demonstrate the efficiency and accuracy of the method and the proposed model. This is mainly a joint work with Prof. Yingda Cheng, Prof. Xiaozhou Li, and Prof. M.Yvonne Ou.

26. Yan Xu, University of Science and Technology of China, China

    **Title:** Local discontinuous Galerkin methods for the $\mu$-Camassa-Holm and $\mu$-Degasperis-Procesi equations

    **Abstract:** In this paper, we develop and analyze a series of conservative and dissipative local discontinuous Galerkin (LDG) methods for the $\mu$-Camassa-Holm and $\mu$-Degasperis-Procesi equations. The conservative schemes for both two equations can preserve discrete versions of their own first two Hamiltonian invariants, while the dissipative ones guarantee the corresponding stability. The error estimates of both LDG schemes for the $\mu$-Camassa-Holm equation are given. Comparing with the error estimates for the Camassa-Holm equation, some important tools are used to handle the unexpected terms caused by its particular Hamiltonian invariants. Moreover, a priori error estimates of two LDG schemes for the $\mu$-Degasperis-Procesi equation are also proven in detail. Numerical experiments for both equations in different circumstances are provided to illustrate the accuracy and capability of these schemes and give some comparisons about their performance on simulations.

27. Zhengfu Xu, Michigan Technology University, USA

    **Title:** Bound preserving flux limiters and total variation stability

**Abstract:** In this talk, we will discuss a family of bound preserving flux limiters for high order finite difference WENO methods solving hyperbolic conservation laws. This family of flux limiters are generalized from the flux-corrected transport method to high order methods solving scalar conservation laws by Boris and Book. We will discuss the algorithm for preserving a global maximum principle and some of the major issues we try to address, total variation stability etc for high order methods.

28. Hui Yu, Tsinghua University, China

    **Title:** Third order maximum-principle-satisfying DG schemes for convection-diffusion problems with anisotropic diffusivity.

    **Abstract:** For a class of diffusion equations with variable diffusivity, we construct third order accurate discontinuous Galerkin (DG) schemes on rectangular meshes which are shown to satisfy a strict maximum principle. The DG method with an explicit time stepping can well be applied to nonlinear convection-diffusion equations. It is shown that under suitable time step restrictions, the scaling limiter proposed in [Liu and Yu, SIAM J. Sci. Comput. 36(5): A2296-A2325, 2014] when coupled with the present DG schemes preserves the solution bounds indicated by the initial data, while maintaining uniform third order accuracy. The crucial for all model scenarios is that an effective test set can be identified to verify the desired bounds of numerical solutions. This is achieved mainly by taking advantage of the flexible form of the diffusive flux and the adaptable decomposition of weighted cell averages. Numerical results are presented to validate and demonstrate the effectiveness of the numerical methods.

29. Xiangxiong Zhang, Purdue University, USA

    **Title:** Recent development of high order positivity-preserving schemes for convection diffusion equations

    **Abstract:** This talk consists of three parts. First I will review some recent results regarding construction of high order positivity-preserving schemes for nonlinear parabolic equations. In the second part, I will explain in detail how a high order compact finite difference scheme can be rendered positivity-preserving for convection diffusion equations by a simple local limiter without losing accuracy or conservation. Finally, I will present a novel superconvergence result of continuous $Q^2$ finite element method for elliptic equations, which can be used to construct a simple fourth order finite difference scheme solving variable coefficient Poisson equation. Such a high order FD variable coefficient solver is needed for applying bound-preserving compact finite difference scheme to variable density incompressible Navier-Stokes equations.

30. Lina Zhao, The Chinese University of Hong Kong, Hong Kong, China

    **Title:** SDG methods of minimal dimension on general meshes

    **Abstract:** In this talk, we will present a locally conservative, lowest order SDG method on general meshes to solve elliptic problems. The method can be flexibly applied to rough grids such as the highly distorted trapezoidal grid, and both h perturbation and h2 perturbation of the smooth grids. Furthermore, hanging nodes can be simply treated as additional vertices, which is highly appreciated from a practical point of view. Optimal convergence estimates for both the scalar and vector variables are analyzed. In addition, a priori error estimates covering low regularity will be given. On the other hand, adaptive mesh refinement guided by a posteriori error estimator is a powerful tool for general meshes due to their flexibility and simplicity in handing hanging nodes. A simple residual-type error estimator on the L2 error in vector variable is derived, and the reliability and the efficiency of the error estimator will be reported. Finally, several benchmark examples will be displayed to demonstrate the efficiency of the proposed method.