Title: High Order Structure Preserving Numerical Methods for Euler Equations with Gravitation

Authors: Eirik Endeve, Guanlan Huang, Jianxian Qiu, Yupeng Ren, Kailiang Wu, Yulong Xing, Tao Xiong and Weijie Zhang

Abstract: Hydrodynamical evolution in a gravitational field arises in many astrophysical and atmospheric problems. In this presentation, we will talk about high order structure preserving discontinuous Galerkin and WENO methods for the Euler equations under gravitational fields, which can exactly capture the non-trivial steady state solutions, and at the same time maintain the non-negativity of some physical quantities. In addition, we consider the Euler–Poisson equations with self-gravity in spherical symmetry, with an equilibrium state governed by the Lane–Emden equation, and design high order well-balanced and total-energy-conserving methods. High order semi-implicit well-balanced asymptotic preserving finite difference scheme, for all Mach Euler equations with gravitation, may also be discussed. Extensive numerical examples — including a toy model of stellar core-collapse with a phenomenological equation of state that results in core-bounce and shock formation — are provided to verify the well-balanced property, positivity-preserving property, high-order accuracy, total energy conservation and good resolution for both smooth and discontinuous solutions.