Spring 2020

PDE II: Topics on Kinetic Collisional Theory: Analysis and Numerical Methods with Applications. M 393C (#53305) and CSE 396 (#61077)

Instructor: Prof. Irene M. Gamba
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Class Webpage: UT Canvas
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Office hours: by appointment
Meeting Hours: RLM 10.176, T-Th 12:30-2:00pm
We will have an extra hour discussion time when needed on a date and place to be set.

Topics on Kinetic Collisional Theory: Analysis and Numerical Methods with Applications.

This topics course covers broad issues on the Boltzmann and Landau equations for conservative and non-conservative systems and their connections to non-equilibrium statistical mechanics.

Introduction and elementary properties. The Boltzmann transport equation for binary elastic and inelastic collisional theory, time irreversibility, conservation laws, H-theorem and energy inequalities for inelastic interactions. The grazing collision limit for Coulomb interactions and the connection to the Landau Equation. Small mean free path, Hilbert and Chapman expansions. Moment methods and connections to hydrodynamic models in fluid dynamics.

Space homogeneous problems. Povzner type lemmas. Existence and uniqueness properties in connection of moment inequalities. Carleman integral representation and comparisons principles for pointwise bounds to solutions. Summability of moments and exponential moments and tails. Solutions to the Cauchy problem. Convolution inequalities for collision operators. Fourier representation of the Boltzmann and Landau equations. $W^{m,p}(R^d)$-theory, $1 \leq p \leq \infty$.

Special case of kinetic equations of Maxwell type, special solutions in Fourier space. Stationary and self-similar solutions for space homogeneous problems.

The space inhomogeneous problem. The Kaniel-Shimbrot iteration method vs the Hamdache method. Boundary value problems. Scattering effects for solutions in all space due to dispersion vs dissipation. Averaging lemmas and renormalized DiPerna-Lions Solutions and connections to derivations of fluid dynamical models.

Numerical approximations to kinetic particle systems. Deterministic solvers for linear and non-linear collisional forms of Boltzmann and Landau type. Conservative spectral and FEM methods. Galerkin-Petrov schemes and moment methods. Comparisons to Discrete Simulation Monte Carlo (DSMC) methods. Stability and error estimates. Applications to kinetic models for plasmas and charge transport as well as to inverse problem in nano-scale. The Boltzmann-Poisson system.

Prerequisites: Some knowledge of Methods of Applied Analysis and Mathematics and Partial Differential Equations.

Testing and examination plan and policies: Attendance at lectures is expected. A 30-min prepared presentation on a topic to be discussed with the instructor. **There will be neither exams nor tests for this course.**

Evaluation: The course and instructor will be evaluated at the end of the semester using the approved form.

The following is a suggested bibliography:

- Cercignani C., *The Boltzmann Equation and its Applications*, Springer, New York, 1988.
- Cercignani C., Illner, R. and Pulvirenti, M.,*The Mathematical Theory of Diluted Gases*", Springer, NY,1994.
- Villani, C., *A review of Mathematical topics in collisional kinetic theory*, Handbook of Fluid Mechanics, 2003.
- Sone, Y., *Kinetic Theory and Fluid Dynamics* (Birkhäuser, 2002): Click here to download supplementary notes and errata
- Sone, Y., Molecular Gas Dynamics (Birkhäuser, 2007): Click here to download supplementary notes and errata
- Class notes and several recent papers to be distributed in class.

This course maybe viewed as complementary to CSE 397 / EM 397

The University of Texas at Austin provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-4641 TTY.