Graduate course: Collisional transport in magnetized plasmas

Introduction

Collisional transport theory is of central importance in modern plasma physics. This course will start from elementary concepts and develop the theory through the research frontier. Basic tools of kinetic plasma theory, such as the drift kinetic equation and the Coulomb collision operator will be addressed and used to calculate collisional transport coefficients. The course is mainly aimed at students in fusion and space plasma physics and is on graduate level. It is based by the book with the same title by P Helander ad D Sigmar.

Organization

The course will start in 11 April 2016 and it is organized as a series of 20 discussion meetings. It is led by John Omotani and István Pusztai. The participants will be asked to read the specific pages before the meeting and be prepared to present part of the material and answer questions about it. Also they will be asked to prepare one question of their own and think about the "take home message" from the material they have read. The examination through this method is oral and continuous. Since the active participation in the discussion meetings is the examination, all meetings are compulsory. The meeting times will be chosen so that the participants are able to be there. The participation in the course will take approximately 8hrs per week (including the discussion meeting) and after completion of the course it will give 6 hec.

Course contents

- Meeting 1: Introduction: Collision frequencies, random-walk estimates. p1-13
- Meeting 2: Kinetic and fluid description of a plasma. Derivation of the Fokker-Planck operator. p14-30 (until 3.2)
- Meeting 3: Electron-ion and ion-impurity collisions. Collisions with Maxwellian background. Collision operator for fast ions. Ion-electron collisions. p31-43 (until 3.6)
- Meeting 4: Collision operator for relativistic particles. The linearized collision operator. Model operator for self collisions. p44-58 (until 4)
- Meeting 5: Plasma fluid equations. Outline of closure in the case of short mean-free path. Lorentz plasma. Onsager symmetry and a variational principle. p59-71 (until 4.4)
- Meeting 6: Spitzer conductivity. Braginskii's equations. p72-83 (until 4.7)

- Meeting 7: Diamagnetic flows. Transport in a cylindrical plasma: Particle transport. p84-94 (until 5.2)
- Meeting 8: The influence of viscosity on ambipolarity. Transport of momentum and heat. Particle motion: Equation of motion. Nearly periodic motion. Guiding-centre motion. p95-109 (until 6.4)
- Meeting 9: Adiabatic invariants. The drift-kinetic equation. Toroidal plasmas: Magnetic field. p110-120 (until 7.2)
- Meeting 10: Magnetohydrodynamic equilibrium. Guiding-centre orbits in tokamaks. p121-136 (until 7.4)
- Meeting 11: Non-axisymmetric systems. Transport in toroidal plasmas: Transport ordering. Collisionality. p137-150 (until 8.3)
- Meeting 12: Transport in toroidal plasmas: Distribution function. Current. Particle and heat fluxes. Flow across flux surfaces. p150-160 (until 8.7)
- Meeting 13: Confinement time. Transport in the Pfirsch-Schlüter regime. p161-178 (until 10)
- Meeting 14: Transport in the plateau regime. p178-187 (until 11)
- Meeting 15: Transport in the banana regime: Ion transport. p188-198 (until 11.3)
- Meeting 16: Transport in the banana regime: Electron transport. Bootstrap current. p199-210 (until 11.5)
- Meeting 17: Variational principle. The moment approach to neoclassical theory. The parallel viscous force. p211-222 (until 12.2)
- Meeting 18: Plasma flows. Collisional regime. Plateau regime. p223-233 (until 12.5)
- Meeting 19: Banana regime. Interpolation between various regimes. p233-242 (until 13)
- Meeting 20: Experimental evidence for neoclassical transport. p272-275 (14)