Turbulence in space plasmas (PHY661) - First Course Handout

(2025-26 Even semester)

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Course Objectives:

The understanding of turbulence in space plasmas is crucial to explain the efficient mixing, heating and the acceleration of space plasmas (e.g. the solar wind, the magnetospheric plasmas). For the last thirty years, extensive research works have been exploring various aspects of space plasma turbulence e.g. universality, anisotropy etc. with the help of a combination of analytical results, numerical simulations and in-situ data analysis of dedicated spacecraft missions. This course will offer an exposure to the key problems and the ongoing research works of this field. In addition, the students will be trained to study several properties of space plasma turbulence using public in-situ data of different spacecraft.

Course content: (38 hours)

(1) Generic introduction to turbulence in fluids and plasmas (7 lectures)

(2) Space plasmas and their properties (4 lectures)

(3) Energy cascade and universal scaling in space plasma turbulence (8 lectures)

(4) Intermittency and dissipation (6 lectures)

(5) Different types of anisotropies (7 lectures)

(6) Reconnection in space plasmas (6 lectures)

Course load and grading:

- **3 lecture hours per week (Tuesday and Thursday, 17h15-18h30)**
- Final grade weightage: **2 quizzes (20 %) + Project (30%) + End-sem (50%)**

Reference books:

(i) Magnetohydrodynamic turbulence, Dieter Biskamp (CUP, 2008).
(ii) The Solar Wind as a Turbulence Laboratory, R. Bruno and V. Carbone (Liv. Rev. Sol. Phys., 2005).
(iii) Anisotropy in Space Plasma Turbulence: Solar Wind Observations, T. Horbury, R. Wicks and C. Chen.
(iv) Compressible turbulence in space and astrophysical plasmas : Analytical approach and in-situ data analysis for the solar wind, Supratik Banerjee (Ph. D. Thesis)
(v) Other relevant papers and research works.