5th Asia-Pacific Conference on Plasma Physics, 26 Sept-1Oct, 2021, Remote e-conference

Wave turbulence in fluid complex plasmas

P. Bajaj[1], A. Ivlev[2], C. Räth[1], M. Schwabe[1]
[1]Institut für Materialphysik im Weltraum, Deutsches Zentrum für Luft- und Raumfahrt (DLR)
[2]Max-Planck-Institut für Extraterrestrische Physik (MPE)
e-mail (speaker): prapti.bajaj@dlr.de

Turbulence is a physical phenomenon observed in out-of-equilibrium systems exhibiting non-linear properties and it is being studied intensively in a plethora of fields like fluid dynamics, plasma physics, active matter and many more. It is broadly divided into two kinds – wave turbulence and vortices turbulence [1].

Here, we study wave turbulence[1] as a nonlinear cascade of dust-acoustic waves driven by the ion streaming instability. We use complex plasmas for this study, which is a system of micrometer-sized particles embedded in a low-temperature plasma. Our experiment to study wave turbulence is conducted by using the ground-based setup of PK-3 Plus [2], where microparticles are injected in a capacitively coupled RF-plasma chamber and a laser is illuminated in the vertical plane to study particle behaviour at the kinetic level by using high-speed imaging.

The microparticles are levitated above the sheath region where the force of gravity balances the electrostatic force. A two-stream instability (ion streaming instability), due to the motion of ions past the microparticles, produces high-speed self-excited dust acoustic waves in our system.

Figure 1(a) shows large-scale waves driven in the vertical direction at frequencies around the maximum of the growth rate. Here, one can also observe that the waves travel downwards, towards higher values of y-axis, similar to the direction of ion flow towards the sheath region of the experiment. Figure 1(b) shows the power spectrum in Frequency-Fourier space, with an overplotted line of slope -5/3, corresponding to the scaling law predicted for Kolmogorovian turbulence. This power law is observed in many other classically turbulent systems [1,3].
Our aim is to investigate the spectrum of short-scale disturbances generated due to the cascade, and their isotropisation.

References:
[1] Nazarenko, S. ‘Wave Turbulence’, Springer Berlin Heidelberg (2011).
[2] H. M. Thomas et. al., ‘Complex plasma laboratory PK-3 plus on the International Space Station’, New J. Phys.10, 033036 (2008).
[3] Frisch, U. ‘Turbulence: The Legacy of A. N. Kolmogorov’, Cambridge University Press (1995).

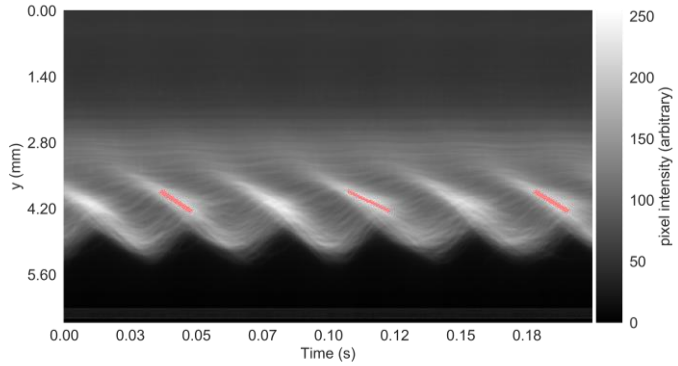

Figure 1(a): Space-time plot of image pixel intensity with some wavefronts overplotted in red. Image intensity is proportional to particle number density and the diagonal lines correspond to the wavefronts.

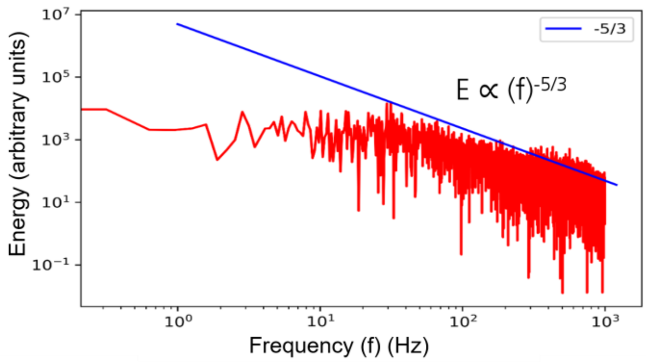

Figure 1(b): Power spectrum in Frequency-Fourier space with overplotted slope of -5/3 in blue which is the scaling law for Kolmogorov turbulence.