**Millimeter-wave scattering measurement system for verifying anisotropy and interactions between scales in microscale turbulence**

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Confinement of high-temperature plasmas is believed to be limited by so-called microscale turbulence, such as ion temperature gradient (ITG) mode, trapped electron mode (TEM), and electron temperature gradient (ETG) mode, etc., which have scales about the Larmor radius of ions and electrons. In order to characterize these turbulences and verify the interaction between them, it is necessary to observe each turbulence at the same time and place. We have installed two types of millimeter-wave scattering systems to observe ion-scale and electron-scale turbulence at the same location and time in LHD plasmas.

For the electron-scale turbulence measurements, a scattering system using 90 GHz millimeter waves have been applied [1] and recently 150 GHz has been added. The incident wave is injected into the plasma along a horizontal axis in a horizontal cross section. The scattered waves are received by three antennas: one receives backscattered waves at about 160 degrees, while the second and third receive scattered waves at nearly 90 and 110 degrees, respectively. This allows multiple wavenumbers to be observed simultaneously. In addition, because of the different angles of reception of the scattered waves, turbulent wavenumber components in different directions can be observed, and the anisotropy of turbulence can be investigated. For further investigation, we have constructed a system that can also observe turbulence of the same magnitude but in different directions using electromagnetic waves of different frequencies.

For ion-scale turbulence measurements, multi-channel Doppler back-scattering (DBS or Doppler reflectometer) has been applied [2-4]. Especially, since the measurement position of DBS varies with the plasma density, a frequency comb was introduced to achieve a position measurement equivalent to that of the above 90 GHz millimeter-wave scattering system by performing simultaneous multi-point measurement.

**References**

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