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INVESTIGATIONS OF THE MAIN COMPONENTS OF TOKAMAK PLASMA TURBULENCE *)

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The report provides an overview of the current state of research of the three main components of the turbulence spectrum, which have relatively wide frequency intervals and sizes larger than the ion Larmor radius. In recent years, new data have been obtained on the characteristics of these fluctuations. At present, it is understood that three main types of fluctuations can be distinguished in the observed turbulence spectra, differing in frequency range and correlation properties. These are broadband (Broad Band-BB), quasi-coherent (Quasi-Coherent-QC), and stochastic low-frequency fluctuations (SLF). BB fluctuations have the widest frequency range from 0 to 200-400 kHz and make the main contribution to the total amplitude of fluctuations. The characteristic sizes of BB are close to those predicted by the theory for the Ion Temperature Gradient (ITG) and Trapped Electron Mode (TEM) instabilities. BB are the least correlated fluctuations, their typical radial and poloidal correlation lengths are about 1 cm, the correlation length along the magnetic field line is < 2 meters. Quasi-coherent fluctuations (QC) appear as local maxima in the frequency spectra, but they are most clearly visible in the coherence spectra, since they have radial and poloidal correlation lengths significantly larger than BB. For QC, correlations were observed along the magnetic field line at a length of up to 10 m. Two types of such fluctuations were observed at T-10: low-frequency – LFQC and high-frequency – HFQC. The characteristic poloidal sizes and dependences on the discharge parameters in the experiments at T-10 allowed us to assume that LFQC and HFQC are manifestations of ITG and TEM, respectively. The poloidal rotation of QC coincides with the drift [ExB] rotation in magnitude and direction. The report shows the relationship between the characteristics of these modes and the discharge parameters. At present, based on the results of foreign tokamaks, the opinion has been formed that there is only one type of QC, observed at low plasma density and it is determined by TEM instability. Additional studies are needed to eliminate this contradiction. At T-10, using diagnostics with a heavy ion beam and at DIII-D, using diagnostics of the Faraday rotation of the plane of polarization, the presence of a magnetic component in QC was shown. Gyrokinetic modeling of these experiments showed that the properties of QC are close to the micro-tearing mode (MTM). Additional evidence for the MTM nature of QCs is the strong dependence of their spectra on the current profile at T-10 and FTU and the discrete mode structure found in the field line correlations in the TEXTOR experiments. Stochastic low-frequency fluctuations (SLF), excited in the range from 0 to 50 kHz, are the least studied. However, at T-10, SLFs were found to have a number of characteristic features. For example, on the weak magnetic field side, these fluctuations can rotate in the direction opposite to QCs. SLF are uncorrelated along the magnetic field line at LFS, but correlated at HFS. Recent experiments at DIII-D have shown by comparing spectra in L, I and H modes that fluctuations in the SLF region (up to 70 kHz) can be related to particle transport. The report presents new data on the SLF characteristics at T-10.

*) abstracts of this report in Russian