

EPS2005, Session "O5_001-O5_004" Abstracts

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O-5.001, Friday July 1, 2005

Laser Spectroscopy Measurements Methods of Divertor and Edge Plasma Parameters

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Development and “proof-of-principle” experiments by laser spectroscopy (LS) methods have been carried out in Kurchatov Institute as part of program of developing diagnostics techniques for ITER divertor plasmas. In experiments which have been made on PNX-U multipole magnetic trap the testing of diagnostics methods were combined with plasma studies in this machine. Today’s concept of ITER program includes making use impurity-seeded plasma experiments. It’s possible to use injected “extrinsic” impurities (Ne, Ar, Kr) for Doppler measurements of temperatures by LS-technique. Measurement of atom and ions temperatures in divertor plasmas is important but difficult problem because “ITER Requirement for Measurements” defines range for $T_{i,a}$ to be $0.3 < T < 200$ eV. It means necessity to measure low values of temperature with good spatial resolution. Series of $T_i(\text{Ar}^{1+})$ measurements have been carried out by scanning laser line across absorption line profile of the ion; fluorescence light has been detected at another wavelength. The experimental T_i values are in the range of $4 < T_i < 25$ eV. Anomalous heating of ions have been discovered during the studies. When helium puffing into discharge was used, Doppler measurement of He I temperature has been measured by scanning across 587.6-nm line profile: summarizing of fluorescence signals at 389-nm line gives input data for estimation of He I density via interpretative CR-model. Collisional transfer of excitation from 3^3D energy level of He I to 3^3P and 3^3S levels give rises to radiation of two fluorescence lines. The CRM was used to calculate intensity ratio of the lines as function of electron density. The diagnostic has been used for the first time in PNX-U experiments for measurements of local electron densities. This method of low n_e values ($n_e < 10^{19} \text{ m}^{-3}$) measurements with high spatial resolution could be applied in plasma edge studies, plasma processing devices etc.

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**Lévy distributions in plasma diffusion across a magnetic field:
experimental evidence**

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In magnetically confined Fusion plasma, the most usual turbulent transport models mainly use the Fick diffusion equation, assuming more or less implicitly turbulent motion to be of the Brownian type. However, there are doubts on the existence of a characteristic small scale where randomness applies. Many authors proposed more general models [1-2], like the continuous time random walks (CTRW). In these models if the probability distribution of the motion is chosen to be of the Lévy type, scale-free transport may result. Until now, very few and only indirect experimental evidences of the presence of Lévy distributions have been reported.

To investigate these plasma transport processes, collective light scattering diagnostic is appropriate. It provides a signal proportional to the spatial Fourier transform of the plasma density, $\tilde{n}(\mathbf{k}, \tau)$, that can be recorded as time series. This signal autocorrelation function is the Fourier transform of the plasma displacement probability distribution function [3].

A collective light scattering device has been set on a simple toroidal magnetized plasma device to investigate plasma turbulence and transport. The displacement probability distributions are reported. They are found to be non-gaussian and long tailed. An analysis in term of CTRW is made. Typical Lévy flight characteristics are found.

References

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Turbulence Imaging of Spatiotemporal Fluctuation Structures in the Scrape-Off Layer of Alcator C-Mod

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The transport of plasma across the magnetic field is strongly related to turbulent fluctuations. The so-called fluctuation induced transport does not only affect the confinement quality of fusion devices but is also important for divertor concepts and first wall recycling phenomena. A common feature of turbulent fluctuations is the formation of spatiotemporal structures. These structures are localized in the poloidal plane but form striations over long distances along the magnetic field. The present paper reports on investigation of the propagation properties of structures in the edge and SOL of the Alcator C-Mod tokamak and on the comparison with numerical models. The main diagnostic tool is turbulence imaging diagnostics [1]. It consists of an ultra-fast camera system (1MHz framerate) measuring the D_α emission of a localized gas puff in the poloidal plane covering the SOL and edge plasma region. This diagnostics provides real-time spatiotemporal information about the formation, propagation, and decay of turbulent density structures. It is observed that after formation close to the separatrix the propagation of turbulent structures is not purely poloidal but has a strong radial component with a typical radial propagation speed of 1-2% of the ion sound speed, thereby significantly contributing to cross-field transport. This finding stands in contrast to previous observations in stellarators and tokamaks, where turbulent structures were observed to propagate predominantly in poloidal direction. The combination of fast D_α diode arrays (1MHz sampling frequency) and reciprocating multi-tip Langmuir probes yields that the potential associated with turbulent density structures is of dipole shape. The associated radial $E \times B$ drift is consistent with the observed propagation velocity of blobs. The experimental findings are compared with two-dimensional numerical simulations [2] done for the specific experimental parameters. The observed radial propagation velocity of blobs is well reproduced by the model. Moreover, the spatial blob structure with a sharp front and a smooth tail is consistent between model and experiment.

References

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Turbulent Transport of Plasma Edge Impurities

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Transport of impurities through the edge region into the plasma core is at present only poorly understood. Neoclassical theory is insufficient to account for the observed high values of diffusion and inward pinch velocities.

The transport of passive impurities in the plasma edge is investigated. The plasma edge is described by a 3D fluid model for electromagnetic drift Alfvén turbulence in flux-tube geometry.

The impurities form a minority ion species and are transported parallel and perpendicular to the magnetic field by collisions and turbulent advection [1]. An approximate decomposition of the anomalous impurity flux into a diffusive part and a pinch velocity is performed, and turbulent diffusion coefficients and pinch velocities are presented. Diffusion and pinching is strongly dependent on poloidal angle and an expression linking the flux surface averaged diffusion times curvature term is derived.

References

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