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The Role of Edge Plasma Instabilities in Dynamical Evolution of Pedestal in the HL-2A Tokamak

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Pedestal behaviors play a key role in determining the global energy confinement of tokamak plasmas, and fusion reaction efficiency of burning plasmas. It is essential to understand the mechanism of the pedestal formation and evolution for optimizing plasma performance and improving accuracy of predictive models. Thus it is important experimentally to track the swift evolution of the pedestal parameters and underlying instabilities in the narrow and steep gradient region.
In HL-2A, the characteristics of the edge plasma instabilities and their effects on the dynamical evolution of pedestal have been investigated. Firstly, quasi-coherent modes have been observed in density fluctuations. The dominant mode with frequencies in the range of (50-100) kHz appears during the ELM-free period prior to the first ELM. By analyzing the pedestal density gradient, we found that there is a threshold for the excitation of the mode. This mode can also be observed during inter-ELMs. Experimental results show that the modes are excited after the ELM crash and terminated before the onset of the next ELM. The radial wave-number of the mode is estimated from the data measured by two radially separated reflectometers. The wave-number spectrum shows that the mode is radially propagating inward. The toroidal mode number of the edge mode is n=7 deduced from Mirnov signals. The corresponding poloidal mode number is about m=21 according to the local safety factor. A statistic method is applied to evaluate the relationship between the amplitude of the pedestal mode and the pedestal electron density gradient during ELM cycle. The result indicates that the modes are excited at about 40% of normalized interval before the ELM onset. During and after the ELM event, the modes disappear. It seems that the presence of the modes is linked to a relatively larger density gradient. In addition, the results made by a gyrokinetic simulation show that a Kinetic Peeling Ballooning Mode (KPBM) is localized in pedestal region, which has similar features to our observation. Thus, the edge mode in HL-2A is very likely a KPBM mode, and which may play a significant role in determining the dynamics of a pedestal.

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