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Kinetic Alfvén-Ballooning Instabilities in Tokamak Plasmas with Weak Magnetic Shears and Low Pressure Gradients

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Kinetic Alfvén-ballooning instabilities (KABIs) are very common in magnetized plasmas both in space and laboratory. In present-day fusion and future burning plasmas, they are easily excited by fast particles and/or pressure gradients. They can not only cause the loss and redistribution of fast particles but also affect plasma confinement and transport. The physics associated with them is an intriguing but complex area of research. For weak magnetic shears and low pressure gradients, the study of KABIs, such as AITG/KBM, has not been paid enough attention.
In the present paper, we will report two experimental results in HL-2A Ohmic and NBI plasmas with weak magnetic shears and low pressure gradients. Firstly, low-frequency oscillations with f=15-40 kHz and n=3-6 were detected by many kind diagnostics in high-density Ohmic regimes. The LF oscillations appeared in the plasmas with the density peaking and weak magnetic shear, which indicates that corresponding instabilities were excited by the pressure gradients. Sometime these modes have the behaviors of the frequency jumping as the stairs or chirping-up. The analysis by the extended generalized fishbone-like dispersion relation (GFLDR-E) revealed that the frequency of the oscillations scaled with the ion temperature and \eta_i, and the frequency lies in the KBM-AITG-BAE ranges. This lets us to conclude that the LF oscillations were more like BAE instabilities although their some characteristics are like AITG. The minor disruption of bulk plasmas is potentially linked with the evolution of the instabilities. Secondly, the low-n AITG instabilities with fBAE<f<fTAE and n=2-8 are found to be unstable in the NBI plasmas with weak shears and low pressure gradients. The measured results are also consistent with the GFLDR-E, and the modes are more unstable |s| is smaller in low pressure gradient regions. The calculation results from the HD7 code also suggest that AITG modes can be unstable for weak shears and low pressure gradients. These modes have possibly opposite effects on the ITB formation. The trapped electrons potentially enhance these modes unstable. It is worth emphasizing that the study of AITG/KBM with or without fast particles should be paid more attention because they link to the ITB and H-mode pedestal physics for weak magnetic shears.

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