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# Diamagnetic MHD equations for plasmas with fast flow and its application to ELM analysis in JT-60U and JET-ILW

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Diamagnetic MHD equations for plasmas with fast flow were derived for the first time by introducing a suitable ordering parameter to two fluid equations. The extended Frieman-Rotenberg (F-R) equation was obtained from the diamagnetic MHD equations by focusing on impacts of the ion diamagnetic drift effect on ideal MHD stability in rotating plasmas. The MINERVA-DI code was developed to solve the F-R equation, and was applied to analyze the edge localized mode (ELM) stability in JT-60U and JET with ITER like wall (ILW). The rotation profiles of deuterium in both toroidal and poloidal directions were estimated numerically based on the neoclassical theory with the measured impurity toroidal rotation by the CHARROT code. In static plasmas, the ion diamagnetic drift effect stabilizes the ELMs as discussed in past works. However, it is found that rotation in both toroidal and poloidal directions can destabilize ELMs, and this destabilizing effect can overcome the stabilizing effect due to the ion diamagnetic drift. In particular, the ion diamagnetic drift effect becomes negligible in a JT-60U type-I ELMy H-mode plasma rotating in the direction counter to the plasma current. In addition, the rotation makes the wavelength of ELMs shorter, and such a change of the wavelength is observed experimentally in JET when carbon wall was replaced with ILW. These results evince that rotation effects are indispensable for discussing the ELM stability in case the ELM wavelength is short as predicted in JT-60U and JET-ILW even when such ELMs are thought to be stabilized by the ion diamagnetic drift.

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**Primary author:** Dr AIBA, NOBUYUKI (Japan Atomic Energy Agency)

**Presenter:** Dr AIBA, NOBUYUKI (Japan Atomic Energy Agency)

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