# Off-axis fishbone-like instability and excitation of resistive wall modes in JT-60U and DIII-D

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**Abstract.** An energetic particle (EP)-driven "off-axis-fishbone-like mode (OFM)" often triggers a resistive wall mode (RWM) in JT-60U and DIII-D devices, preventing long-duration high-$\beta_N$ discharges. In these experiments, the EPs are energetic ions (70–85 keV) injected by neutral beams to produce high-pressure plasmas. EP-driven bursting events reduce the EP density and the plasma rotation simultaneously. These changes are significant in high-$\beta_N$ low-rotation plasmas, where the RWM stability is predicted to be strongly influenced by the EP precession drift resonance and by the plasma rotation near the $q = 2$ surface (kinetic effects). Analysis of these effects on stability with a self-consistent perturbation to the mode structure using the MARS-K code showed that the impact of EP losses and rotation drop is sufficient to destabilize the RWM in low rotation plasmas, when the plasma rotation normalized by Alfvén frequency is only a few tenths of a percent near the $q = 2$ surface. The OFM characteristics are very similar in JT-60U and DIII-D, including nonlinear mode evolution. The modes grow initially like a classical fishbone, and then the mode structure becomes strongly distorted. The dynamic response of the OFM to an applied $n = 1$ external field indicates that the mode retains its external kink character. These comparative studies suggest that an energetic particle-driven "off-axis-fishbone-like mode" is a new EP-driven branch of the external kink mode in wall-stabilized plasmas, analogous to the relationship of the classical fishbone branch to the internal kink mode.

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