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Observation and interpretation of tornado modes coupled to near-axis Alfvén cascade eigenmodes in JET sawtoothing plasmas

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The seeming coupling between fast upwards frequency sweeping modes and tornado modes in a set of JET sawtoothing discharges was investigated. The frequency sweeping modes were identified as near-axis Alfvén cascade eigenmodes associated with a very flat yet strictly monotonic q-profile near the axis, in contrast with the common reversed-shear scenarios. The evolution of the modes'frequency during the post-sawtooth regime, characterized by a gradually decreasing q-profile, was numerically reproduced and the transition from cascade modes to tornado modes was demonstrated to occur when the q profile takes specific values on-axis given by q0=(n-1/2)/n, with n the toroidal mode number of the mode. An MHD spectroscopy technique based on this result is proposed to track the evolution of q0 when such transitions are observed. Calculations of the resonant interaction between the modes and an ICRH-heated hydrogen minority population indicate the population contributed to driving the mode unstable.

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