Fractional Scaling of External Resistive Kink Modes

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The scaling of the growth rate for resistive external kink magnetohydrodynamic (MHD) instabilities responsible for the ideal-like disruptive instabilities in DIII-D limited and diverted discharges with $q_{95} < 2$, and calculated with the MARS code, is shown to follow a fractional power scaling with respect to the plasma resistivity, $\gamma \sim \eta^{\nu}$, but with variable exponents $0 < \nu < 1$. Resistive MHD instabilities characteristically show fractional power scalings, for example, for the resistive tearing mode where $\nu = 3/5$ and internal resistive kink modes with scaling exponent $\nu = 1/3$ [1]. Even though the resistivity is a small parameter, the resulting growth rates are thus large and competitive with ideal growth rates. The external resistive kink has recently been shown to be responsible for the ideal-like disruptive instabilities in DIII-D limited and diverted discharges with $q_{95} < 2$. While the scaling for these modes is found to have a fractional exponent, the exponent is variable. For the limiter discharges with a realistic resistivity profile increasing rapidly in the edge, ν varies continuously from $\nu = 1$ at low η to $\nu \sim 0$ at very high η. For the diverted case, ν varies from $\nu \sim 1/2$ at low η to 1/3 at high η. In contrast to the internal kink studies, there appears to be no transition in mode structure. Additionally, the limiter and divertor scalings are different; the transition in the latter from $\nu \sim ½$ (or from $\nu \sim 3/5$) to $\nu \sim 1/3$ shows a possible discontinuity.

[1] Huysmans G.T.A., et al, Phys. Plasmas **B5**, 1545 1993

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