Energetic decomposition of modes in resistive plasmas

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In magnetically confined fusion plasmas, magnetohydrodynamic (MHD) instabilities can cause massive losses of confinement. The analysis of MHD stability is, therefore, crucial for the operation of future fusion devices.

While solving the set of linearized MHD equations yields the structure and growth rate of instabilities, there is no information on the energetic drives of the instability. The energy functional relates the kinetic energy of the perturbation to the driving and restoring forces in the plasma [1]. For ideal MHD, the energy functional can be transformed to an "intuitive form", where the energetic contributions are separated into different sources of energy (pressure drive, current drive and stabilizing terms) [2]. However, for some equilibria, the presence of finite resistivity can influence MHD stability, lowering the critical parameters relative to the ideal MHD case and changing the mode structure. In order to analyze the energy sources driving these resistive instabilities, the intuitive form of the ideal energy functional must be generalized to plasmas with finite resistivity.

In this work, we extend the intuitive form of the ideal energy functional to include resistive instabilities. Since the resistive energy functional is not in the form of a solvable eigenvalue problem, it cannot be used to search for resistive instabilities directly, but it can be used to analyze the different energetic drives of resistive instabilities. The intuitive form of the resistive energy functional has been implemented in the stability code CASTOR3D in general curvilinear coordinates [3][4]. The functional has also been applied to a numerical test case showing equality of the kinetic and potential energy terms in different coordinate systems as well as the change of the different energetic contributions with increasing resistivity.

References

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