The utility of electron-ion energy coupling: from disruptions to diagnostics

S. Jin[1], A. H. Reiman[1], N. J. Fisch[1]

[1] *Princeton Plasma Physics Laboratory, Princeton, NJ, USA*

Due to the large mass difference between electrons and ions, both species come to thermal equilibrium within themselves, long before equilibrating with each other. As a result, a two-temperature description is necessary whenever the relevant time scales of the problem are comparable to electron-ion energy exchange rate. Here we discuss two examples where the coupled diffusion equations for electron and ion temperatures provide critical insights: the stabilization of NTMS via the rf condensation effect [1-7], and perturbative thermal diffusivity measurements [8].

In the former, the relevant time scale is set by the characteristic thermal diffusion time within the island, which scales quadratically with the island width. The relative strength of energy coupling thus increases with island width. While this energy coupling can reduce the stabilization efficiency when the ion temperature is at or below the electron temperature, it can also dramatically enhance stabilization in a hot ion mode. This opens the possibility of self-healing islands in steady-state LHCD operation, particularly in a hot ion mode.

The latter example has the relevant time scale set directly by the modulation frequency used. We show that the electron temperature response is not only affected by coupling as a damping term, but bears the signature of the ion heat transport properties as well. The sensitivity of the electron temperature to coupling can be exploited to provide simultaneous measurements of both electron and ion thermal diffusivities.

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