Nyquist analysis of kinetic effects on the plasma response in NSTX and DIII-D experiments*

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Externally applied, nonaxisymmetric magnetic perturbations can strongly modify tokamak plasmas, leading to the plasma response. Plasma response, often closely related to the resonant field amplification and to the ELM control using magnetic coils, has been systematically observed in tokamak experiments. In particular, the importance of drift kinetic effects on modifying the plasma response has been demonstrated via quantitative modeling of NSTX and DIII-D high beta experiments [1, 2]. In this work, Nyquist analysis, as a very powerful tool in stability theory, is applied to analyze the plasma response with the intrinsically stable plasmas, where the technique, combined with Padé approximation, provides the deep physics understanding of the plasma behavior. Based on the idea that the plasma response to externally applied 3D fields is often due to the linear combination of certain stable eigenmodes' response, Nyquist analysis clearly shows how the kinetic effects change the damping rate of these stable eigenmodes in the plasma, without resorting to direct stability computations. The capability of Nyquist analysis to infer the plasma stability for potential ELM mitigation or suppression, direct observation of so-called multi-mode response and identification of amplification associated with the preferred eigenmode is also presented in this work, where the multi-model response is a phenomenon currently under extensive discussions [3]. The results suggest the application of Nyquist technique in 3D plasma response experiment since the plasma transfer function extracted from the experiments directly can be very useful to design the MHD control system and to better predict plasma behavior in future experiments.

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