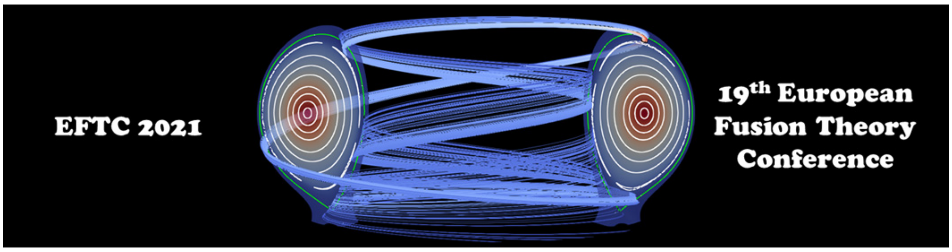

Contribution ID: **16**

Type: **Oral**

The nonadiabatic response of passing electrons and ion-gyroradius-scale electrostatic microinstabilities in the limit of small electron-to-ion mass ratio

Tuesday 12 October 2021 14:30 (20 minutes)

The passing electron response to ion-gyroradius-scale instabilities is often considered to be adiabatic: on irrational flux surfaces, passing electrons are assumed to be able to transit the entire flux surface on time scales faster than the mode e-folding growth time as a result of the small electron-to-ion mass ratio. This argument fails on mode-rational flux surfaces where magnetic field lines only cover a subset of the surface. In fact, gyrokinetic simulations have revealed modes driven by the passing electron response in narrow radial layers near rational flux surfaces in both electrostatic and electromagnetic scenarios, with possible impacts on transport. In the ballooning representation, these modes appear with giant tails in extended poloidal angle. The small electron-to-ion mass ratio limit of linear electrostatic gyrokinetics is presented, for ion-gyroradius-scale modes, in the ballooning representation, including the nonadiabatic response of passing electrons. This theory reveals novel modes driven solely by the nonadiabatic passing electron response, and recovers the usual ion and trapped-electron driven instabilities. The collisionless and collisional limits of the theory are considered, and simple scaling predictions for basic properties of the eigenmodes are obtained. The scaling predictions are shown to be in agreement with simulation results from the gyrokinetic code GS2. The extension of the theory to the electromagnetic case is discussed: the extended theory may be relevant to the study of micro-tearing modes. Finally, it is observed that the novel electrostatic passing-electron-response-driven modes may be insensitive to equilibrium flow shear, since these modes form narrow radial layers. Hence, it may be important to consider the stability of passing-electron-response driven modes in projected scenarios where turbulence is assumed to be suppressed by equilibrium flow shear.

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Session Classification: ORAL SESSION

Track Classification: 10. Basic plasma theory