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Gap eigenmode in linear plasma: theory and simulation

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Benefitting from simple geometry, easy diagnostic access and low cost, linear plasma such as low-temperature plasma cylinder has been attracting great attention to study fundamental plasma physics regarding magnetically confined fusion. The topics include plasma-material interaction for first wall design, basic wave activities and particle dynamics, together with the gap eigenmode of electromagnetic waves propagating in a periodic system with local defect. This presentation will cover the theoretical and numerical effort that was taken recently with Boris Breizman (University of Texas at Austin) and Matthew Hole (Australian National University) to form the gap eigenmodes of whistlers and Alfvén waves in a plasma cylinder. Self-consistent models based on Maxwell's equations and cold-plasma dielectric tensor for the gap eigenmode with frequency below and above the ion cyclotron frequency will be presented in detail, following which full-wave computations showing clear whistler and Alfvén gap eigenmodes will be given. Typical profiles of these two gap eigenmodes are shown in Fig. 1 and Fig. 2, respectively[1, 2]. The effects of magnetic mirror parameters such as number and depth will be also discussed[3]. The progress of the experimental implementations of these gap eigenmodes on the LAPD (Large Plasma Device) and self-constructed facility will be introduced at the end. Recent modelling work of the Alfvén gap eigenmode on the LAPD will be also presented. The investigation of these gap eigenmodes in linear plasma can reveal more physics about their formation and interactions with energetic particles in fusion plasma, and is thereby practically very interesting.

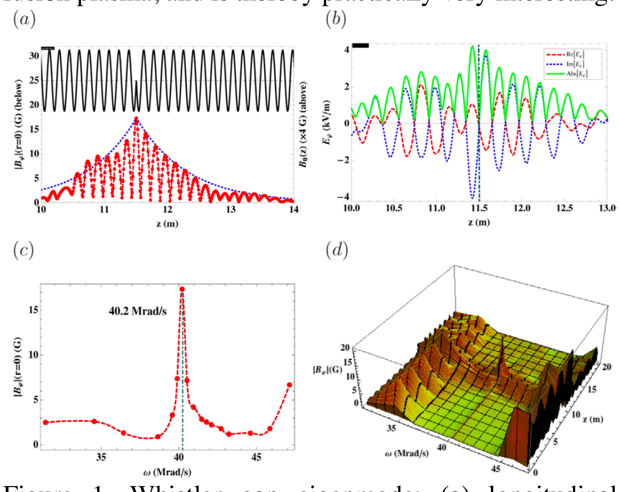

Figure 1. Whistler gap eigenmode: (a) longitudinal profiles of static magnetic field (solid line) and RF magnetic field (dots), together with theoretically calculated envelope (dotted line), (b) longitudinal profile of wave electric field, (c) dependence of the amplitude of the RF magnetic field on driving frequency at the location of the defect, (d) 3D plot of wave field strength.

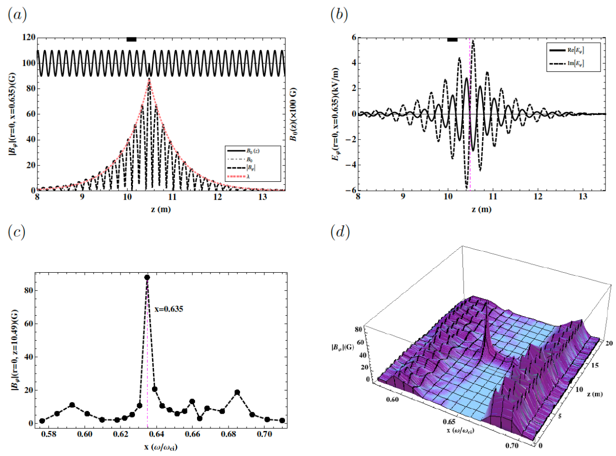

Figure 2. Alfvén gap eigenmode: (a) longitudinal proles of static magnetic field (solid line) and RF magnetic field (dashed line), together with analytical decay constant (dotted); (b) longitudinal prole of wave electric field; (c) dependence of the amplitude of RF magnetic field on driving frequency at the location of the defect; (d) surface plot of the wave field strength.

References:

[1] L. Chang, B. N. Breizman, and M. J. Hole, Plasma Phys. Control. Fusion 55, 025003 (2013).
[2] L. Chang, The impact of magnetic geometry on wave modes in cylindrical plasmas, PhD Thesis, Australian National University (2014).
[3] L. Chang, N. Hu, and J. Y. Yao, Chin. Phys. B 25, 105204 (2016).
[4] L. Chang, B. Breizman, and M. Hole, "Modelling the Alfvénic gap eigenmode on a linear plasma", to be submitted to Plasma Phys. Control. Fusion.