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Galactic cosmic rays driven MHD waves and gravitational instability dusty molecular clouds

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This talk reports recent results on the impact of galactic cosmic rays (CRs) in terms of CR pressure and parallel CR diffusion on the low-frequency magneto-hydrodynamic (MHD) waves and linear gravitational instability in the typical dusty plasma environment of molecular clouds (MCs). The dusty fluid model is formulated by combining the equations of the magnetized electrons/ions and dust particles, including the CR effects. The interactions between CR fluid and gravitating magnetized dusty plasma have been studied with the help of modified dispersion properties of the MHD waves and instabilities using the hydrodynamic fluid–fluid (CR–plasma) approach. CR diffusion affects the coupling of CR pressure-driven mode with dust-Alfvén MHD mode and causes damping in the MHD waves. It persists in its effect along the direction of the magnetic field and is diminished across the magnetic field.

The phase-speed diagram shows that for super-Alfvénic wave, the slow mode becomes the intermediate Alfvén mode. The fundamental Jeans instability criterion remains unaffected due to CR effects, but in the absence of CR diffusion, the effects of dust-acoustic speed and CR pressure-driven wave speed are observed in the instability criterion. It is found that CR pressure stabilizes while CR diffusion destabilizes the growth rates of Jeans instability and significantly affects the gravitational collapse of dusty MCs. The charged dust grains play a dominant role in the sub-Alfvénic and super-Alfvénic MHD waves and the collapse of MCs, triggering gravitational instability. The consequences have been discussed to understand the gravitational instability in the dense photodissociation regions of dusty MCs [2].

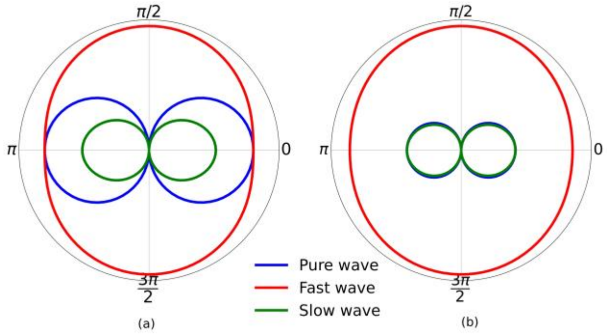

Fig. 1. Friedrichs diagram for the normalized phase speed of the fast, slow, and intermediate MHD waves. (a) For sub-Alfvénic flow (b) For super-Alfvénic flow.

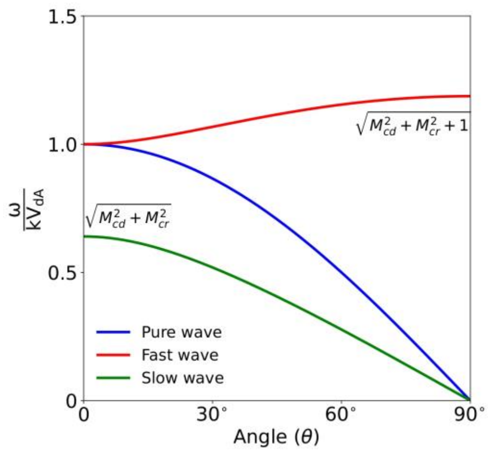

Fig. 2. Normalized phase speeds of the fast, slow an intermediate MHD waves versus propagation angle.

References:

[1] Ram Prasad Prajapati, MNRAS, **510**, 2127 (2022).
[2] Pallab Boro and Ram Prasad Prajapati, MNRAS, **522**, 1752 (2023).