6th Asia-Pacific Conference on Plasma Physics, 9-14 Oct, 2022, Remote e-conference

Cosmic-rays driven MHD waves and gravitational instability in magnetized plasmas

Ram Prasad Prajapati
School of Physical Sciences, Jawaharlal Nehru University (JNU)
e-mail: rpprajapati@mail.jnu.ac.in

The energetic galactic cosmic rays (CRs) (mainly protons) play a significant role in the ionization and heating of the gas in interstellar medium. The CRs pressure gradients is responsible for producing acoustic modes and hence the propagation of magneto- hydrodynamic (MHD) waves is significantly affected. Also, the CR diffusion along the magnetic field plays a crucial role on the gravitational collapse of radiative molecular clouds mainly in the H II region [1-2].

In this talk, I will present the effects of CR diffusion and finite Larmor radius (FLR) corrections on the propagation of MHD waves and gravitational instability in thermally conducting and radiative plasmas typically in the H II regions of the molecular clouds. The hydrodynamic fluid–fluid approach has been used to consider the interactions of CR fluid with the self-gravitating and magnetized plasmas. The MHD fluid model is constructed accounting for the effects of CR pressure, CR diffusion, FLR corrections and radiative heat-loss functions. The dispersion properties of the MHD waves and gravitational instability have been discussed using the normal mode analysis. The dispersion relation has been discussed for the transverse and longitudinal propagations.

It is found that the gravitational collapse of the system is supported by high-energy CR particles with the Larmor radii comparable or less than the molecular cloud size. In the absence of CRs, the FLR effects reduce the growth rate for wavenumber smaller than a critical value, and above it gets increased. The growth rate is strongly suppressed in the presence of combined CRs and FLR effects. The individual behaviour of FLR effects is observed to destabilize the growth rate of the gravitational instability in the presence of CR effects. The CR pressure decreases the growth rates of the gravitational and thermal instabilities, whereas parallel CR diffusion enhances the growth rate of the gravitational instability. The Jeans length of the gravitating gas cloud gets increased due to an increase in the CR-to-gas pressure ratio. The present results have been applied to understand the role of CRs and FLR corrections on the gravitational collapse in the H II regions of molecular clouds [3].

References

1. T. Kuwabara and Chung-Ming Ko, Dynamics of the Parker–Jeans instability of gaseous disks including the effect of cosmic rays. Astrophys. J **899**, 72 (2020).
2. E. Heintz and E. G. Zweibel, The Parker instability with cosmic ray streaming. Astrophys. J. **860**, 97 (2018).
3. R. P. Prajapati, Gravitational instability in radiative molecular clouds including cosmic ray diffusion and ion Larmor radius corrections. MNRAS **510**(2), 2127–2138 (2022).