國立中央大學太空科學與工程學系

Department of Space Science and Engineering, National Central University

專題演講

Hybrid particle simulations of the observed mirror waves in space environments

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摘 要/Abstract：

Mirror instability may occur in anisotropic plasmas for the condition of $T_\perp/T_\parallel > 1$ and $\beta_\perp/\beta_\parallel > (1+\beta_\perp)/\beta_\parallel$, where $\beta_{\perp,\parallel} = p_{\perp,\parallel}/(B^2/2\mu_0)$, $T_\perp$ and $T_\parallel$ are the two temperatures, perpendicular and along the magneic field. The mirror waves associated with the mirror instability have been widely observed in the solar wind, terrestrial magnetosheath, planetary magnetosheaths and heliosheath, etc. The important characteristic of the observed mirror wave structures is that the magneitic field is increased or decreased with the decreasing or increasing plasma density, or, there exists an anticorelation between these two quantities. In addition, the anticorrelation between the perpendicular temperature and magnetic field has also been observed. The present study first shows that the linear mixed kinetic-MHD theory can quantitatively describe the phase relations and thermodynamic conditions of the observed mirror waves in the terrestrial magnetosheath. Furthermore, it is shown that the theoretical predictions and mirror observations may be verified by the kinetic simulations of the time evolutions of proton mirror instability. We examine the proton mirror instability based on the hybrid particle simulations for twenty sets of initial $\beta_\perp$ and $\beta_\parallel$ values and the quantitative comparisons are made between the kinetic simulations, linear theory and mirror observations in terms of the growth rates, phase relations and thermodynamic conditions, etc. The results show that the simulations and observations are in high agreements with the theoreitcal predictions. In particular, the polyropic exponents in the saturated states of the kinetic simulations are in the ranges of $\gamma_\perp = 0.64 \pm 0.21$ and $\gamma_\parallel = 1.07 \pm 0.12$, which are consistent with theoretical predictions and mirror observations of $\gamma_\perp < 1$ and $\gamma_\parallel \gtrsim 1$. It is shown that the observed features, including various perturbations and wavelengths etc., may be reproduced by the nonlinear simulations. The analyses of statistical results indicate that the saturated temperature anisotropy $\beta_\perp/\beta_\parallel$ and plasma $\beta_\parallel$ are anticorrelated and the relation may be fitted by the modified mirror instability threshold of $\gamma_\parallel \beta_\parallel = \beta_\perp^2/(2+\gamma_\perp \beta_\perp)$ with $\gamma_\perp \approx 0.8$ and $\gamma_\parallel \approx 1.3$.

※歡迎聽講※

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