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Formation of intermediate shock in nonlinear Alfvén wave and plasma heating

Shinji Koide[1], Kento Shiiba[1],
[1] Department of physics, Kumamoto University
e-mail (speaker): koidesin@kumamoto-u.ac.jp

Plasma heating by Alfvén waves has been discussed for many years in relation to the problem of solar corona heating. Physical processes such as nonlinear mode conversion, phase mixing, resonance absorption, and magnetohydrodynamic turbulence cascades can be considered as heating mechanisms by Alfvén waves. Nonlinear mode conversion is a model that compressional waves are generated by nonlinear processes of Alfvén waves and plasmas are heated by shock waves[1]. The previous numerical calculations of the coronal heating by Alfvén waves mimicked the magnetic field configuration and plasma parameters of the region above the solar photosphere because the non-uniform structure of the solar corona has been considered important[1,2,3]. To investigate the primary plasma heating by Alfvén waves itself, we performed the nonlinear ideal MHD simulation of Alfvén waves in a uniform magnetic field/plasma. It was found that an intermediate shock wave, which was investigated by Wu[4], is naturally generated by the nonlinear effect as the Alfvén wave propagates, and the plasma is heated by the shock wave. The nonlinear process of the Alfvén wave induces a longitudinal velocity oscillation and forms an intermediate shock wave (see Figure 1: time t= 2.5). The longitudinal velocity causes the intermediate shock as shown in the panel of B_y at $t = 2.5$ of Figure 1. However, at $t = 2.5$, the average of the temperature ($< T >$) remains the initial value, while the temperature T is perturbed by the plasma compression. At $t = 5.0$, overall increase in temperature due to plasma heating by the intermediate shock wave is found. The numerical simulation suggests that the intermediate shock wave heads the plasma without a dissipation effect, while the heating by the intermediate shock with the dissipation effect had been proposed[5]. In our talk, we show the details of the formation mechanism of the intermediate shock and the heating of the plasma due to the shock.

References
[1] J. V. Hollweg, S. Jackson, D. Galloway, Solar Physics, **75**, 35 (1982).
[2] T. Kudoh, and K. Shibata, ApJ, **710**, 1857 (1999).
[3] T. Sakaue and K. Shibata, ApJ, **900**, 120 (2020).
[4] C. C. Wu, J. Geophysical Research, **95**, 8149 (1990).
[5] T. Inoue and S. Inutsuka, Prog. Theor. Phys. **118**, 47 (2007).

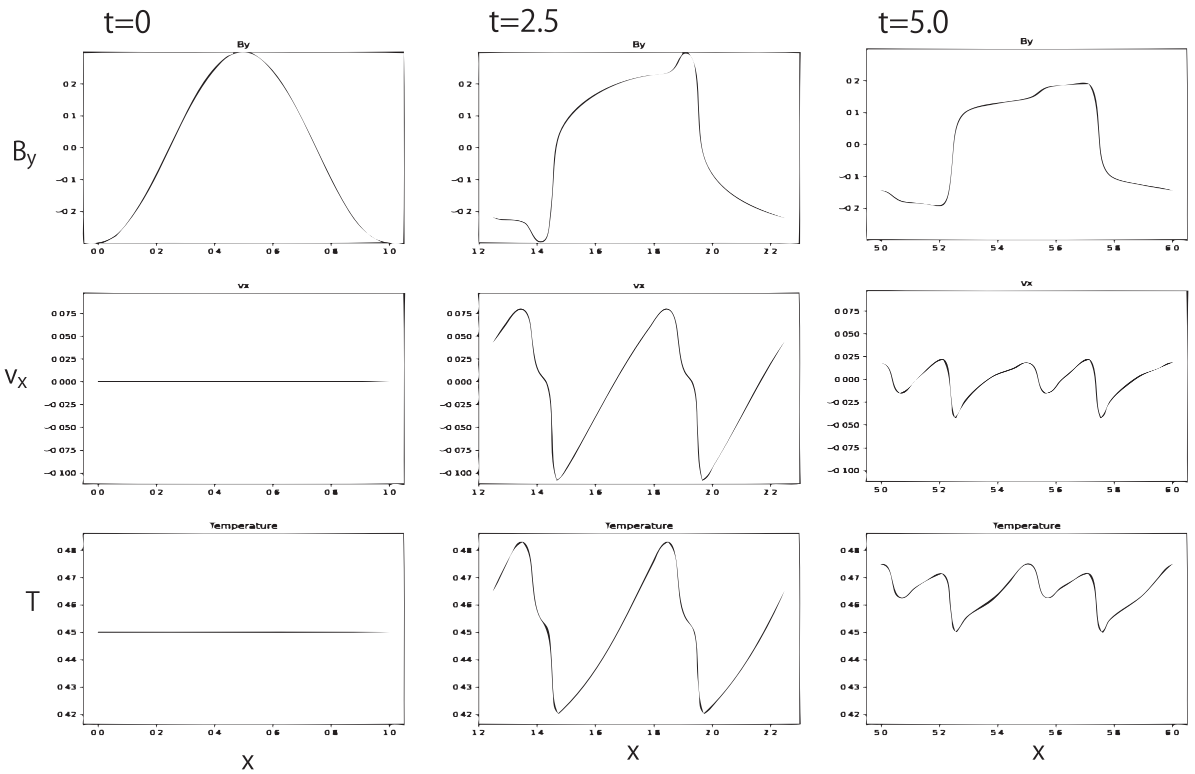

Figure 1. Nonlinear time evolution of Alfvén waves at $t = 0, 0.25, 0.5$. B_y : Transverse component of magnetic field, v_x: Longitudinal component of velocity of plasma, T: Temperature of plasma.