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Kinetic Alfven Wave (KAW) in nonuniform magnetic plasma atmospheres and its applications

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Both the solar and stellar coronal heating problems are significant challenges in astrophysics. As early as about 1940, Lyot [1] and Edlen [2] inferred from spectral observations that the temperature of the solar corona might be as high as 10^6 K. Our previous researches show that the solar coronal heating mechanism should be magnetic correlation to provide appropriate transmission and conversion channels for the heating energy, non-uniform heating to provide reasonable explanation of the structured characteristics of heating non-uniformity, and sufficiently high heating efficiency to balance the cooling of the corona [3].

The first heating mechanism involving the role of magnetic fields is the Alfv´en wave (AW) heating, which was proposed by Alfv´en (1947) [4]. However, how to effectively transform the AW energy into the kinetic energy of particles in the thin coronal plasma is the basic problem that still needs to be solved. Kinetic Alfv´en waves (KAWs) are small-scale dispersive AWs with a short perpendicular wavelength comparable to the kinetic scales of plasma particles, such as the ion gyroradius or the electron inertial length [5, 6]. Since the heating rate of KAWs sensitively depends on the local magnetic field strength and hence has the strongly magnetic correlation, it has been proposed as a pivotal candidate mechanism for this heating process [3].

It is speculated from observations that the density structures with scales of a few kilometers are common features of the solar magnetic atmospheres, which may cause the resonance mode conversion of AWs to KAWs. Therefore, in this talk, we propose a universal mode conversion mechanism from AW to KAW due to the nonuniform characteristics of solar atmospheres.

Our finding reveals that KAWs can be effectively generated through the resonant mode conversion of AWs in the chromosphere, with the amplitude ratio of KAWs to AWs $E_{KAW} / E_{AW} \sim 0.01$-$0.1$. In the chromosphere, the dissipation of KAWs through Coulomb collisions balances radiative cooling. As KAWs propagate into the corona, the Landau damping of KAWs becomes the dominant dissipation mechanism for coronal heating. The results provide a unified mechanism for the generation, propagation and dissipation of KAWs, and may have great significance in solving the heating problems of the solar and stellar corona.

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