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Generation of Kinetic Alfvén Waves and Parallel Ion Cyclotron Waves Triggered by Ion Beam Modes in the Solar Wind

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Kinetic Alfvén waves (KAWs) and ion cyclotron waves (ICWs) are thought to play a crucial role in solar wind heating and acceleration and are widespread in space and astrophysical plasmas. However, the mechanism underlying their coexistence remains unclear. This study introduces a new scenario for the generation of KAWs and parallel ICWs in a homogeneous solar wind plasma based on hybrid simulations. An example of the simulation results of k-space spectra at the initial stage and later stage are shown in Figure 1. The results indicate that the ion beam (IB) mode in a homogeneous alpha or proton beam plasma can trigger the emission of KAWs and parallel ICWs, provided the beam velocity exceeds $\geq 1.2v_A$ for alpha particles or $\geq 1.6v_A$ for proton beams, where v_A is the local Alfvén velocity. The growth rates of both KAWs and parallel ICWs significantly surpass that of the IB mode. Moreover, an inverse correlation is found between the initial background proton beta and KAW growth. Ultimately, the saturation energy of the triggered emissions can be comparable to that of the IB mode. Given the frequent occurrence of IBs in the solar wind, this triggering mechanism offers a plausible explanation for the origin and coexistence of KAWs and parallel ICWs in beam plasma environments.

References
[1] L. Xiang, K. H. Lee*, L. C. Lee, D. J. Wu, L. Chen, H. Q. Feng, G. Q. Zhao, and T. C. Tsai, Triggered Emissions of Kinetic Alfvén Waves and Parallel Ion Cyclotron Waves by Ion Beam Mode in the Solar Wind, ApJ 976 (2024)
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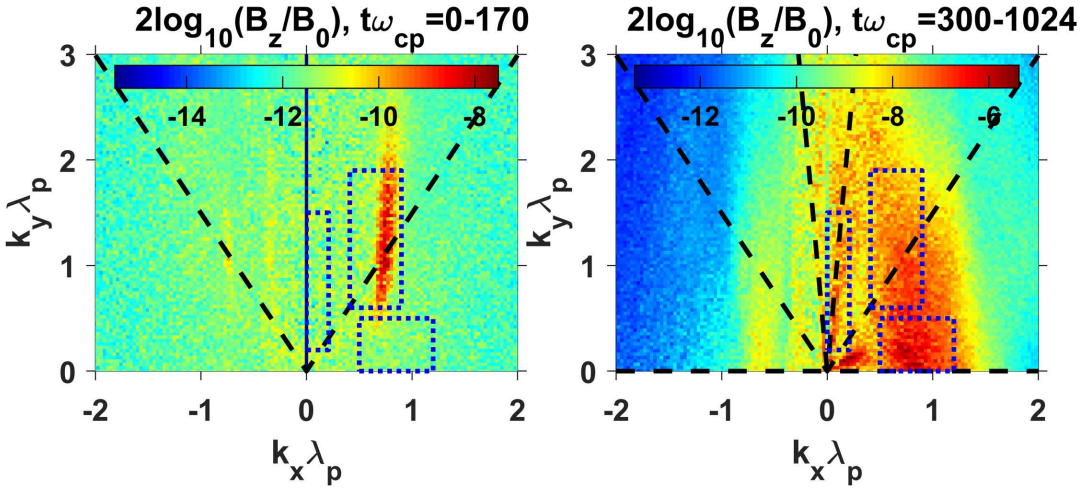

Figure 1. Generation of the KAWs and Parallel ICWs triggered by ion beam mode. (left) At the initial stage, only the ion beam mode is excited. (right) At the later stage, the quasi-parallel and parallel ICWs and quasi-perpendicular KAWs are generated.