Invited Review: Theoretical aspects of wave acceleration in open magnetic structures

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Abstract

Theoretical studies of the solar wind outflow in open magnetic structures motivated by SOHO observations indicate that both, high frequency ion-cyclotron waves and low frequency MHD waves play a role in the acceleration and heating of the solar wind plasma. In particular, the high temperature anisotropy of O^{5+} ions deduced from SOHO UVCS observations suggests that resonant heating due to ion cyclotron waves is important in minor ions. However, there are theoretical difficulties with the ion-cyclotron wave heating model of protons. The low-frequency waves are required to transport energy and to accelerate the solar wind on large scales. In addition, the source of electron heating is still an open question. I will review some of the recent wave heating models of the fast solar wind that rely on low frequency (MHD) and high frequency (kinetic) waves. I will discuss the 3-fluid model, that describes electrons, protons, and minor ions as three coupled fluids. This description allows to model different properties and heating processes for each particle species and to model the high temperature of the minor ions in accordance with observations. I will review the results of 2.5D 3-fluid, simulations of the solar wind plasma that combine the effects of MHD waves self-consistently, and ion-cyclotron waves parametrically as the sources of energy. I will review the results of hybrid kinetic models of ion-cyclotron wave heating of the minor ions.