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Contribution of Interplanetary Alfven Waves on Solar Wind Plasma Heating

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Since the 1960s, the frequent presence of Alfvén waves (AWs), or Alfvénic fluctuations (AFs), has been identified from in situ observations of solar wind fluctuations over the radial range from 0.3 to 20 au and from the ecliptic plane to high latitudes. The AW contribution to the energetics of the corona and solar wind has been considered since its discovery. The interactions of counter-propagating AFs are thought to be an important source of solar wind plasma heating. However, it is hard to make a quantitative evaluation in an open interplanetary space from the perspective of observation. Besides, solar wind AFs are found to be generally outward and sunward-propagating Alfvénic fluctuations (SAFs) are rarely observed in the literature.

Recently, we proposed a new approach for identifying large-amplitude interplanetary AWs, which can reduce the uncertainties of AW identification, and further obtain the AW properties in the frequency domain. As a relatively close system with the magnetic field connected with the solar surface, the interplanetary coronal mass ejections (ICMEs) provide a good media to study plasma heating by AW dissipation. We observationally confirmed the contribution of AW to solar wind plasma inside the ICMEs, from a statistical survey and a case tracking study. Also, we reported clear sunward-propagating AW events observed by Voyager 2 and found that the percentage of SAFs increases gradually with heliocentric distance, from about 2.7% at 1.0 au to about 8.7% at 5.5 au.

The parametric decay instability (PDI) of AWs is believed to be responsible for the generation of SAFs but has not been directly observed in the solar wind. Based on the statistical survey of heliospheric current sheets (HCSs), where the PDI of AWs are incident, we found that the incidence of MHD waves around HCS is modulated by the plasma β. For example, which satisfied the prediction of PDI theory. Furthermore, we also presented some indirect observational clues of PDI.

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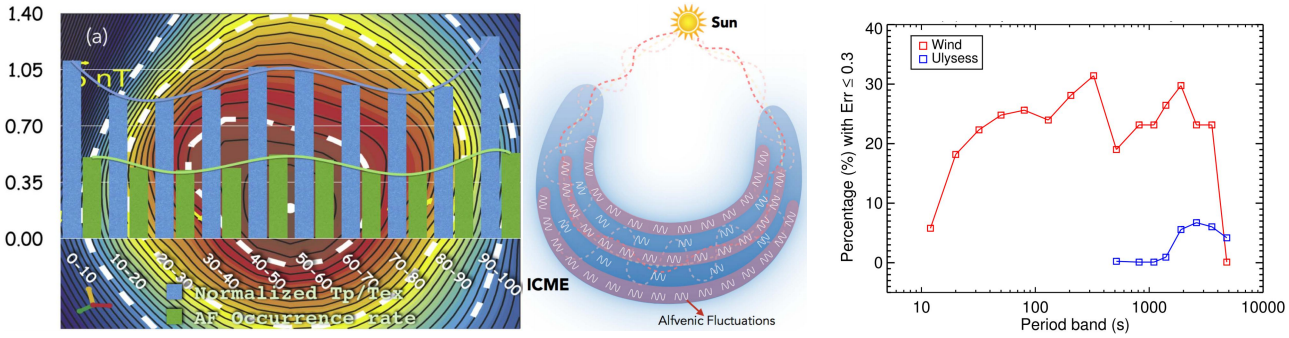

Figure 1. Distribution of AF occurrence rate and normalized Tep/ Tp across ICMEs based on the superposed epoch analysis (Left); Sketch of ICME plasma heating due to AF dissipation (Middle); AF dissipation with the ICME evolution from 1 au to 5.4 au (right).