Solar wind acceleration driven by plasma waves

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Physical mechanism(s) underlying the solar wind formation is still under debate. Promising ideas regarding the energy feeding mechanism include coronal-loop opening triggered by magnetic reconnection and wave and turbulence powered by turbulent surface convection [1]. In particular, the fast solar wind is believed to be powered by Alfvén wave and turbulence. Owing to the rapid increase of computational resource, direct numerical simulations of the solar wind acceleration based on wave/turbulence-driven scenario are now available [2,3]. In addition to the theoretical benefits, these simulations are also valuable for interpretating data from ongoing in-situ spacecrafts such as Parker Solar Probe [4] and Solar Orbiter [5].

Based on this background, development of the direct numerical simulation of the solar wind turbulence is reviewed in this talk. Turbulence in the MHD scale is discussed in particular. Recent three-dimensional simulation [6] shows that two fundamental processes play critical roles in heating and accelerating the (fast) solar wind: parametric decay instability and Alfvén-wave turbulence. Parametric decay instability, an unstable resonant coupling between Alfvén and slow-mode waves, induces large-amplitude density fluctuation that promotes wave reflection. MHD turbulence is triggered by the collision between outward and reflected Alfvén waves, by which the solar wind is found to be heated. The two processes should be considered simultaneously..

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