TWO-DIMENSIONAL HYBRID MODELS OF SOLAR WIND PLASMA HEATING BY TURBULENT WAVE SPECTRUM AND HE^{++} ION BEAMS

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Remote sensing observations of solar wind plasma show preferential heating and acceleration of heavy ions over protons and ion temperature anisotropies. In-situ observations of fast solar wind streams at distances of 0.29 AU and beyond by Helios and recently at 1 AU by STEREO, ACE, and Wind spacecraft provide direct evidence for the presence of turbulent Alfvén wave spectrum and of left-hand polarized ion-cyclotron waves in the coronal plasma. The future Solar Probe+ mission, scheduled for 2018, will provide for the first time in-situ observations of solar wind plasma close to the Sun, where it is expected to be inhomogeneous on small scales, and where the kinetic heating processes are strong. In the present work we study the heating and the acceleration of solar wind ions (H^+, He^{++}) in inhomogeneous expanding plasma with a driven turbulent spectrum of Alfvénic fluctuations and with initial $H^+ - He^{++}$ ion velocity drift using a 2.5D hybrid code. The 2-D model allows exploring inhomogeneities in the plasma and obliquely propagating waves self-consistently. We extend previous work by including the expansion of the solar wind and study its effect on the perpendicular ion heating and cooling, and on the spectrum of the magnetic fluctuations in the inhomogeneous background wind. We find that the expansion tends to decrease the ion velocity drift that causes instabilities that lead to plasma heating. The inclusion of the turbulent spectrum tends to decrease the proton anisotropy due to phase-space diffusion, while sub-Alfvénic drift enhances the perpendicular ion heating by the spectrum of waves. Our results demonstrate the preferential heating of He^{++} ions in inhomogeneous solar wind plasma by turbulent spectrum of waves in agreement with current observations and can be used to interpret future measurements near the Sun by future missions.