A self-consistent model of the coronal heating and solar wind acceleration including compressible and incompressible heating processes

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We propose a novel one-dimensional model that includes both shock and turbulence heating and qualify how these processes contribute to heating the corona and driving the solar wind. Compressible MHD simulations allow us to automatically consider shock formation and dissipation, while turbulent dissipation is modeled via a one-point closure based on Alfvén wave turbulence. Numerical simulations were conducted with different photospheric perpendicular correlation lengths, which is a critical parameter of Alfvén wave turbulence, and different root-mean-square photospheric transverse-wave amplitudes. For the various correlation length, we obtain a low-temperature chromosphere, high-temperature corona, and supersonic solar wind. Our analysis shows that turbulence heating is always dominant when the correlation length is smaller than 1 Mm. This result does not mean that we can ignore the compressibility because the analysis indicates that the compressible waves and their associated density fluctuations enhance the Alfvén wave reflection and therefore the turbulence heating. The density fluctuation and the cross helicity are strongly affected by the correlation length, while the coronal temperature and mass loss rate depend weakly on it.

Keywords: Coronal heating, Solar wind acceleration, Alfvén wave turbulence, Parametric decay instability