A two-step role for plasma expansion in solar wind heat flux regulation

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Already several decades ago, it was suggested that kinetic instabilities play a fundamental role in heat flux regulation at relatively large distances from the Sun, R > 1 AU [Scime et al, 1994]. Now, Parker Solar Probe observations have established that this is the case also closer to it [Halekas et al, 2020].

Electron scale instabilities in the solar wind are driven and affected in their evolution by the slow, large scale process of solar wind expansion, as demonstrated observationally [Stverak et al, 2008; Bercic et al, 2020], and via fully kinetic Expanding Box Model simulations [Innocenti et al, 2019b].

Now, connecting the dots, we examine an indirect role of plasma expansion in heat flux regulation in the solar wind. We show, as a proof of principle, that plasma expansion can modify heat flux evolution as a function of heliocentric distance, with respect to what is expected within an adiabatic framework, due to the onset of kinetic instabilities, in this case, an oblique firehose instability developing self consistently in the presence of a core and suprathermal electron population [Innocenti et al, 2020].

This result highlights, once again, the deeply multi scale nature of the heliospheric environment, that calls for advanced simulation techniques. In this work, the simulations are done with the fully kinetic, semi-implicit [Markidis et al, 2010], Expanding Box Model [Velli et al, 1992] code EB-iPic3D [Innocenti et al, 2019a].