



Can the electron heat flux at 1 AU be collisional ? Results from kinetic simulations.

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Recent results using statistically significant data of the solar wind at 1AU (see Bale et al. ApJL 769:L22, 2013) have shown that when the thermal Knudsen number, the ratio between the electron mean free path and the temperature scale height, falls below ~ 0.3 , the electron heat flux Q does rapidly approach the classical collisional Spitzer-Harm limit $Q_{SH} \sim T^{5/2} dT/dr$, where T is the temperature and r the heliocentric distance. This experimental finding seems to contradict a number of theoretical works which suggest that the collisional expression for the heat flux is only guaranteed for Knudsen numbers smaller than ~ 0.001 (e.g. Shoub ApJ, 266, 339-369, 1983; Scudder & Karimabadi, ApJ, 770:26, 2013).

Indeed, using a fully kinetic model including the effect of Coulomb collisions and the expansion of the solar wind with heliocentric distance, we do observe that the heat flux strength approaches the collisional value for Knudsen numbers below ~ 0.3 , in rather good agreement with the experimental data of Bale et al (2013). However, closer inspection of the variation of the plasma parameters with heliocentric distance shows that for Knudsen numbers between 0.01-0.3 the heat flux Q does NOT vary with temperature as predicted by Q_{SH} . We conclude that even though observations at 1 AU seem to indicate that the electron heat flux intensity Q approaches the collisional limit Q_{SH} for Knudsen below ~ 0.3 , the latter is not a generally valid closure in the solar wind for Knudsen large than 0.01.