Electron Heat Flux Near the Sun

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Background: Solar wind electrons have complex velocity distribution functions (VDFs) that evolve with heliocentric distance under the influence of competing physical processes, including Lorentz and gravitational forces, Coulomb collisions, and plasma instabilities. The electron VDFs therefore carry information about these processes, with implications for the solar wind energy balance and the physics of the near-Sun environment. See J.S. Halekas et al., A&A, 2020, for details.

Method: We survey the electron heat flux observed by the Parker Solar Probe (PSP) in the near-Sun environment at heliocentric distances of 0.125–0.25 AU. We utilize measurements from the Solar Wind Electrons Alphas and Protons and FIELDS experiments to compute the solar wind electron heat flux and its components and to place these in context.

Results: The PSP observations reveal a number of trends in the electron heat flux signatures near the Sun.

- The magnitude of the heat flux is anticorrelated with solar wind speed, likely as a result of the lower saturation heat flux in the higher-speed wind.
- When divided by the saturation heat flux, the resulting normalized net heat flux is anticorrelated with plasma beta on all PSP orbits, which is consistent with the operation of collisionless heat flux regulation mechanisms.
- The net heat flux also decreases in very high beta regions in the vicinity of the heliospheric current sheet, but in most cases of this type the omnidirectional suprathermal electron flux remains at a comparable level or even increases, seemingly inconsistent with disconnection from the Sun.
- The measured heat flux values appear inconsistent with regulation primarily by collisional mechanisms near the Sun. Instead, the observed heat flux dependence on plasma beta and the distribution of suprathermal electron parameters are both consistent with theoretical instability thresholds associated with oblique whistler and magnetosonic modes.
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- Electrons efficiently conduct heat from the solar corona
- Parker Solar Probe has made the first measurements of the electron heat flux in the near-Sun environment
- These new observations suggest that plasma instabilities limit the heat flux to a fraction of its maximum or “saturation” level, with broad implications for heat conduction from our star and other astrophysical objects