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Whistler instability driven by the sunward electron deficit in the solar wind: High-cadence Solar Orbiter observations

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Solar wind electrons exhibit complex electron velocity distribution functions (VDFs) shaped by expansion, Coulomb collisions, and field-particle interactions. We investigate how the suprathermal electron deficit in the anti-strahl direction, which was recently discovered in the near-Sun solar wind, drives a kinetic instability and creates whistler waves with wave vectors that are quasi-parallel to the direction of the background magnetic field.

Our study is based on high-cadence measurements of electron pitch-angle distribution functions combined with measurements of electromagnetic waves provided by Solar Orbiter during its first orbit.

The suprathermal electron deficit creates kinetic conditions under which the quasi-parallel whistler wave is driven unstable. We directly test our predictions for the existence of these waves through solar wind observations. We find whistler waves that are quasi-parallel and almost circularly polarised, propagating away from the Sun, coinciding with a pronounced suprathermal electron deficit in the electron VDF. The cyclotron-resonance condition is fulfilled for electrons moving in the direction opposite to the direction of wave propagation, with energies corresponding to those associated with the suprathermal electron deficit.

We conclude that the suprathermal electron deficit acts as a source of quasi-parallel whistler waves in the solar wind. The quasilinear diffusion of the resonant electrons tends to fill the deficit, leading to a reduction in the total electron heat flux.

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