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When a comet is sufficiently close to the Sun, the sublimation of ice leads to outgassing and the formation of a coma of gas and dust. Ionisation of the outgassing material then results in mass-loading of the solar wind and magnetic field draping around the cometary nucleus. Here we present three-dimensional fully kinetic simulations of the solar wind interaction with comet 67P/Churyumov- Gerasimenko at a low-activity regime, before collisions have any impact on the plasma dynamics. The interaction scales are well below the relevant ion gyroradii. Non-equilibrium electron distributions develop. To first order, the dynamical interaction is representative of a four-fluid coupled system [Deca et al., PRL 2017, Divin et al., submitted]. Our approach is self-consistent and allows to distill Ohm's law directly from the electron dynamics in the simulation, rather than imposing it beforehand.
In the vicinity of the cometary nucleus, the balance changes between the different terms in the equation. Deciphering the relative importance of each term allows to identify the driving physics in the various regions of the cometary plasma environment. For example, we find that close to the outgassing nucleus the electron pressure gradient dominates; that at sub-ion scales, the total electric field is a superposition of the solar wind convective electric field, where electrons are frozen-in, and the ambipolar electric field; that the latter accelerates electrons parallel to the magnetic field and is the source of/provides feedback to the electron pressure gradient that balances the Ohm's law perpendicular to the magnetic field, and that the role of electron inertia is negligible to balance the electric field.
In conclusion, Ohm's law shows us what happens to all ion and electron species, and why.