Show Us the Electric Energy, PSP

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The Sun is an immense spherical ball of gravitationally bound plasma, generating copious fusion energy. This energy is emitted in all directions, mainly as electromagnetic waves, called light and heat. The Sun also emits about one-millionth as much energy in beams of energetic protons with accompanying electrons, called the Solar Wind. This Wind energizes the Earth's magnetosphere, causes our atmospheric auroras, and can negatively impact satellite communications.

One of the NASA /ESA big questions for satellite missions is, "What heats the Solar Corona and energizes the Solar Wind ?" A new theory perspective supported by satellite data is now converging on a strikingly simple answer: "The permanent electric field originating below the Corona."

That is, the new electric theory now shows quantitative agreement with satellite data, from both the Parker Solar Probe and the older Ulysses mission. [C.F. Driscoll, "The electric fields and "lightning jets" of the Sun and Solar Wind", Physics of Plasmas, **30**, 102903 (2023), doi:10.1063/5.0139215.

The theory analyzes the solar *surface* effects which are energized by an *underlying* net positive charge. The surface effects include proton jets glowing as the ubiquitous "spicules" before accelerating to form the Solar Wind, local surface currents and magnetic fields, and the visually spectacular levitated arcs and prominences.

The requisite (miniscule) charge is quantitatively determined by a new "plasma virial limit", giving the maximal electric potential in terms of the well-known gravitational potential, with no adjustable parameters. Quantitatively, the net solar charge gives a potential $\Phi_Q = 6000.V^*$ (Rs / r), decreasing with radius; and this accelerates surface protons out of the 2,000 eV gravitational "well", up to a maximum kinetic energy of 4,000 eV.

Ulysses This maximal proton acceleration agrees closely with the "hard" upper limit of proton energies measured over the 15 years of Ulysses data. (McComas, 2000) Here, Ulysses provides the *only* measurements of proton energies out of the dusty and turbulent ecliptic plane of the planets, where lower proton velocities are necessarily observed.

PSP Separately, two research teams have published analyses of PSP-measured electron and proton velocities versus distance from the Sun, obtained during PSP's close (but in-ecliptic) encounters. [Bercic 2021, Halekas 2022] They uncovered distinctive non-thermal signatures in the high energy electrons, from which they were able to estimate ambient electric potentials. This included reference to various "exospheric" models, which *start* in the Corona. Surprisingly, the parameter-free electric model for Φ_Q [shown as Red dashed Overlays] agrees broadly with these several inferred potentials, over radii of 15 to 80 *Rsun.

However, the electric field originating in the plasma sheath *below* the Corona energizes surprisingly strong surface effects. This is because the outward electric force on every proton is 3x stronger than the inward gravitational force; and only the thin neutral Hydrogen atmosphere above the plasma sheath mediates the outward flow of energetic particles.

The electric perspective informs the surprising days-long "levitation" of glowing arcs and prominences, and may help in the interpretation of "space weather" which impacts the Earth. More broadly, It also may inform the theory perspective on the birth, stable burning, and unstable collapse of the myriad types of stars.

