How much Solar Charge, at what Radii?

A new "charge-electric" model of the Sun provides a broad energy basis for the stunning visible surface prominences, and gives quantitative agreement with Solar Wind measurements by the Ulysses and PSP satellites. Moverover, the analysis uncovers a novel "virial" relation between the gravitational energy and the electrostatic energy, which uniquely determines the magnitude of the electric effects.

Most simply, the Sun is a hot plasma ball of protons and electrons, held together by gravity and electric forces, respectively. The electric model is based on two quanitative "standard models" of the Sun, which describe the gravity part well.

--The **Core** model [Bahcall 2005] quantitatively describes the interior mass density and temperature profiles, quantifying the fusion energy release of light and heat. The Core model ends at the (un-modeled) Plasma Sheath, where the plasma transitions from ionized and optically opaque, to a neutral and transparent hydrogen Atmosphere. --The **Photospheric** model [Avret 2015] is based on an abundance of spectroscopic measurements, and describes a 2.Mm thick radiating Atmosphere at 0.4eV (i.e. 4600 Kelvin), with a sudden transition to a 100.eV Corona.



C.F. Driscoll **UCSD** Physics NNP.ucsd.edu /Solar

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This peculiar temperature jump has led to the long-standing NASA /ESA big mission question of, "What heats the solar Corona and energizes the Solar Wind ?" (?) Several generations of "kinetic exospheric" models have attempted to match the observed Solar Wind proton velocities, always starting up in the hot Corona. --In contrast, the new electric model provides a simple answer of "Electric fields from the net charge within the Sun."

The net solar Charge begins in the dense Core, where a static electric field is *required* to confine the electrons. (Pannekoek 1924) The "few" missing electrons leave a net positive charge of $Q_1 = +77$. Coulombs (i.e. 0.5×10^{21} e-), guantitatively determined by the known mass profile.

In the Plasma Sheath, additional electrons are "dragged out" by the strong electromagnetic energy flow; but theory estimates of this drag vary widely. Rather, a novel "virial limit" predicts that the central electric energy $e\Phi(0)$ is *limited* to the gravitational energy $m_0\Psi_c(0) = 10$.keV, and thus determining the maximal net charge to be $6 * Q_1 = 460.C$.

This total charge creates an outward electric force of 8.4 eV/Mm on every proton at R_s, which is 3x the inward gravitational force of 2.8 eV/Mm. This energizes proton "Lightning Jets" penetrating the neutral hydrogen Atmosphere, with broad electron neutralization, maintaining the total net charge. These Jets glow as the pervasive (~10⁷) "spicules" covering the solar surface. The Jets **heat** the outer Atmosphere and **form** the hot Corona, generating strong magnetic fields from the ~10⁹ Amps of proton and electron currents in each Jet.

The proton Jet can accelerate up to an energy of $e\Phi(R_s) - m_p\Psi_G(R_s) = 4.\text{keV}$. However, this coherent energy can be dissipated by gas, dust, and electro-magnetic turbulence in the ecliptic plane of the planets; and satellites typically measure proton energies ranging from 0.5 to 2.keV. However, the Ulysses satellite alone travelled north and south of the ecliptic, and 15 years of data shows a "hard limit" of $\mathcal{E}_{D^+}^{\text{max}} = 4.\text{keV}$.

Surprisingly, two recent analyses of the PSP *electron* velocity data have detected a signature of the static electric potential $\varphi_{c}(r)$, albeit with a puzzling $(r/Rs)^{0.66}$ dependence, suggesting widely distributed charge Q_{c} from Poisson's equation. However, this is closely consistent with the electric model from interior charge alone.

The charge-electric model provides a broad energy basis for understanding many other puzzling surface effects. Electric potential variations as small as 10. Volts may drive the stunning surface flashes recorded by Solar Orbiter, which resemble Earth surface lightning, in slow motion. **Prominences** and **arcs** which persist for hours and days may be 1/3 ionized gas which is "neutrally buoyant", with driven internal currents. **Sunspots** may represent the electric and magnetic interaction of hundreds of Jet currents. More importantly, the occasional energetic "coronal mass eruptions" which adversely impact Earth may involve large-scale interactions of all of these electric and magnetic effects.