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Presentation Type: Oral

Sorting Category: 2.00 Space plasma (within heliosphere)

Sub-Category: 02.05 Solar physics

Category Type: Theoretical

Abstract Title: Electric Fields and Electric Jets of the Sun and Solar Wind

A simple model of solar electric fields explains the solar wind energetics and coronal "heating", invoking only thermo-electric and photo-electric forces. In the (collisional) solar interior, thermal electron pressure generates a radial electric field $eE \sim m_p g/2$. In the (less collisional) photospheric plasma "sheath", the outward photon energy flux $\Gamma_e$ gives $eE = \sigma_{\gamma e} \Gamma_e / c$. Here, the photon-electron cross-section $\sigma_{\gamma e}$ varies widely with density and temperature: The minimum (Thompson) cross-section is $\sim 0.7$ barn, but correlated 2- or 3-body "rydberg" states (and H-) have $\sigma_{\gamma e} \sim 10^8$ barn. Here, a modelled $\sigma_{\gamma e} \sim 3 \times 10^4$ barn generates the observed solar wind: "collisional runaway" protons are accelerated out of the $-2.\text{keV}$ gravity well and up to $+1.3$ keV within several Rs, accompanied by neutralizing electrons. Spatial variations will be caused by the solar surface convective cells, with runaway generation more prevalent in the cold downflow edges. Moreover, plasma "pinch" dynamics may concentrate the edge acceleration into smaller "jets" (e.g. $\sim 10.\text{km}$), consistent with the "campfires" imaged by Solar Orbiter. This proton/electron flow will glow as the K-Corona, obviating the traditional $T=200\text{eV}$ "hydrostatic un-charged electron gas" models. NNP.ucsd.edu/Solar.

Abstract Body:

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The Sun emits copious energy in the form of light; and it also emits about one millionth as much energy in a persistent "solar wind" of protons and electrons. The physical mechanism by which the solar wind is generated (and the solar corona is heated) has been a long-standing mystery. Here, it is shown that the protons are accelerated by weak electric fields, which arise naturally due to the outward thermoelectric and photo-electric forces on the electrons. Essentially, the wind consists of "runaway" protons, emerging out of the collisional plasma of the solar surface, accompanied by neutralizing electrons. And surprisingly, even the weak field of 3 flashlight batteries every thousand kilometers would be sufficient to launch solar protons outward, integrating to a heliospheric potential of ~3 kV.

Prior analysis has focused on magnetic fields, which are readily observed from afar, but which can "do no work". In contrast, electric fields are harder to detect and harder to predict theoretically, since the requisite electric fields arise from a deficit of 1 electron out of about 10^36 electrons. Even small electric effects (i.e. as weak as gravity) are precluded by the "no charge, just currents" assumption of the standard (magneto) hydrodynamic theories.

For example, the "traditional" theory of the K-Corona (Van de Hulst 1950, et seq) invokes a hydro-static gas of low-mass particles (called electrons) at T~200 eV which scatter solar light. However, the requisite number of (charged) electrons would produce an electric potential of ~10^22 Volts, unless they are part of the complete e-/p+ electric energetics as proposed here. Similarly, the electric "jets" modeled here are accelerated and focused by electro-magnetic plasma effects in the Maxwell/Lorentz equations, not by hydro-dynamic processes as for the de Laval nozzle of 1950’s theory.

Speaker is: Senior Researcher