# Show Us the Energy, Ulysses

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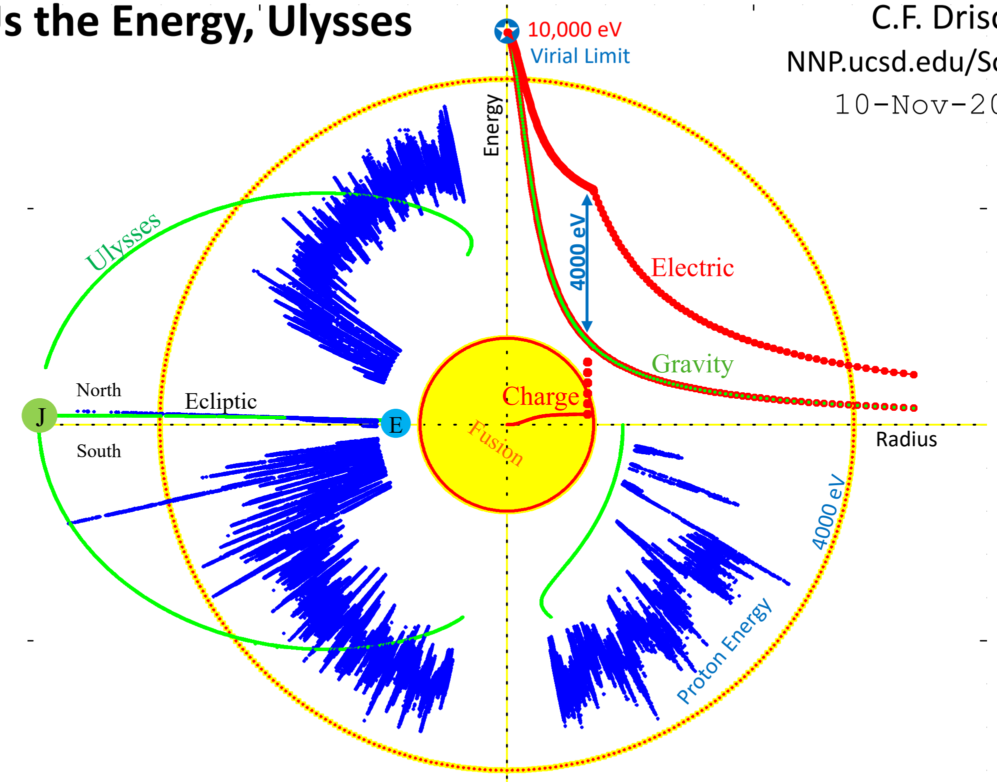
10-Nov-2023




The Sun is an immense spherical ball of gravitationally bound plasma, generating copius fusion energy. This energy is emitted in all directions, mainly as electro-magnetic waves (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. One of the NASA/ESA big questions for satellite missions is "What heats the Solar Corona and energizes the Solar Wind ?"

The Ulysses satellite travelled to Jupiter, where a gravity-assist gave it a unique north-south Solar orbit well out of the ecliptic plane of the planets. The largest proton velocities were measured well out of the ecliptic plane. (McComas 2000) Here, a polar plot of 15 years of Solar Wind proton *energies* show a "hard" upper limit of 4000 electron-Volts (orange circle)

Over the past 50 years, Solar Wind models have variously incorporated thermal energy, magnetic turbulence and weak electric fields, always beginning *outside* of the Sun itself.

Professor Charles Driscoll at UCSD has developed a new model which describes the electric fields arising from net charge *inside* the Sun, obtaining quantitative agreement with the Ulysses limit. This has now been published in the Physics of Plasmas. (doi:10.1063/5.0139215)

The electric model posits a net Solar charge displacement of 460.Coulombs, mainly located at the Solar plasma sheath. In simplest terms, this net positive charge occurs because electrons are continuously pushed outward by the enormous outflow of electro-magnetic energy, whereas the protons are not.

Significantly, this displaced charge is uniquely determined by a novel "virial limit", limiting the electric energy to the (accurately known) 10,000.eV gravitational energy at the center of the Sun. This then determines the 4000 eV available to accelerate protons off the Solar surface. The simple model then suggests that dissipation from ecliptic gas, dust, and plasma turbulence cause the intermittent, patchy "slow wind", which impacts the magnetosphere of Earth and displays as the colorful aurora Borealis.

Even given the requisite energy, significant questions remain as to the dynamics, uniformity, and constancy of the proton beam generation. The electric model posits pervasive, persistent "proton lightning jets", analagous to Earth lightning. These appear as the glowing, ever-present "spicules", which densely cover the Solar surface. Moreover, these spatially distributed beams each constitute billions of Amperes, and so can readily create the patchy, fluctuating kilo-Gauss magnetic fields observed on the surface.

Intermittent surface currents can also create the intense surface flashes imaged by the Solar Orbiter satellite, which look distinctly like ground lightning propagation on Earth, in appropriately slow motion. Similarly, the electric model may provide description for the large flowing near-surface "prominences", which remain levitated for hours
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More importantly, the electric model may provide a basis for modelling extreme "space weather" events such as coronal mass ejections, in terms of large-scale collective potential variations and resultant currents near the Solar surface. This poses substantial challenges and opportunities for future theory and simulations.