

# Solar Charge Electric Fields and Jets, in Quantitative Agreement with Ulysses and PSP

or.. Show us the Energy, Ulysses !!

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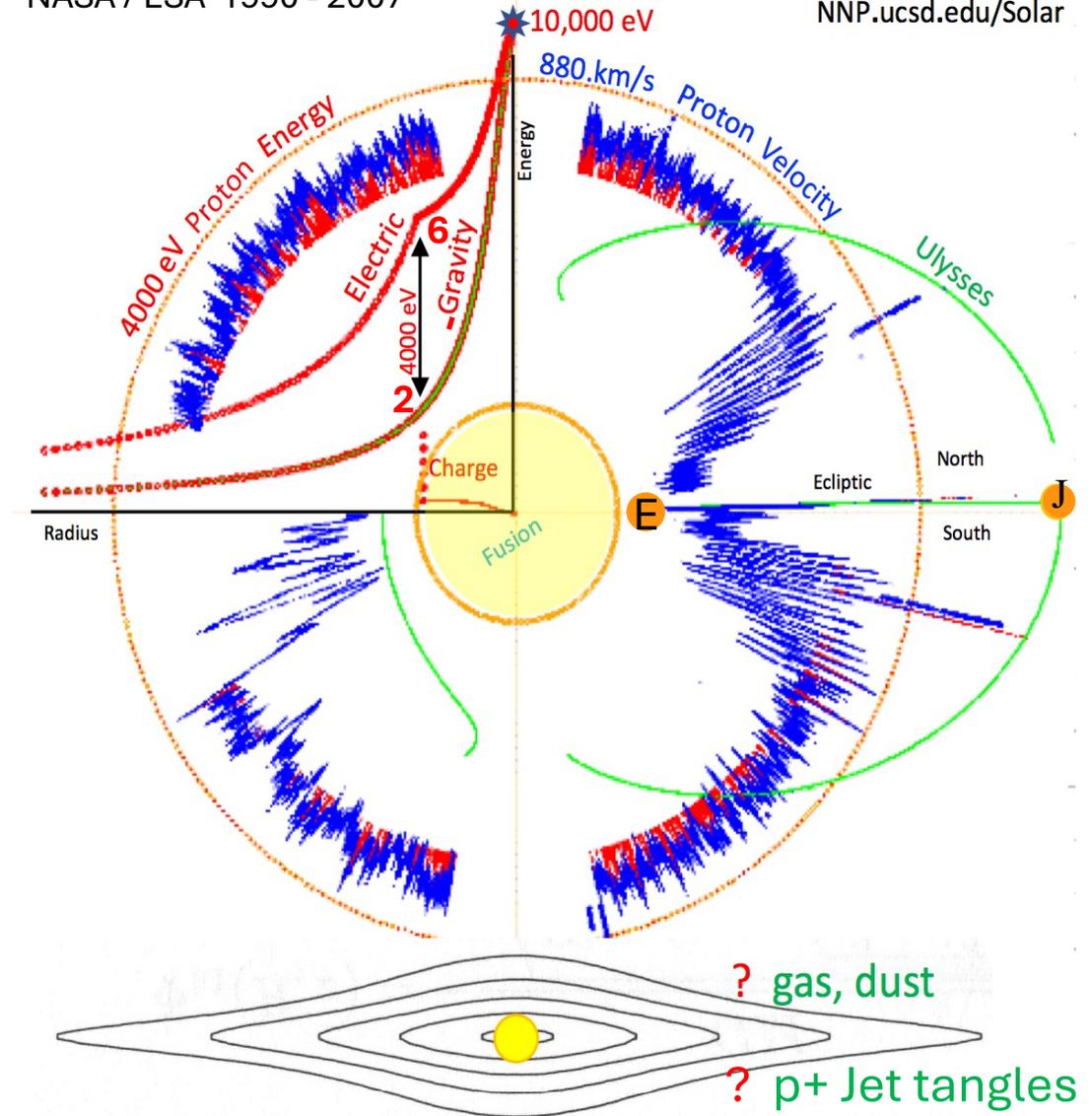
APS/DPP-2024  
JO05.01

- (1) The Sun is charged, by **+460. Coulombs**, mainly resident in the plasma sheath at  $R_S$ .
- (2) The resulting electric energy is **+6.keV** at  $R_S$ , whereas the proton gravitational "well" is **-2.keV** at  $R_S$ .
- (3) The **4.keV** excess electric energy can accelerate proton Jets to **880.m/s**, when not slowed by ecliptic-plane gas & dust & turbulence.
- (4) The Ulysses proton data shows a "hard limit" at **880.km/s**, over all directions and decades in time, away from the ecliptic.
- (5) Recent PSP eVDF data analyses show space potentials in close agreement, over  $15 < r < 80 R_S$ .
- (6) This electric potential is **quantitatively determined** by the "virial" equality of gravity & electric energies ( **10.keV** ) at  $r = 0$ , with **no free parameters**.

Ulysses Solar Wind from Maximal Electric Potential

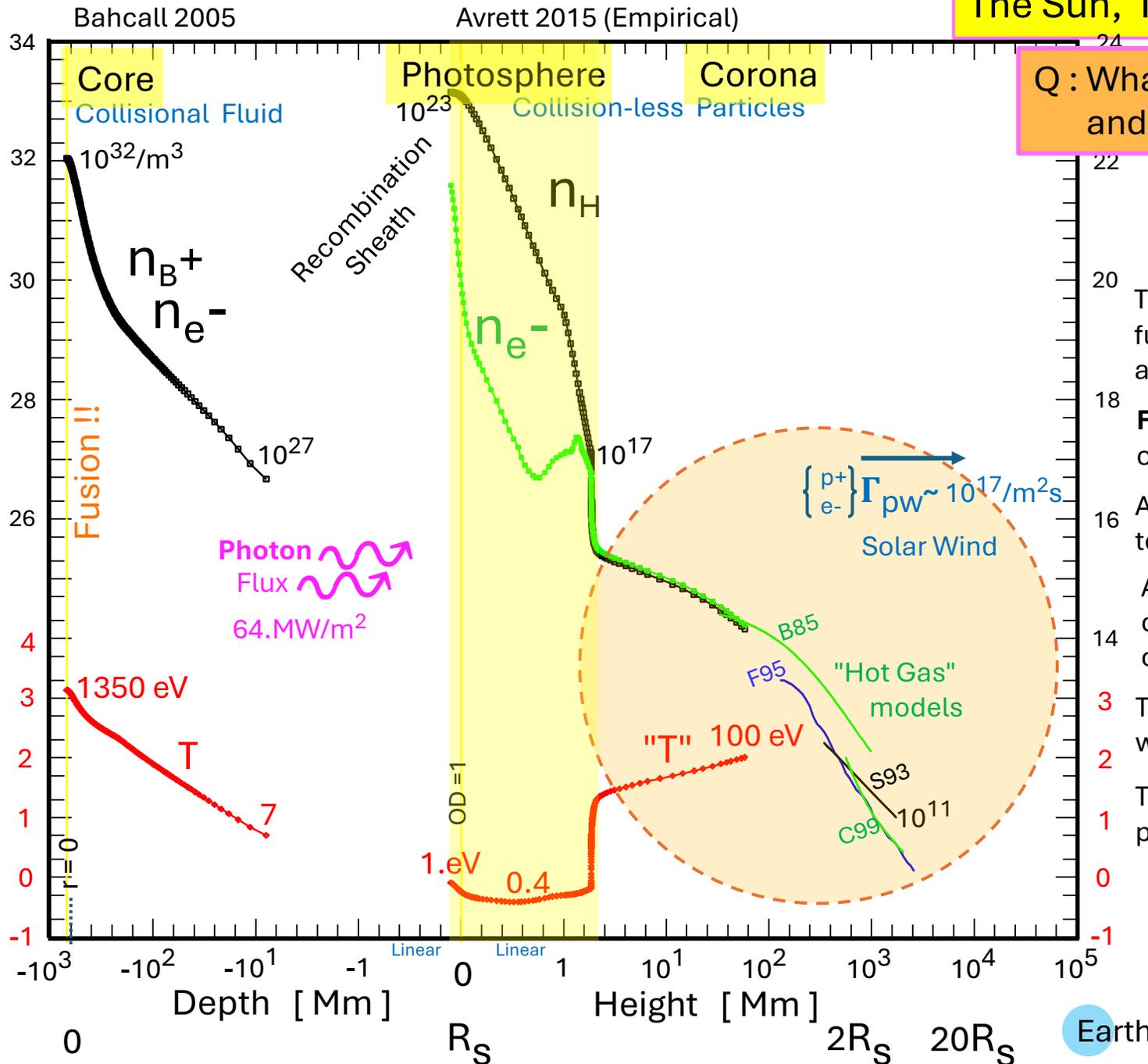
NASA / ESA 1990 - 2007

NNP.ucsd.edu/Solar



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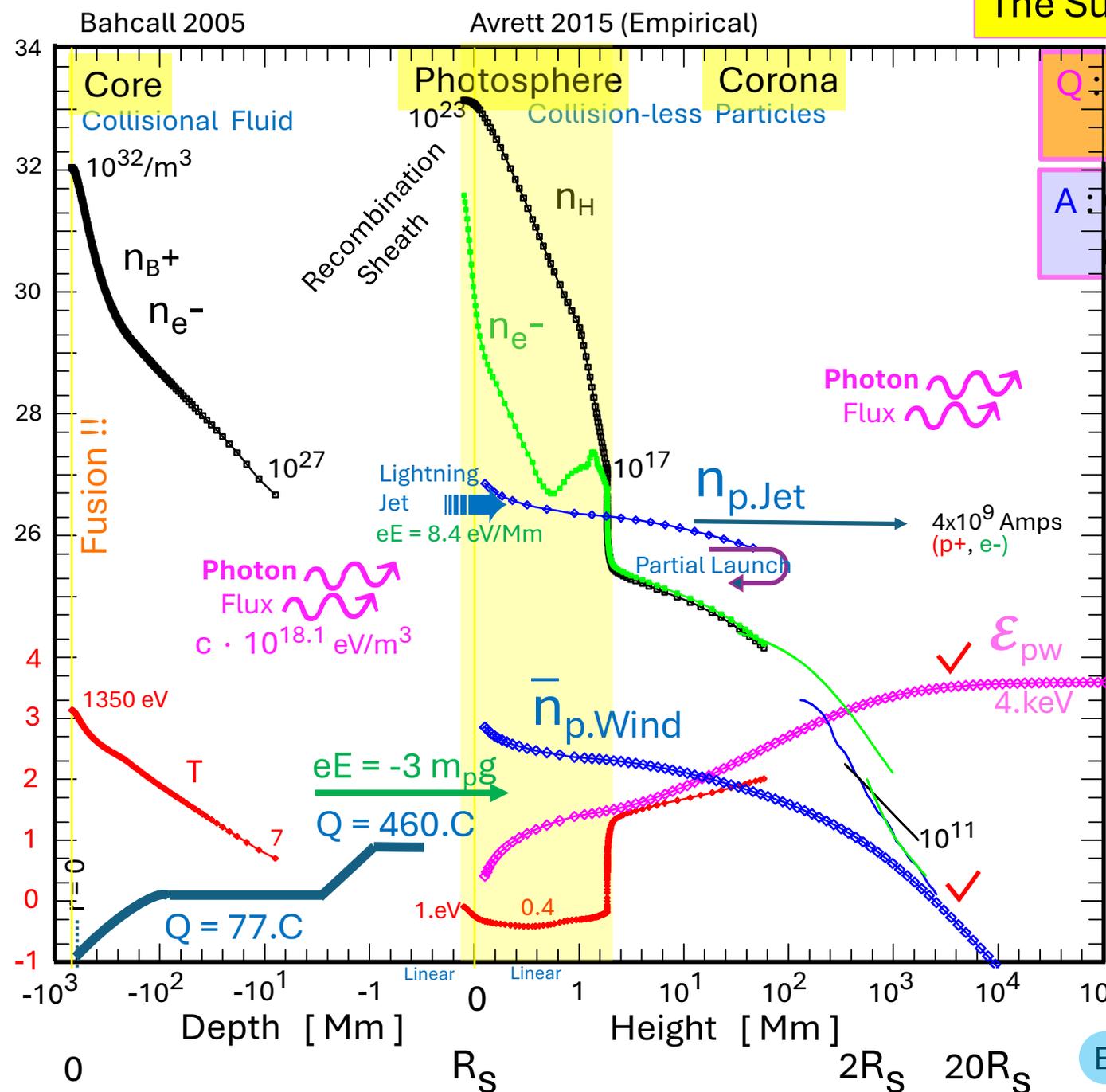
# The Sun, In & Out



Q : What heats the Corona and Energizes the Solar Wind ?

- The **Core** is described as a highly collisional, fully ionized fluid of baryons and electrons, with a central temperature  $T \sim 1350 \text{ eV} = 1.6 \times 10^7 \text{ Kelvin}$ .
- Fusion** energy diffuses out to  $R_{\text{sun}}$  as a **Photon Flux** of magnitude  $64 \text{ MW/m}^2$ .
- A plasma **Recombination Sheath** forms where the temperature drops below  $1 \text{ eV}$ ; here, no model exists.
- A weakly-ionized **Photosphere**  $\sim 2 \text{ Mm}$  thick (yellow), covers the interior plasma. Here, the description must change from a collisional fluid to collision-less particles.
- The **Corona** is a very low density, collisionless plasma, with empirical energy of about  $100 \text{ eV}$  per particle.
- The proton/electron Solar **Wind** is an energetic, pervasive, persistent, low-density flux  $\Gamma$  of particles.

# The Sun, In & Out



**Q:** What heats the Corona and Energizes the Solar Wind ?

**A:** Charge and Electric Fields, which accelerate proton "Lightning Jets" through the Photosphere.

The **Core** is described as a highly collisional, fully ionized fluid of baryons and electrons, with a central temperature  $T \sim 1350\text{ eV} = 1.6 \times 10^7$  Kelvin .

**Fusion** energy diffuses out to  $R_{Sun}$  as a **Photon Flux** of magnitude  $64\text{ MW/m}^2$  .

A plasma **Recombination Sheath** forms where the temperature drops below  $1\text{ eV}$  ; here, no model exists.

A weakly-ionized **Photosphere**  $\sim 2\text{ Mm}$  thick (yellow) covers the interior plasma. Here, the description must change from a collisional fluid to collision-less particles.

The **Corona** is a very low density, collisionless plasma, with empirical energy of about  $100\text{ eV}$  per particle.

The Charge increases to  $460.C$  at  $R_S$ , giving  $eE = -3 m_p g$  .  
Lightning Proton Jets form in pinched avalanche breakdown of Photospheric resistivity, and accelerate to  $4\text{ keV}$  unless slowed by neutrals, dust, or turbulent fields.

The Jets appear as Spicules; the Corona is diffuse Jets, inflowing neutrals, and downward runaway electrons.

# Equilibrium Stellar Fluid Eqns:

mass charge photons  
 $m_p m_e e^- p^+ \gamma$

1a  $\nabla^2 \Psi(r) = G m_p n_p(r)$  Gravity  $m_p \Psi' \approx 2.8 eV / Mm @ R_s$

1b  $\nabla^2 \Phi(r) = -k_1 e (n_p - n_e)$  Electric Potential  $G m_p^2 \sim 10^{-36} k_1 e^2 !!$

2  $\nabla \cdot \Gamma_\epsilon(r) = \frac{d}{dt} \mathcal{E}(r)$  Fusion Energy Flux

3  $-(4aT^3) T'(r) l_\gamma = \frac{4}{c} \Gamma_\epsilon$  Thermal Energy Diffusion  $\Gamma_{\epsilon\gamma} \sim 65. MW / m^2 @ R_s$

4a  $[n_p T]' + n_p m_p \Psi' + (+e) n_p \Phi' = 0$  Proton Fluid Momentum

4b  $[n_e T]' - \frac{\Gamma_{\epsilon\gamma}}{c l_{\gamma e}} + n_e m_e \Psi' + (-e) n_e \Phi' = 0$  Electron Fluid Momentum

4a+4b  $[(2n)T]' - \frac{\Gamma_{\epsilon\gamma}}{c l_{\gamma e}} + n m_p \Psi' = 0$  Total Fluid Momentum

4a-4b  $\frac{\Gamma_{\epsilon\gamma}}{c l_{\gamma e} n_e} + m_p \Psi' + (2e) \Phi' = 0$  Electric Field

$-\frac{1}{2} m_p g(r) \approx eE(r)$   
 @  $R_s \approx 1.4 eV / Mm$

Gravito-Electric in high-density collisional regime  
 A. Pannekoek  
 S. Rosseland (1924)  
 A.E. Eddington

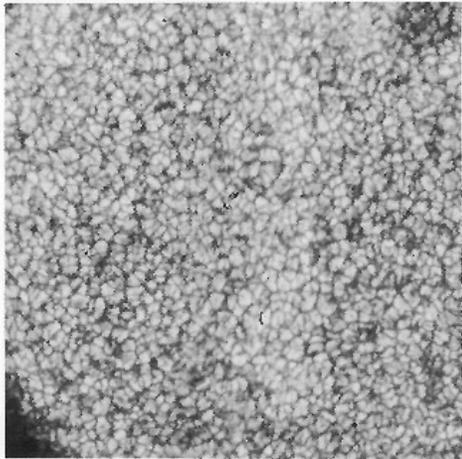
$\sigma_{\gamma e} \equiv \frac{1}{l_{\gamma e} n_e}$   
 $\frac{\Gamma_{\epsilon\gamma}}{c} \sigma_{\gamma e} = eE(r)$

Photo-Electric:  $\gamma/e$ - cross-section is large for correlated e-/p+  
 $(1 < \sigma_{\gamma e} < 10^8) \times 10^{-28} m^2$

@  $R_s = 8.4 eV/Mm$

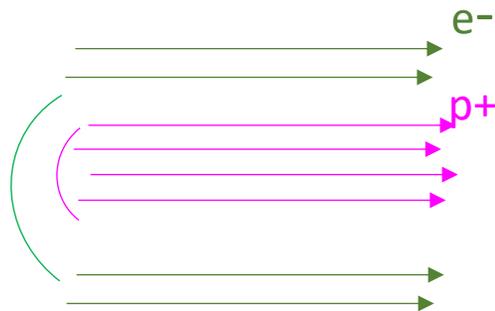


Surface **Convection Cells**,  
 $A \sim (1.Mm)^2$ ,  $\tau \sim 5.min.$   
 $\# \sim 10^7$

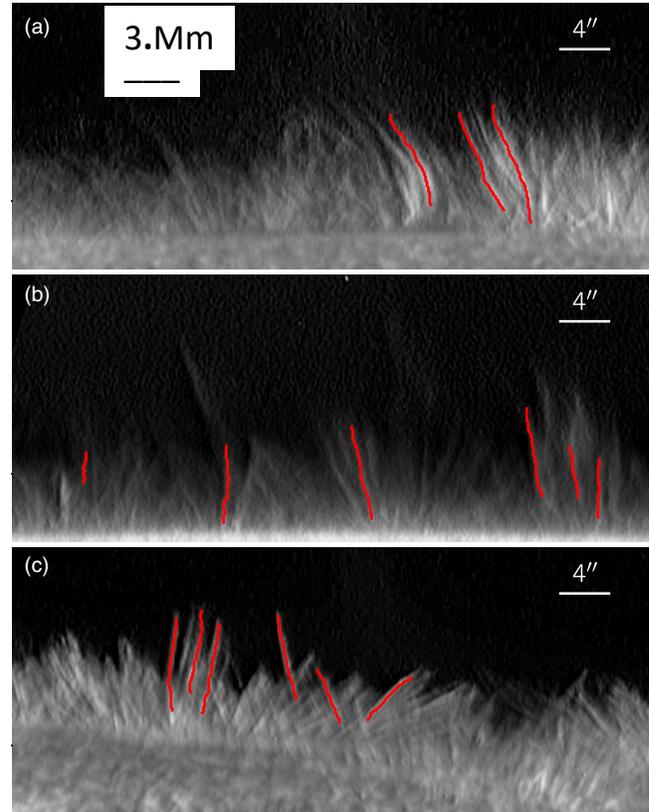


Brandt 1970

? Initiation points for  
 "avalanch breakdown" Jets ?



"**Lightning Jets**" appear as  
 Filamentary **Spicules**

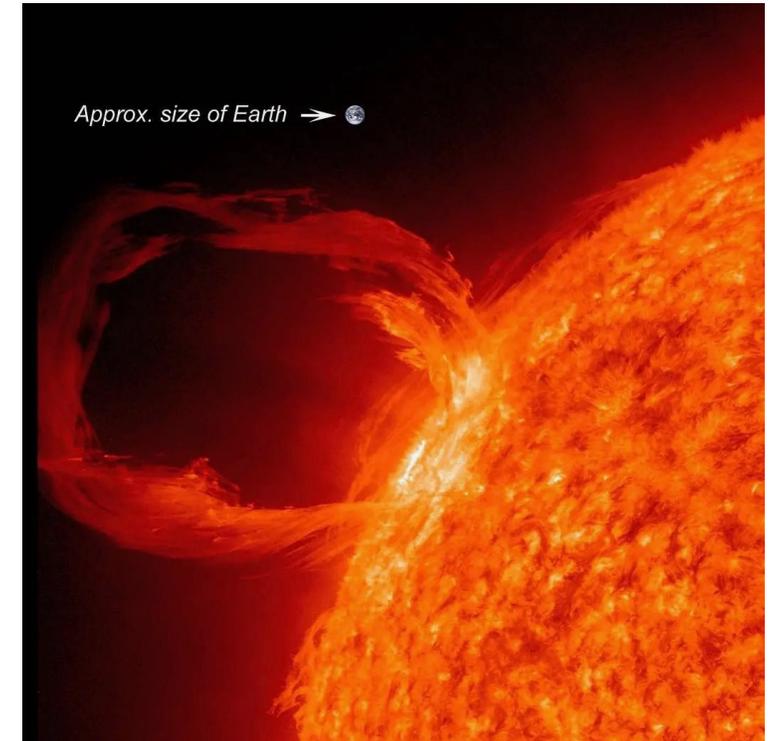


Pereira "Quantifying Spicules" 2012

**Jets** are  
 "broadly neutral",  
 (+ and -)  $10^9$  Amps

Magnetic Field  $B = ?$

**Levitated and Flowing Prominences**



NASA / SDO 2010 "What is a Solar Prominence?"

"may persist in the corona for months. "

$$- eE = 3 * \{ P^+ \} g \rightarrow \text{accelerate } P^+$$

$$= 1 * \{ P^+ + 2H^0 \} g \rightarrow \text{neutrally bouyant}$$