

# Physics 681: Solar Physics and Instrumentation – Lecture 25

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## The Corona

- ❑ Coronal temperature is much higher ( $> 10^6$  K) than the temperature of the photosphere
- ❑ Electron temperature  $T_e \neq$  ion temperature  $T_{\text{ion}}$
- ❑ Energy has to be pumped from low to high temperatures
- ❑ *F* (Fraunhofer) corona (2–3 solar radii, weakly polarized, scattered photospheric light, zodiacal light)
- ❑ *K* (*german*: Kontinuum) corona (Thomson scattering by free electrons, highly polarized, strong dependence on the position angle, drops steeply with distance from the Sun)
- ❑ The shape of the corona is closely related to the Sun's (magnetic) activity cycle
- ❑ Minimum corona: polar plumes, lines of force resemble a bar magnet
- ❑ Maximum corona: spherically symmetric, more structured
- ❑ Condensations, enhancements, helmets, and streamers

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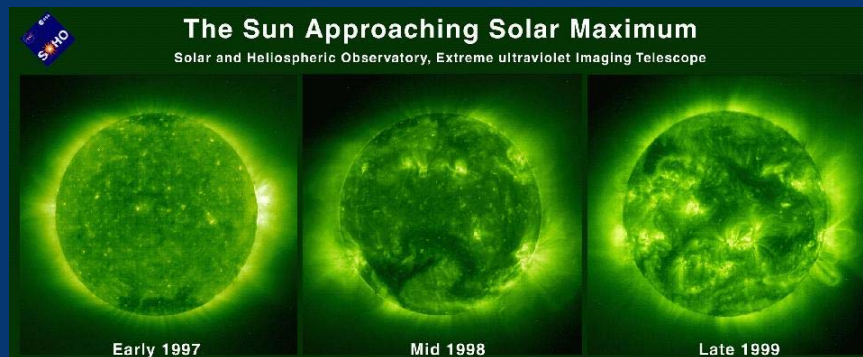
- ❑ Emission lines (exceed continuum brightness by a factor of 100)
- ❑ Forbidden transitions (e.g., Fe X (637 nm) and Fe XIV (530 nm), "coronium",  $\Delta L = \pm 1$ )
- ❑ Large ionization potential of emission lines  $\Rightarrow$  high temperatures, non-LTE, Saha equation does not describe ionization equilibrium  $\Rightarrow$  statistical equilibrium (electron collisions, radiative recombination, and dielectronic recombination)
- ❑ The UV/EUV is dominated by emission lines (e.g., N VII, O VIII, Fe XVIII to Fe XXIII (during flares))
- ❑ Plasma loops with a width of about  $10^6$  m
- ❑ The (isothermal) loops are not in hydrostatic equilibrium
- ❑ X-ray corona appears bright and highly structure in front of the cool, dark photosphere
- ❑ Coronal holes



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## Maximum and Minimum Corona



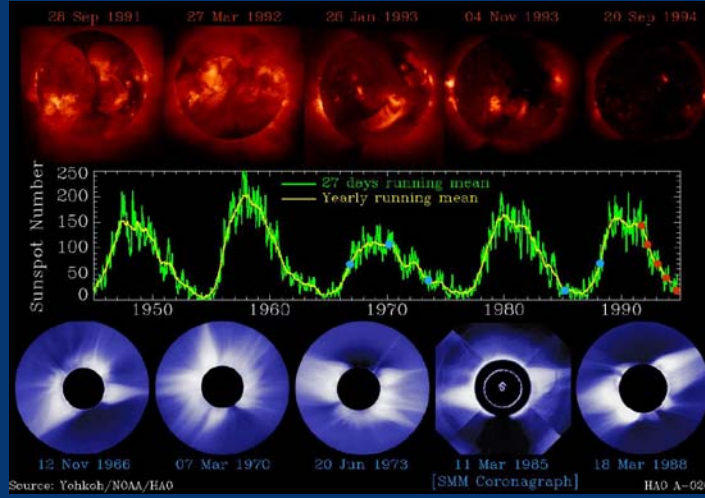
[http://www.kis.uni-freiburg.de/~peter/teach/stellar\\_coronae/eit.html](http://www.kis.uni-freiburg.de/~peter/teach/stellar_coronae/eit.html)



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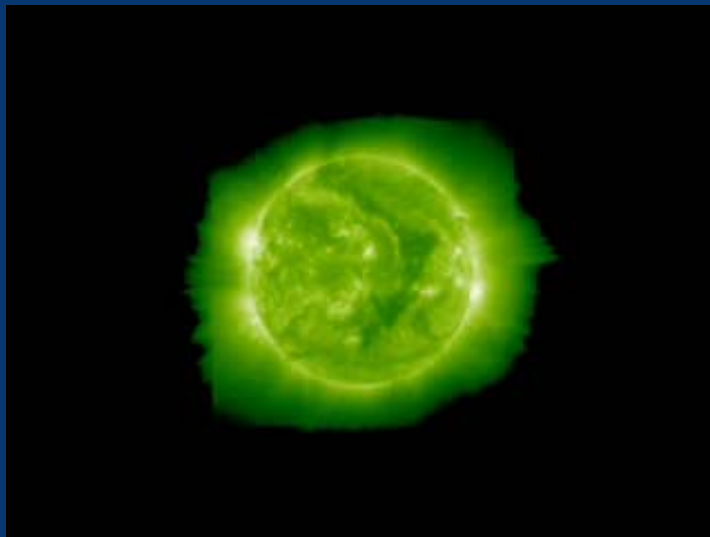
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# Solar Cycle



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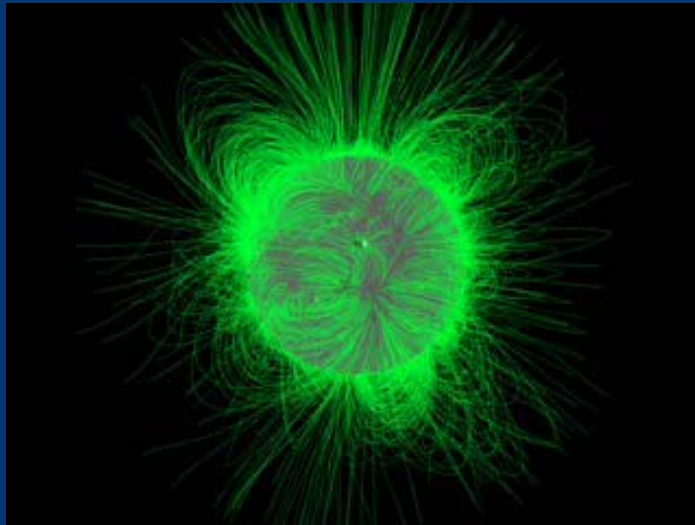


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## Solar Wind

- ❑ Ion tails of comets (small angle  $<5^\circ$  between solar radius vector)
- ❑ Radiation pressure only accounts for dust tail
- ❑ High-speed (supersonic), continuous, variable flow of ionized matter
- ❑ Electrons, protons, and  $\alpha$ -particles
- ❑ High-speed streams (about 700 km/s) originate at locations of "open" field lines (coronal holes)
- ❑ 27-day rotation modulation
- ❑ Transition region outflows with up to 20 km/s in the chromospheric network of coronal holes
- ❑ Ulysses out-of-ecliptic measurements of the solar wind latitude dependence
- ❑ First Ionization Potential (FIP) Effect: Elements with a FIP lower than 10 eV are enriched
- ❑ Ambipolar diffusion (ions and neutral particles are subject to different diffusion velocities and different drift velocities in the magnetic field)

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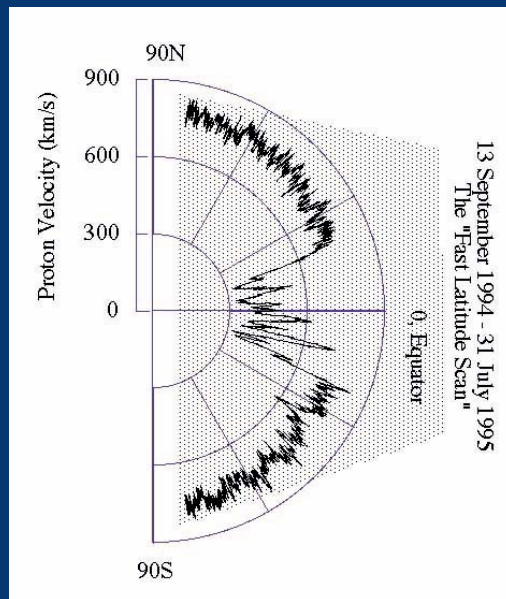
# Comet Hale-Bopp



<http://antwrp.gsfc.nasa.gov/apod/ap050522.html>

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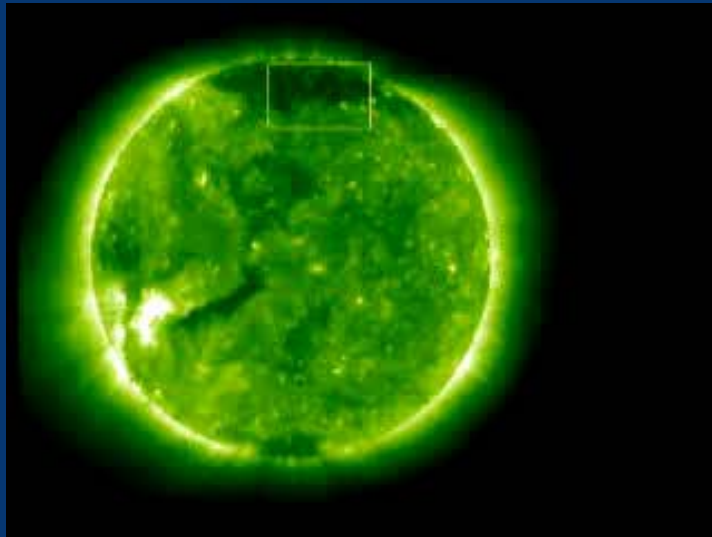


<http://science.msfc.nasa.gov/ssl/pad/solar/suess/SolarProbe/Page1.htm>

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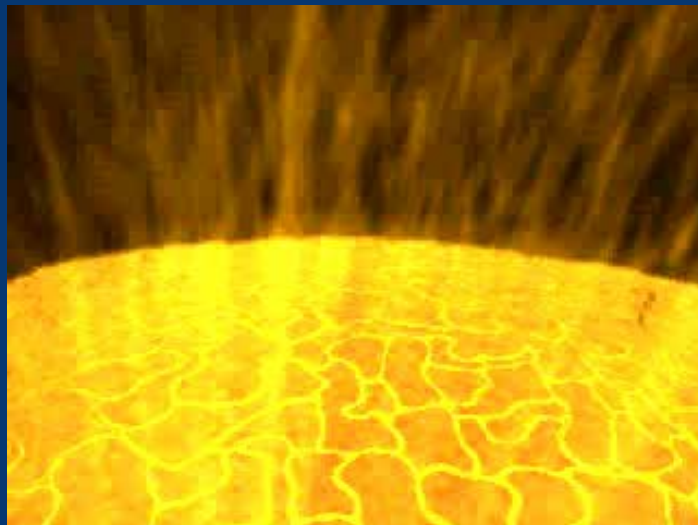




[http://sohowww.nascom.nasa.gov/hotshots/1999\\_01\\_03/](http://sohowww.nascom.nasa.gov/hotshots/1999_01_03/)

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