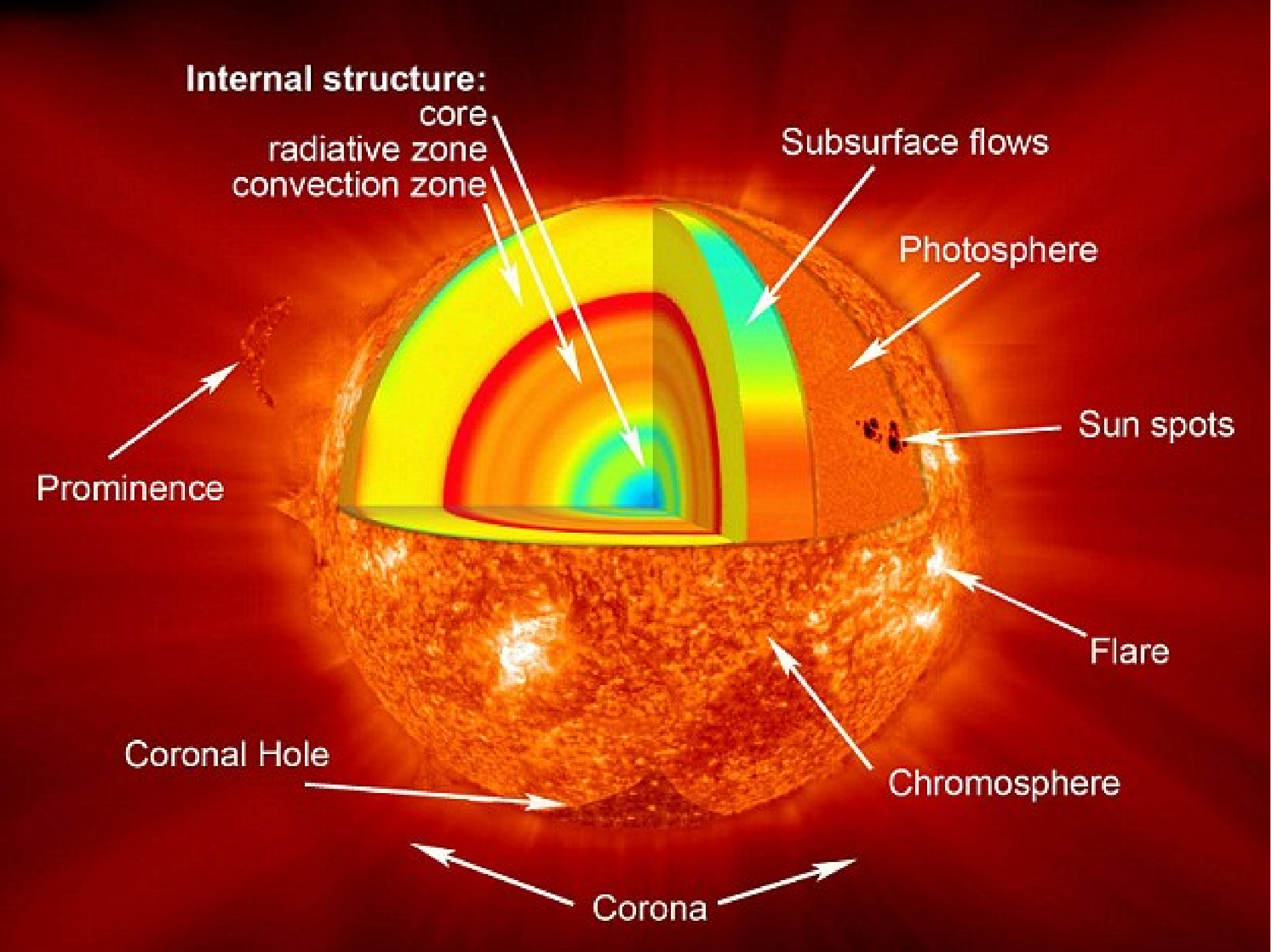
Solar Photospheric and Coronal Observations

Dr. Karin Muglach
NASA/GSFC and CUA

SW-REDI 2017

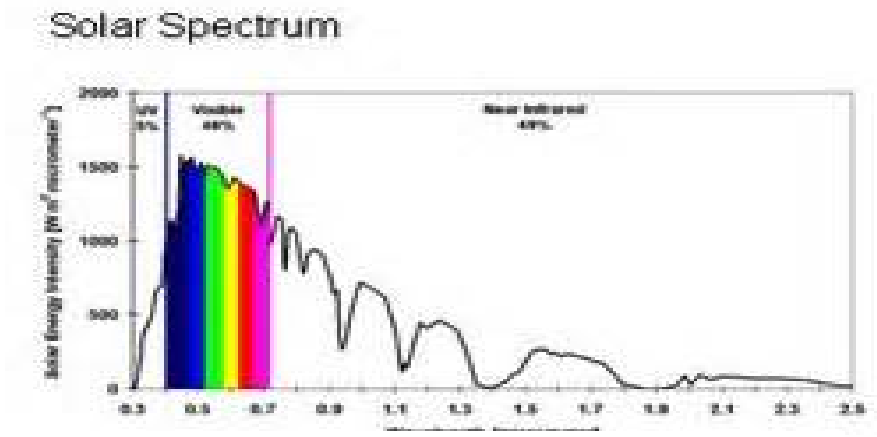

Internal structure:
core
radiative zone
convection zone
Subsurface flows
Photosphere
Sun spots
Prominence
Flare
Coronal Hole
Chromosphere
Corona

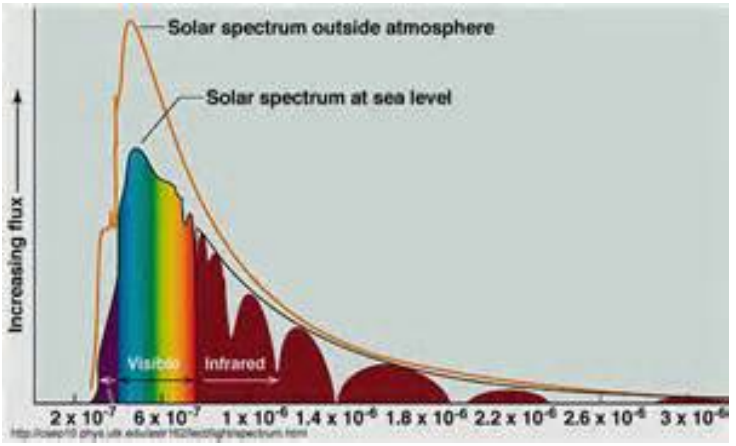
Large Scale Structures Near the Solar Surface

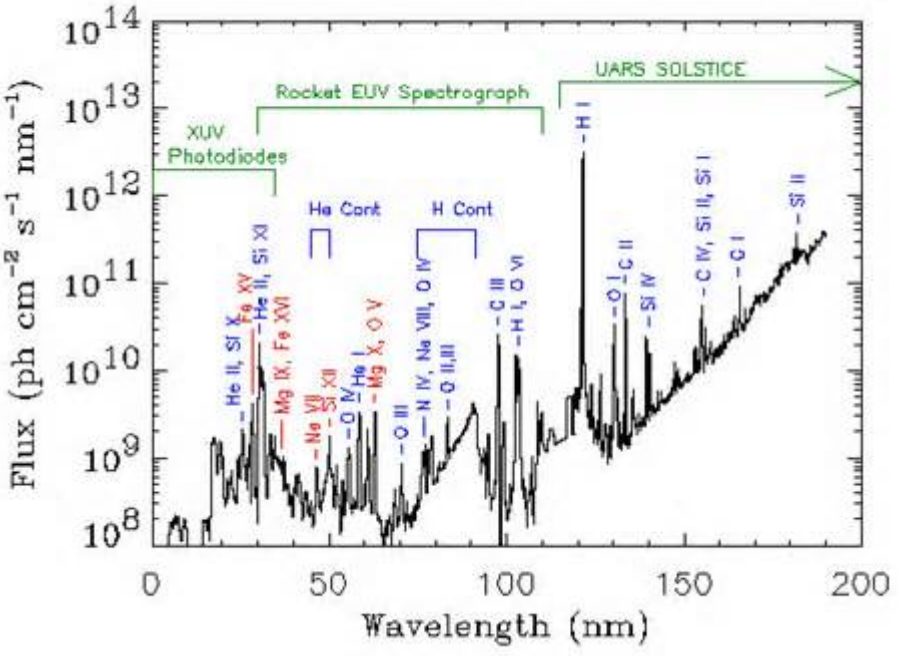
two kinds of measurement to collect information about the Sun:

Remote Sensing and In-situ Measurement

Key for remote sensing of the sun (and stars): Solar Spectrum







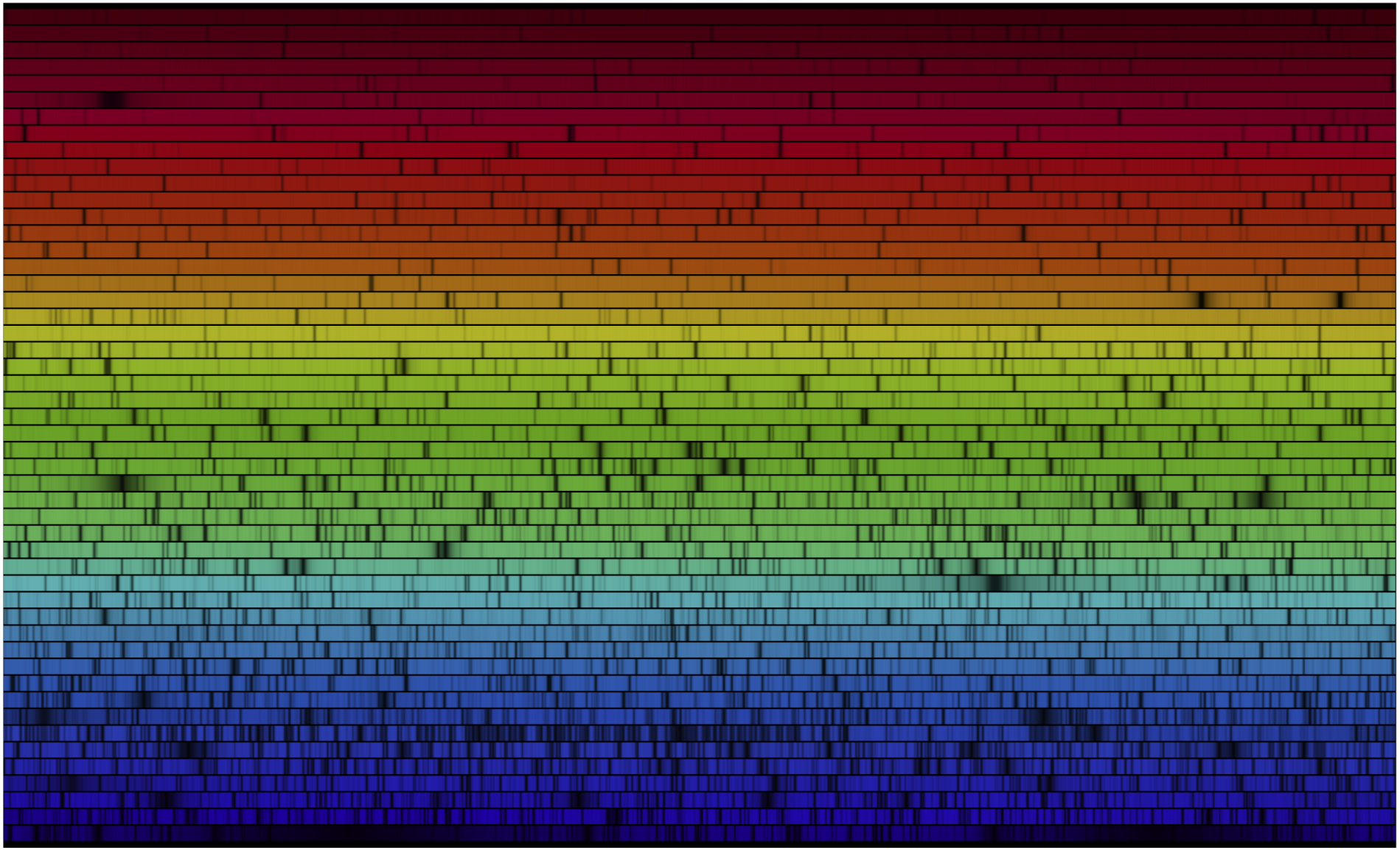
complete solar spectrum

and

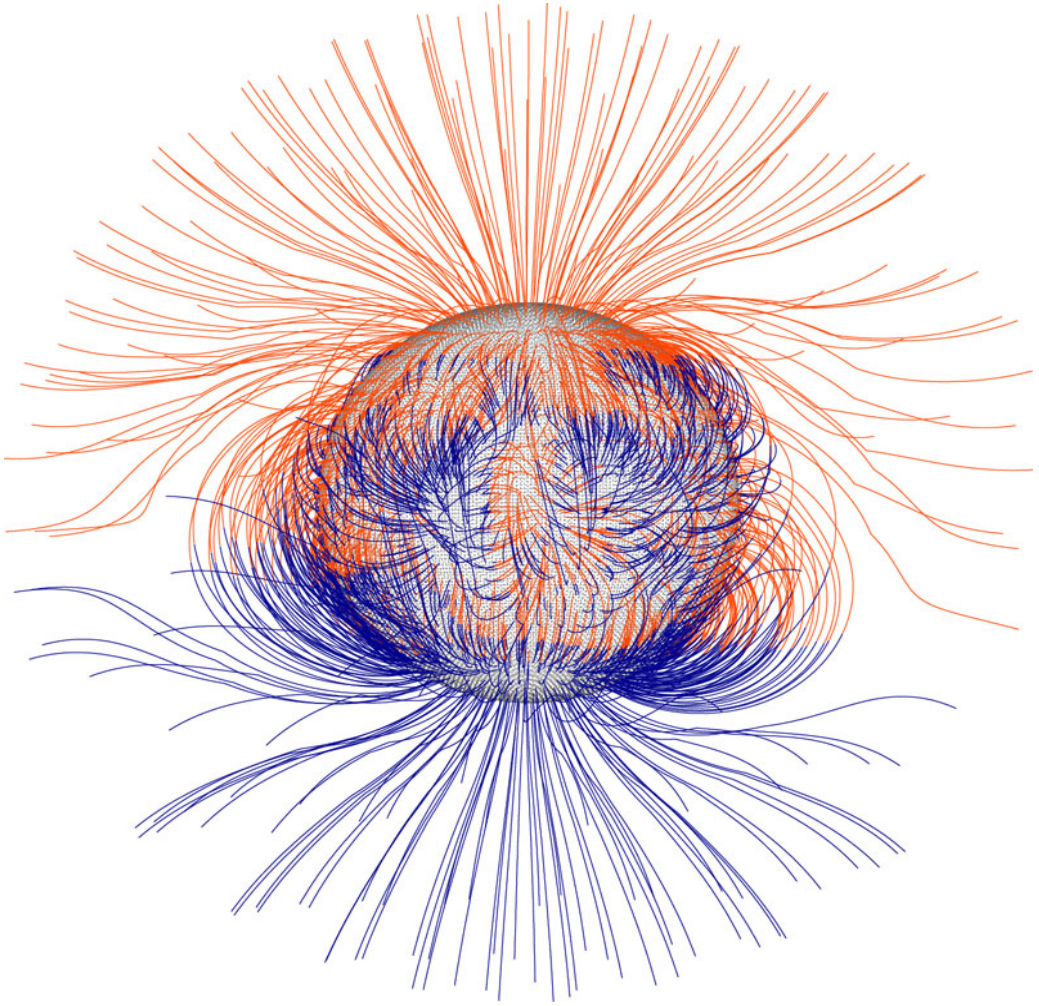
EUV part of solar spectrum

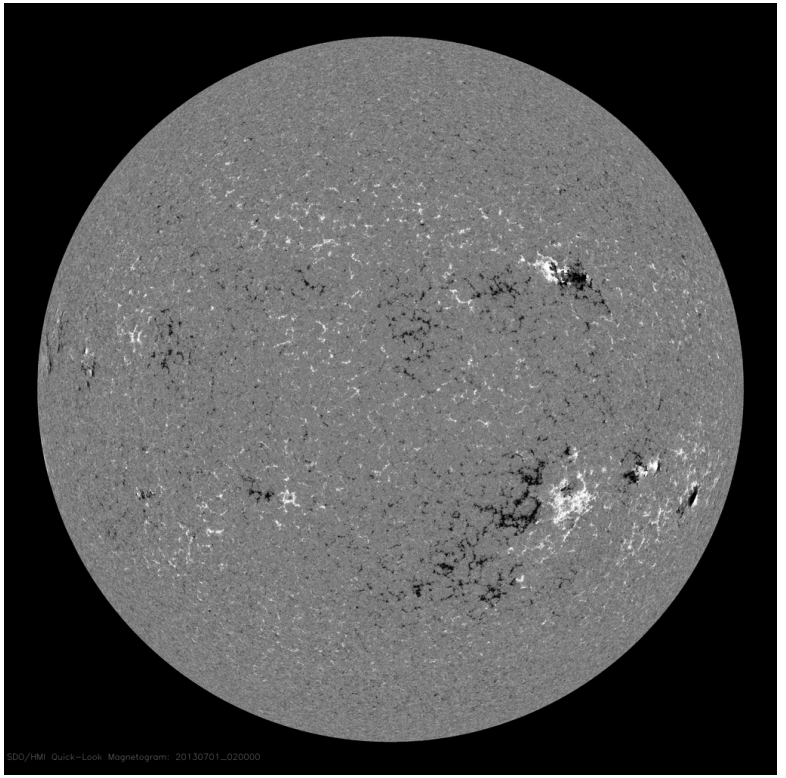
Key for remote sensing of the sun (and stars): Solar Spectrum

True-Color Irradiance Spectrum 392 to 692 nm from Kitt Peak Residual Irradiance Atlas (Kurucz 2005)



Key for understanding solar activity: the solar magnetic field

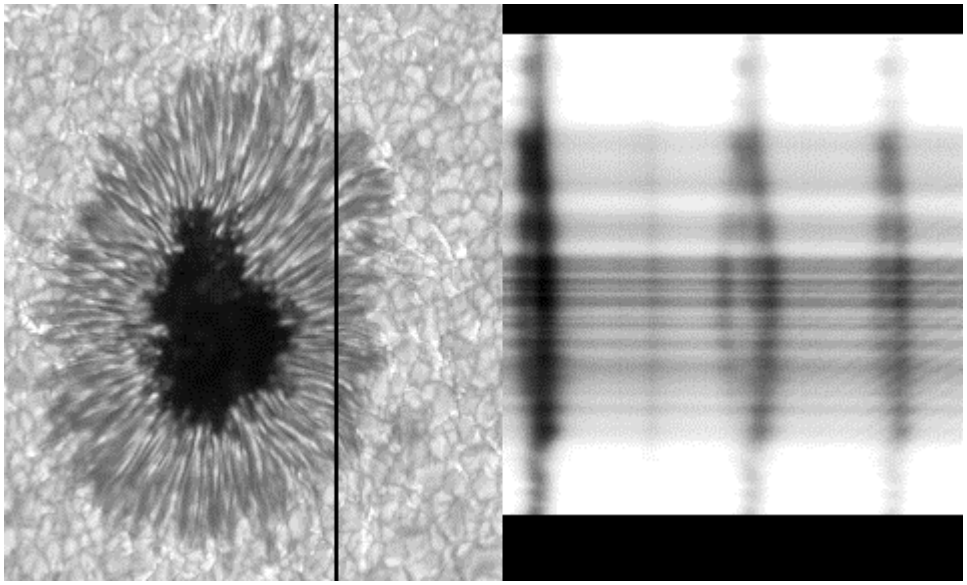




Global magnetic field (extrapolation): 3d structure

Line-of-sight full disk magnetogram: 2d cut at photosphere

Key for understanding solar activity: the solar magnetic field



How to measure the solar magnetic field?

- In-situ: magnetometer
- Remote: magnetographs

Method: Zeeman Effect:

a magnetic field in a plasma produces:

- splitting of certain spectral lines (mostly photospheric and chromospheric)
- polarisation of light

Key for understanding solar activity: the solar magnetic field

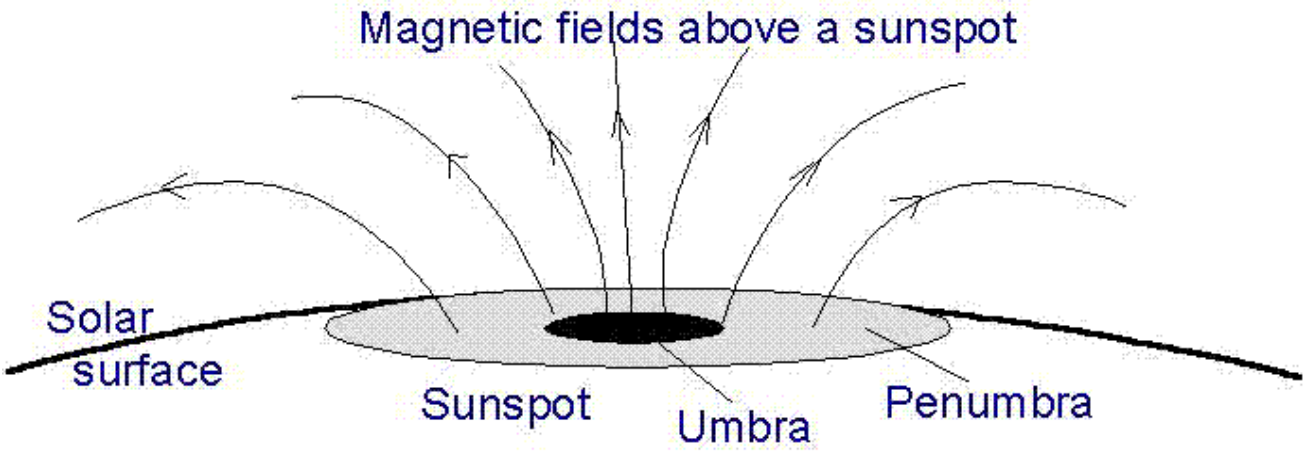
Zeeman Effect:

Longitudinal Zeeman Effect:

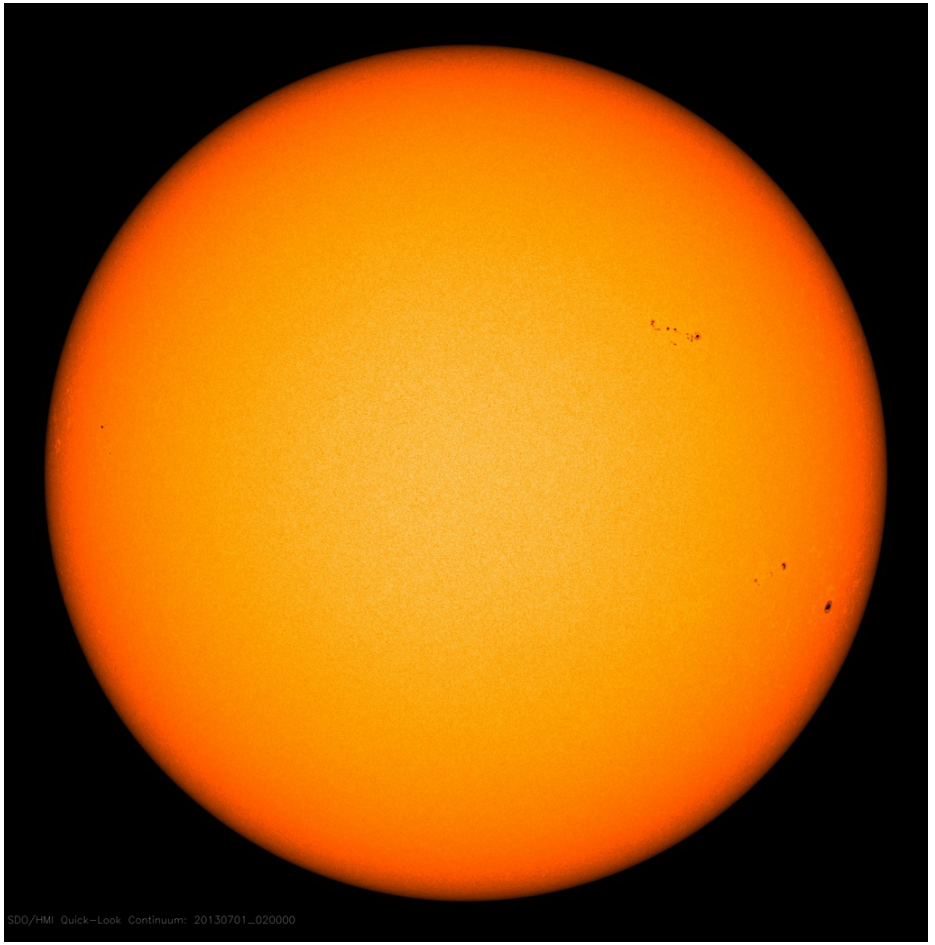
the component of the magnetic field vector parallel to the line of sight produces circular polarization

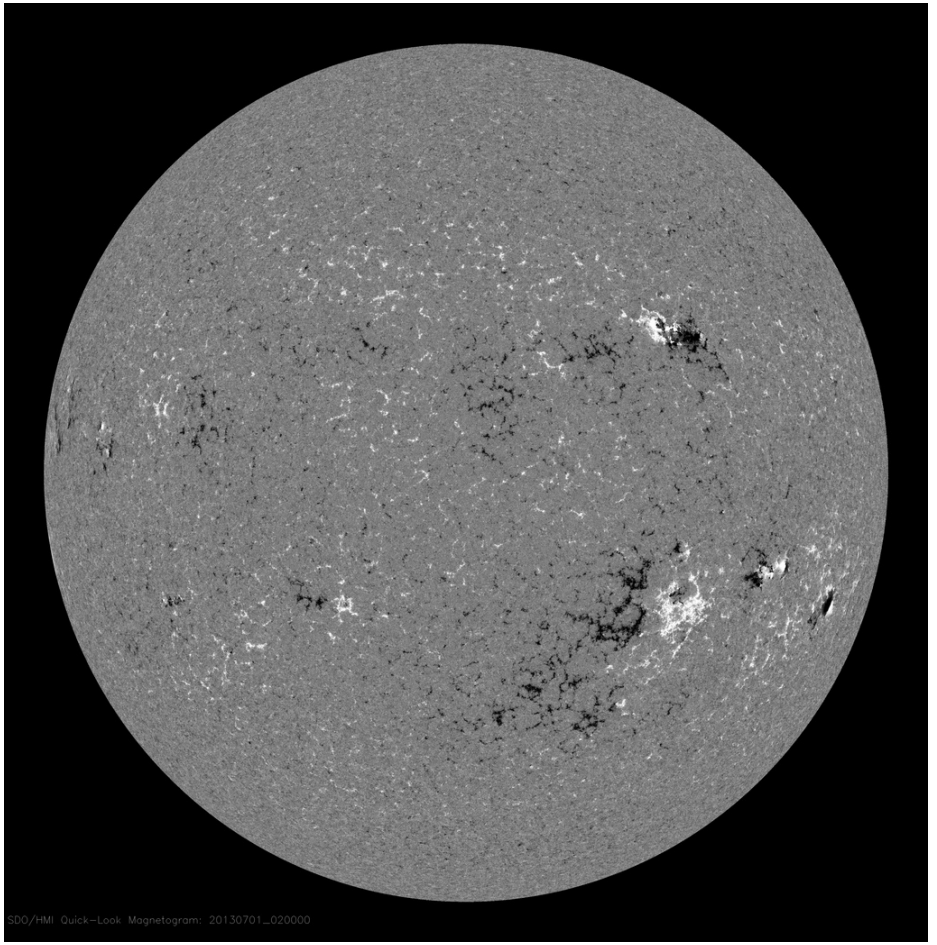
Transverse Zeeman Effect:

the component perpendicular to the line of sight produces linear polarisation of light



Key for understanding solar activity: the solar magnetic field





Full disk white light image (SDO), full disk line-of-sight magnetogram (SDO)

Key for understanding solar activity: the solar magnetic field

Active Region evolution in white light and magnetogram (SDO).

Key for understanding solar activity: the solar magnetic field

If we just have white light images and magnetograms:

Q: How are the polarities connected?

Key for understanding solar activity: the solar magnetic field

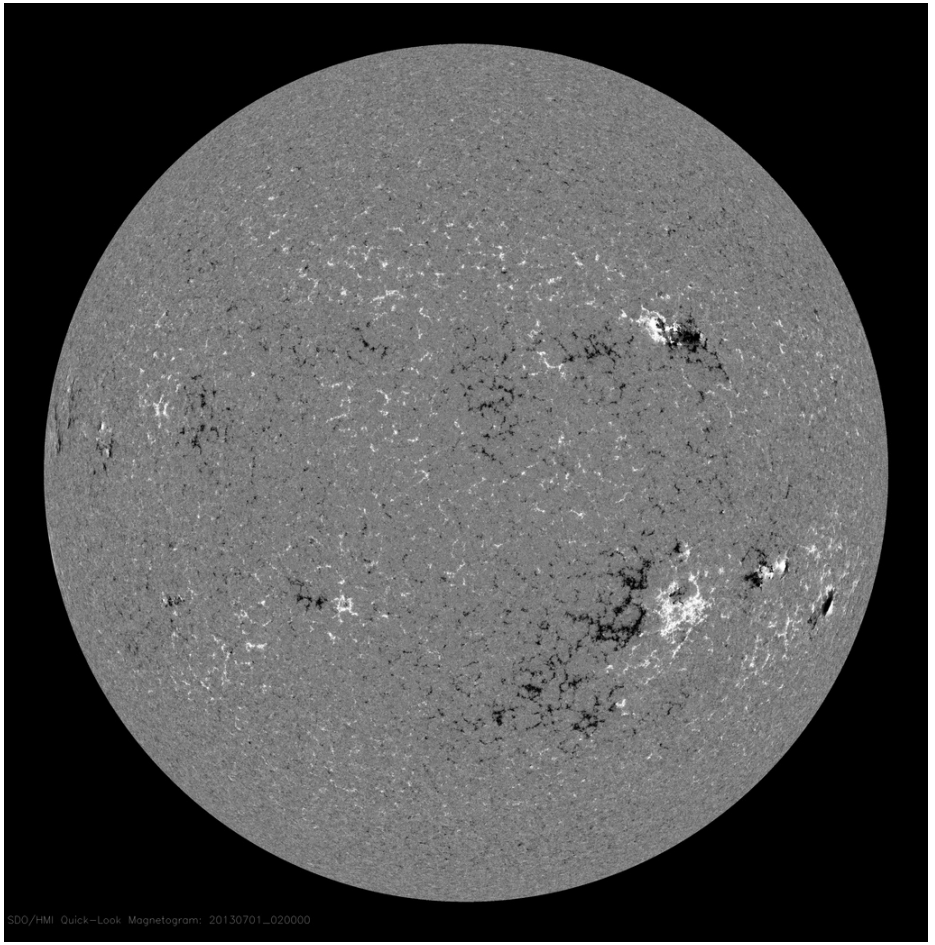
If we just have white light images and magnetograms:

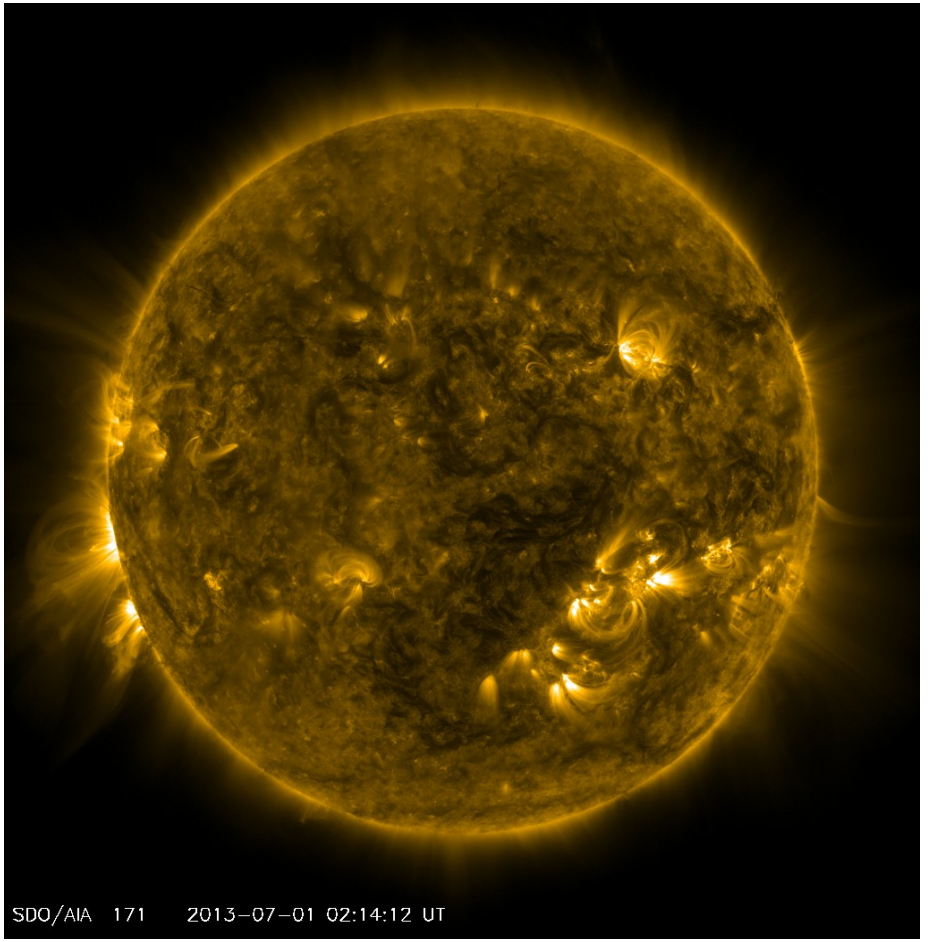
Q: How are the polarities connected?

A1: extrapolation

A2: corona images: outline (some) of the magnetic field connectivity!

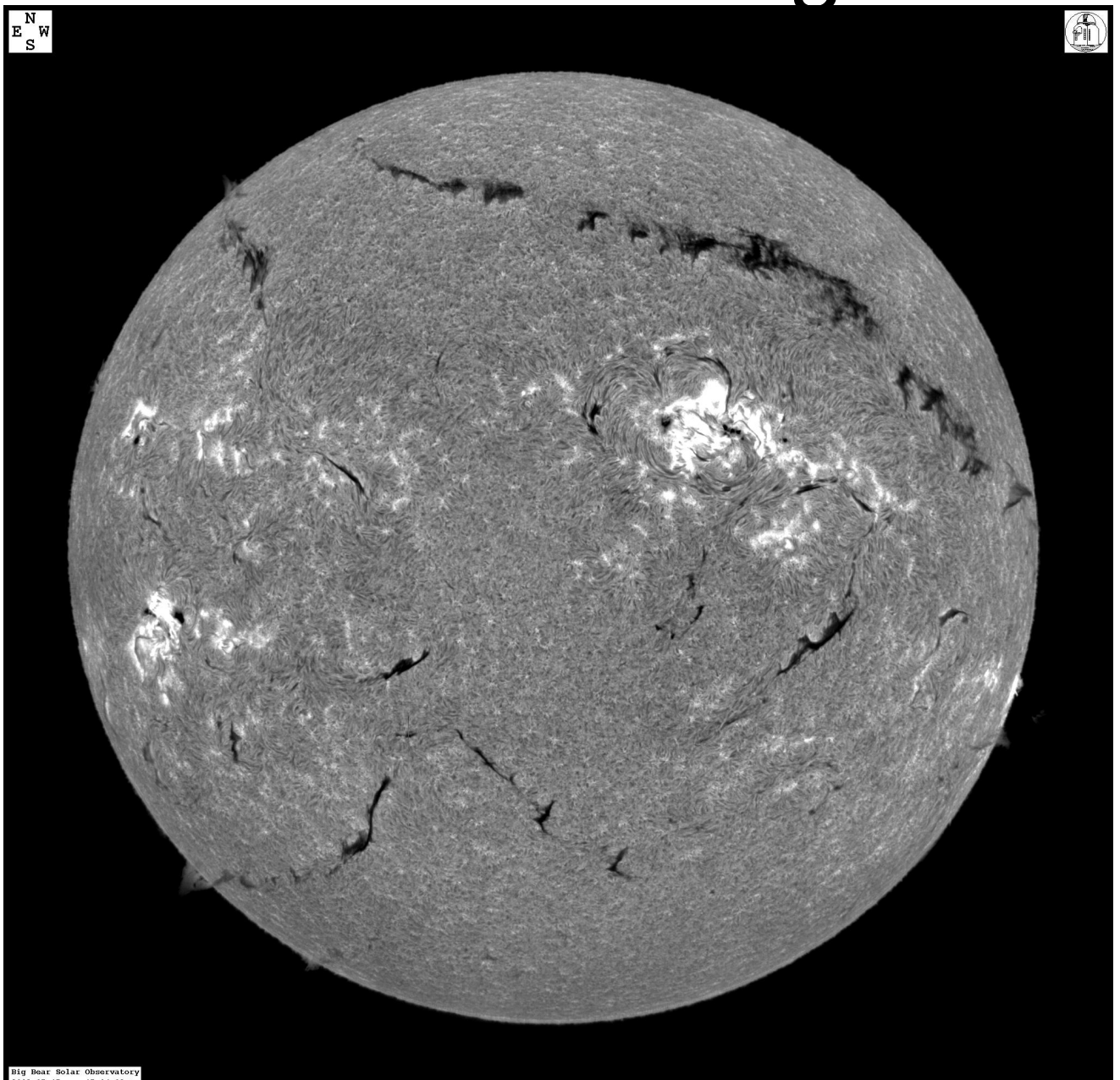
Key for understanding solar activity: the solar magnetic field





Full disk magnetogram and 171 image (SDO)

Key for understanding solar activity: the solar magnetic field

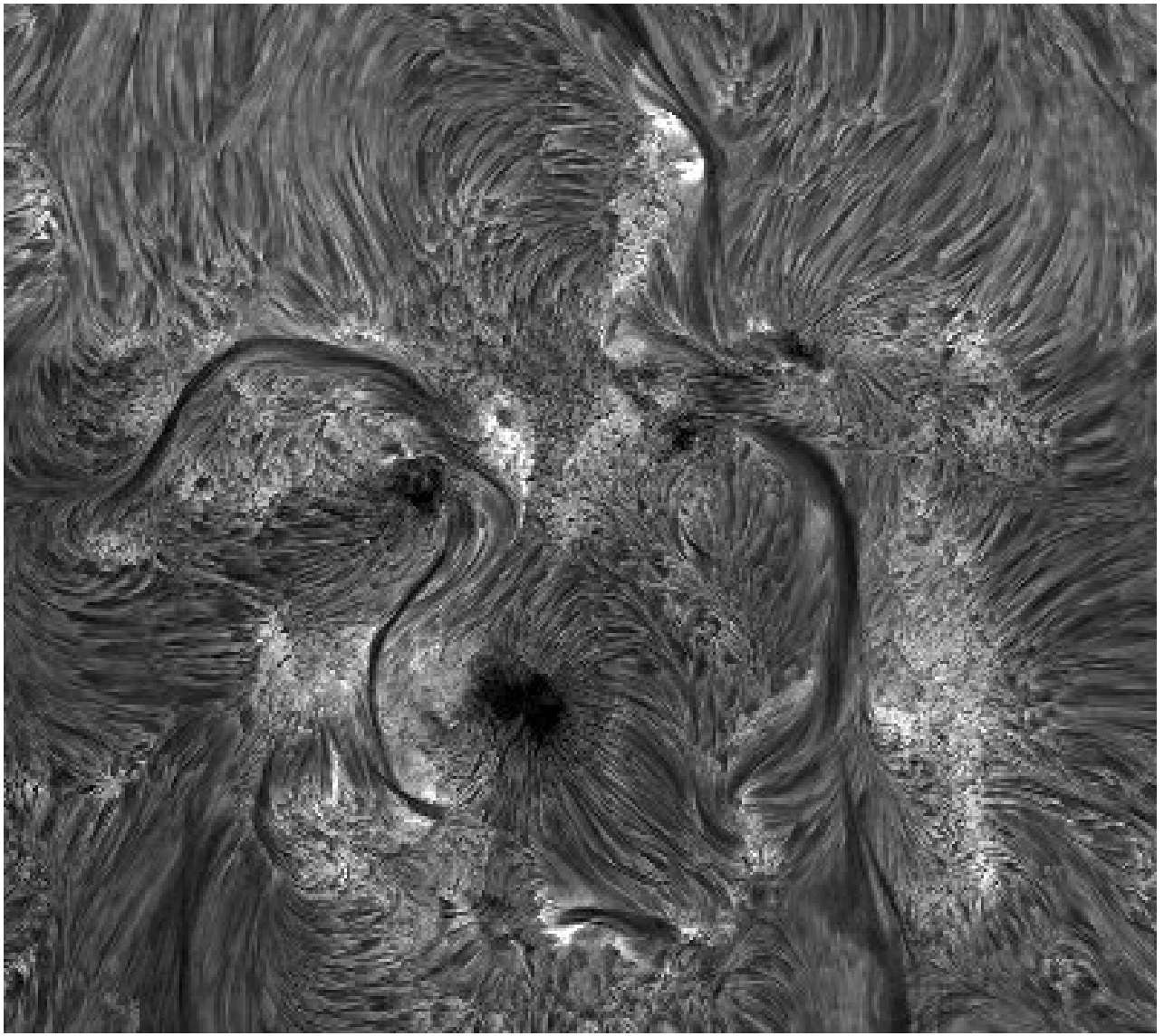


Full disk image in H alpha

(BBSO):

filaments seen as dark absorption structures

Key for understanding solar activity: the solar magnetic field



High resolution image in H alpha (Dutch Open Telescope)

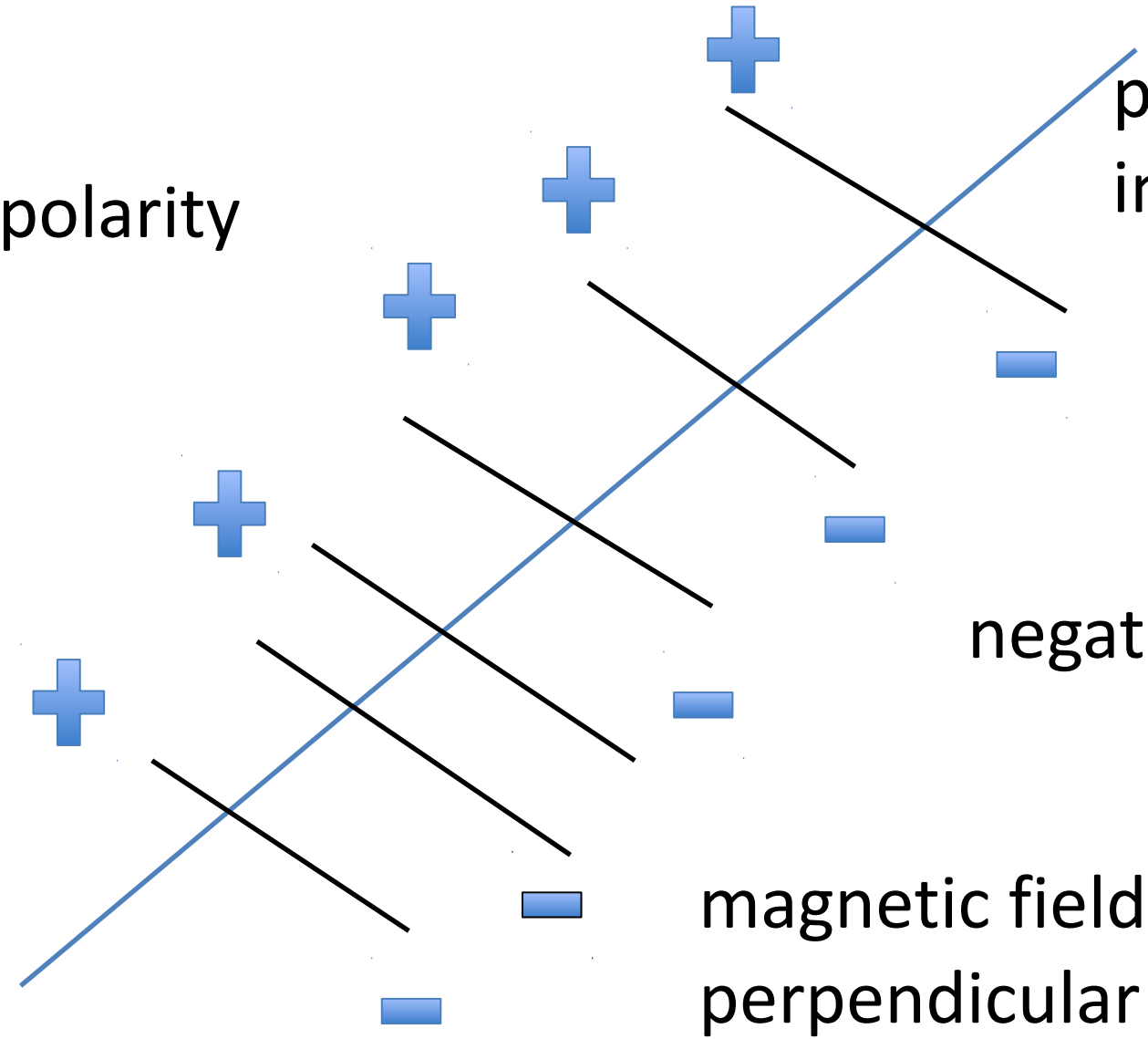
filaments seen as dark absorption structures

Key for understanding solar activity: the solar magnetic field

Example of filaments:

- Quiescent filament in high spatial resolution (Hinode SOT)
- Filament eruption (SDO, composite)

SIMPLE (!!) cartoon of active region magnetic field



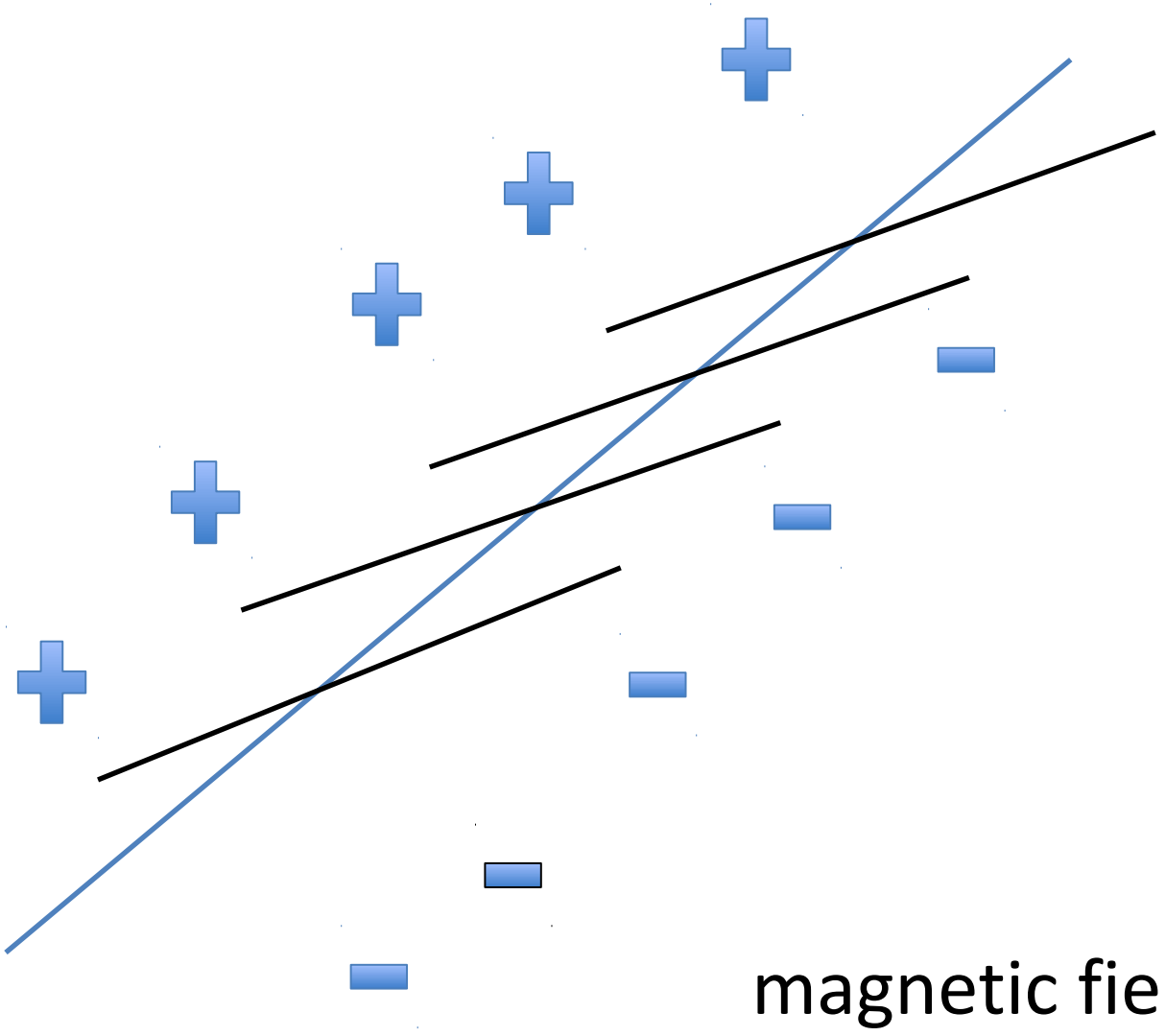
positive polarity

polarity inversion line

negative polarity

magnetic field lines almost perpendicular to PIL

SIMPLE (!!) cartoon of filament magnetic field



magnetic field lines almost parallel to PIL

Key for understanding solar activity: the solar magnetic field

Notes on filaments:

- Filament: on-disk structure (seen in absorption)

  Prominence: same structure off limb (seen in emission)
- Best wavelengths: H alpha, He II 304, Fe XII 195 A (AIA, STEREO)
- All filaments have a PIL
- But not all PILs are filaments!

- Caution: full disk magnetograms give only the line-of-sight magnetic field – projection effects near the solar limb!

Key for understanding solar activity: the solar magnetic field

Solar magnetograms: Problems:

- Most full-disk magnetographs measure circular polarization only! (MDI, HMI 45s, ground-based magnetograms like GONG), not very reliable beyond 60 deg from disk center!
- No magnetograph data on the far side of the sun!

To produce global magnetograms use solar rotation (27.27 d rotation rate) to get synoptic maps of the photospheric magnetic field. Due to tilt angle of solar rotation axis, poles of the sun are also not well observed!