Solar-B domestic meeting
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Solar-B/EIS high-cadence observation for diagnostics of the corona and TR

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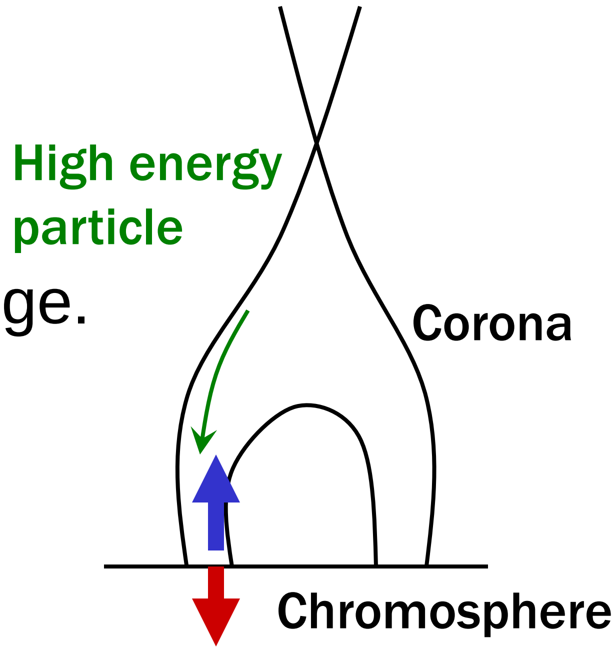
Chromospheric evaporation

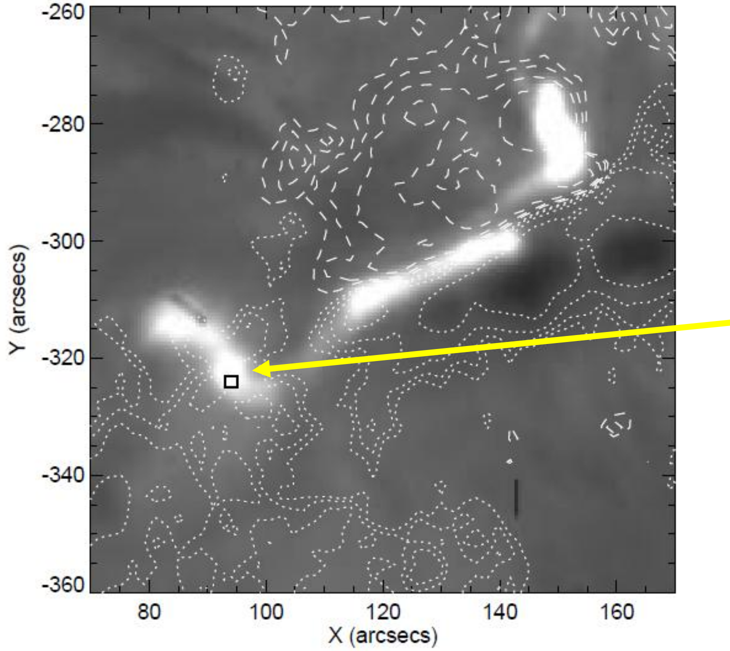
- High energy particles generated in the flare penetrate into the chromosphere.
- Explosive heating in the chromosphere
- Hot plasma (10^7K) is supplied into the coronal loop
  (Neupert 1968, Hirayama 1974)

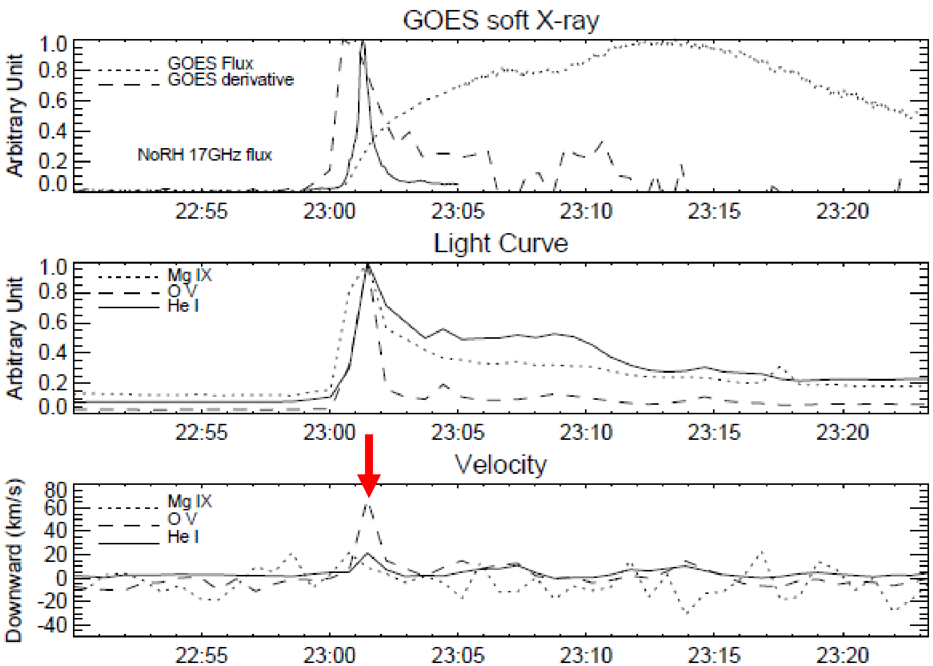
- Down flow and up flow should be observed in different temperature range.
  ➔Spectroscopic observation
  in many lines

Schematic model



Flare observed with SOHO/CDS



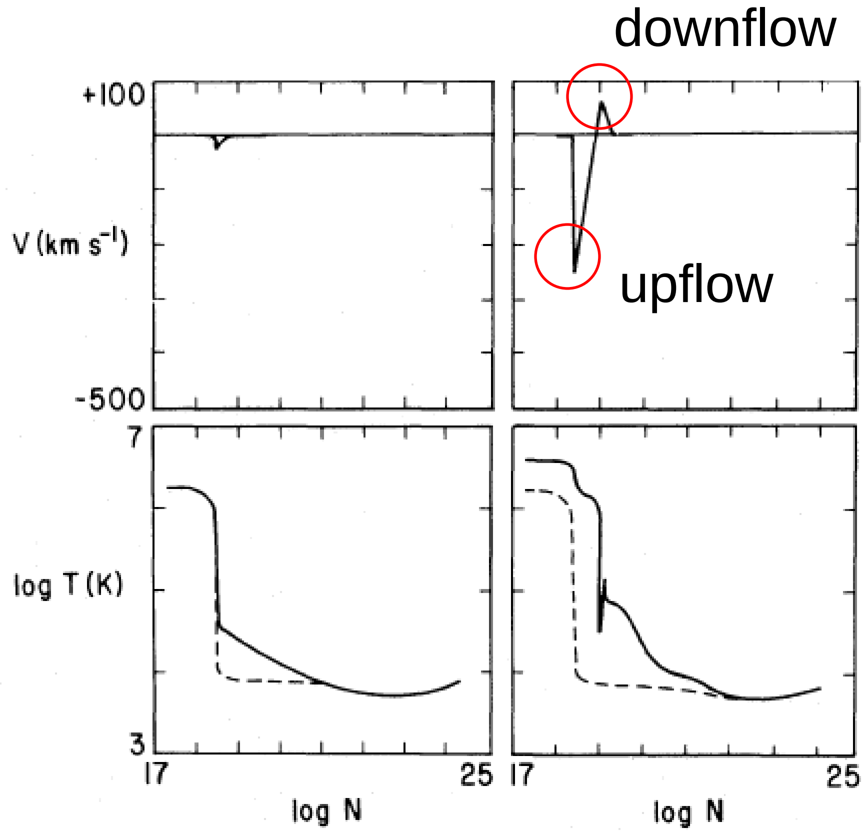


(Kamio et al. 2005 ApJ 625, 1027)

- Observed 4 flares (GOES B–M class) with SOHO/CDS and Hida/DST
- Impulsive downflows (60–80km/s) in the transition region (10^5K) in flare kernels.

Evaporation model

- Velocity behavior depends on energy flux of non-thermal electrons. (independent of total energy)
- High speed flow can be observed in a small flare (< GOES C class)
- high resolution of EIS enables detection of small events



gentle
$F = 10^9$
$(erg/cm^2/s)$

explosive
$F = 5x10^{10}$

Fisher et al (1985)

Velocities and temperature

T

Ca XIX (10^7 K) 250km/s component (Wülser et al. 1994)

Fe XIX (8×10^6 K) Upflow component (Brosius 2003)

Fe XVI (2×10^6 K) No significant flow (Teriaca 2003)

Mg IX (10^6 K) No significant flow

O V (2×10^5 K) 50-80km/s

He I (4×10^4 K) 10-20km/s

(Kamio et al. 2005)

- Solar-B/EIS can simultaneously observe these velocities.

Network structure

- Network magnetic field must be important in terms of connection between the photosphere and the corona
- Origin of EUV blinkers and explosive events?
- De Pontieu (2004)
  Inclined field cause wave leakage into the corona.
- Zhang et al (2000)
  Macrospicule were triggered by interaction of magnetic elements

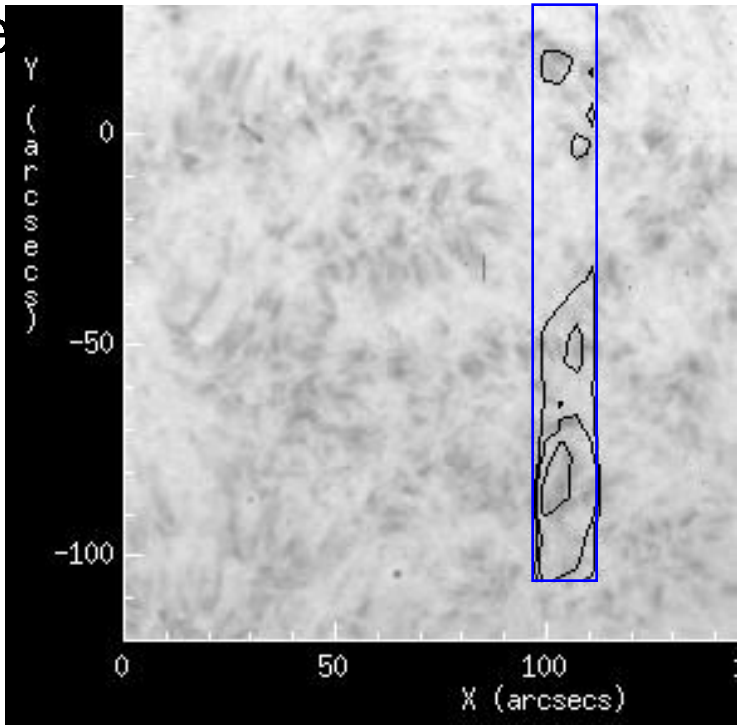


Image: Hα –0.6Å
Contour: OV intensity

Strong emission lines for EIS

- Wide temperature range (10^5-10^7K)
  ➔ Good diagnostics in coronal temperature
- Better spatial and spectral resolution
  ➔ small events
  ➔ line broadening
- Desired count: 50
  (velocity error < 10 km/s)
  Corona (10^6K): 1 sec
  Transition region (10^5K): 10 sec

Ion	log T_e	λ (Å)	EIS DN* (sec^{-1})		
			QR	AR	Flare
He II	4.7	256.3	2	7	$6x10^3$
O V	5.4	192.9	0.5	1	$7x10^2$
Mg VI	5.6	270.0	1	6	$5x10^2$
Fe XII	6.1	195.1	30	$6x10^2$	$7x10^3$
Fe XXIV	7.3	192.0	0	0	$4x10^5$

*Counts (with 2"x2" binning) estimated by CHIANTI 5.1 (Dere et al. 1997, Young et al. 2003)

- SOT(NFI) or ground-based telescope is needed for chromospheric velocity (Hα, or Mg I)

Example

- Active region dynamics
  5 spectral lines (16 pixel width)
  Exposure: 10 sec
  FOV: 10” x 512” (5 step)
  Cadence: 1 min

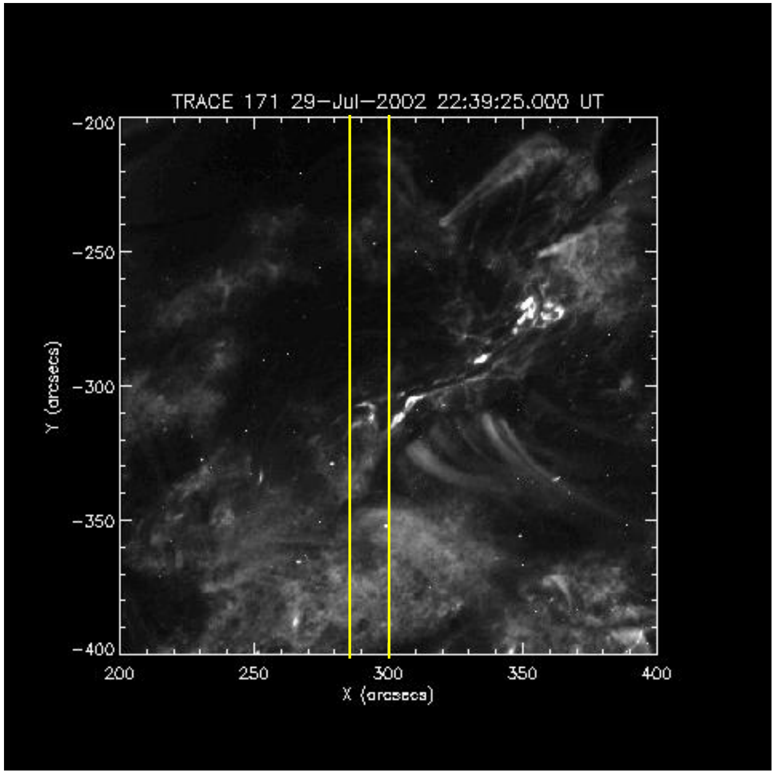
Data rate
(no compression)
➔ 32 kbps

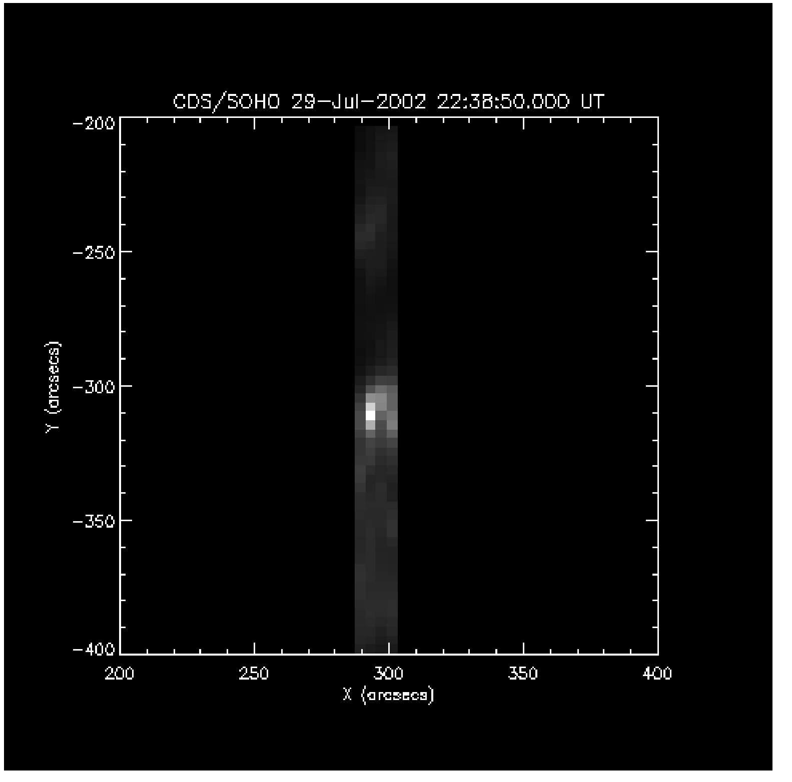
Long 512” slit can cover both active and quiet regions

- Flare
  5 spectral lines (16 pixel width)
  Exposure: 1 sec
  FOV: 1” x 128” (sit-and-stare)
  Flare detection by XRT
  or EIS (slot observation)

Data rate
(20% compression)
➔ 32 kbps

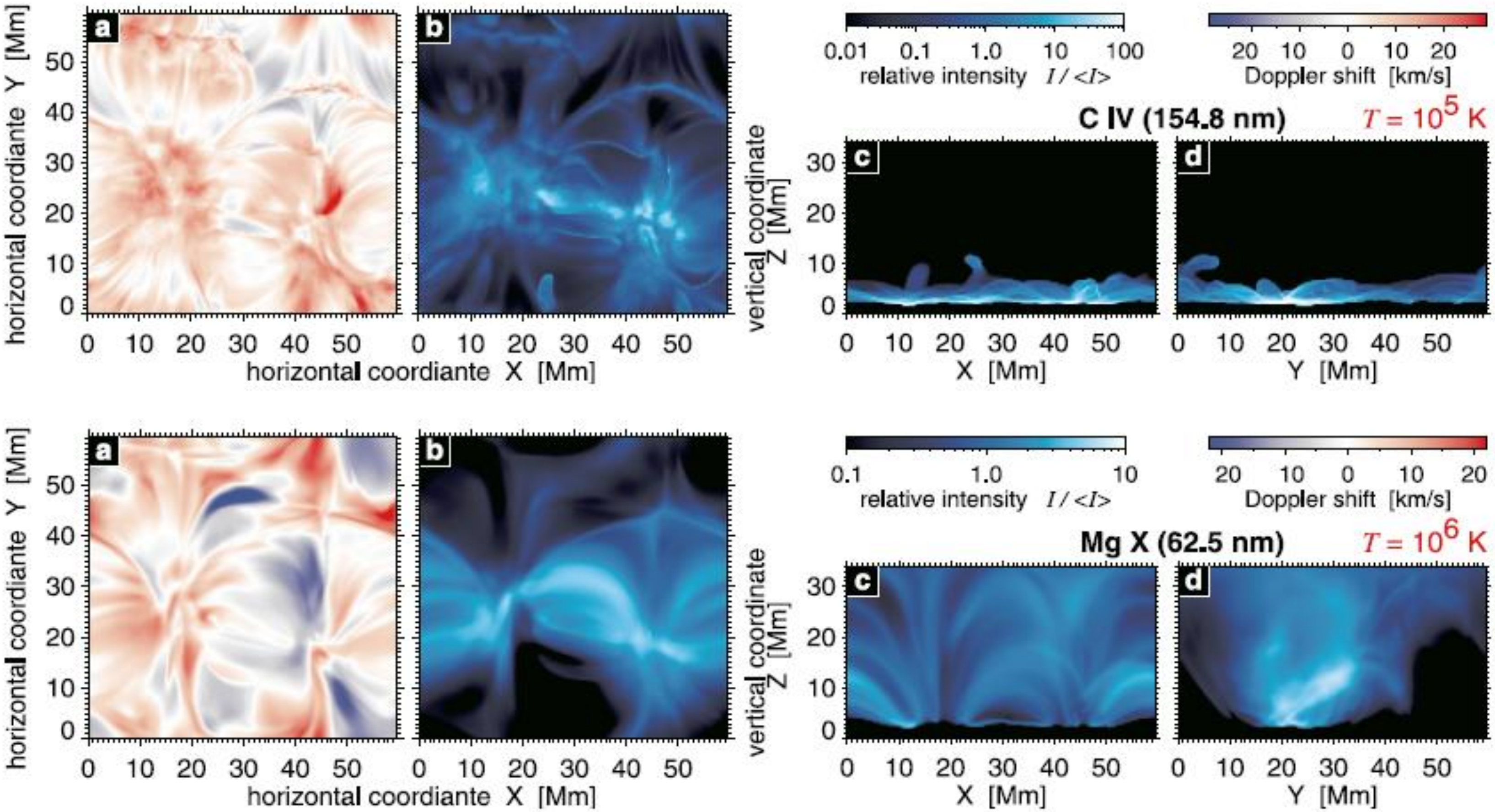
Imager v.s. spectrometer





- Cooperation with EUV imager is necessary (TRACE or STEREO)

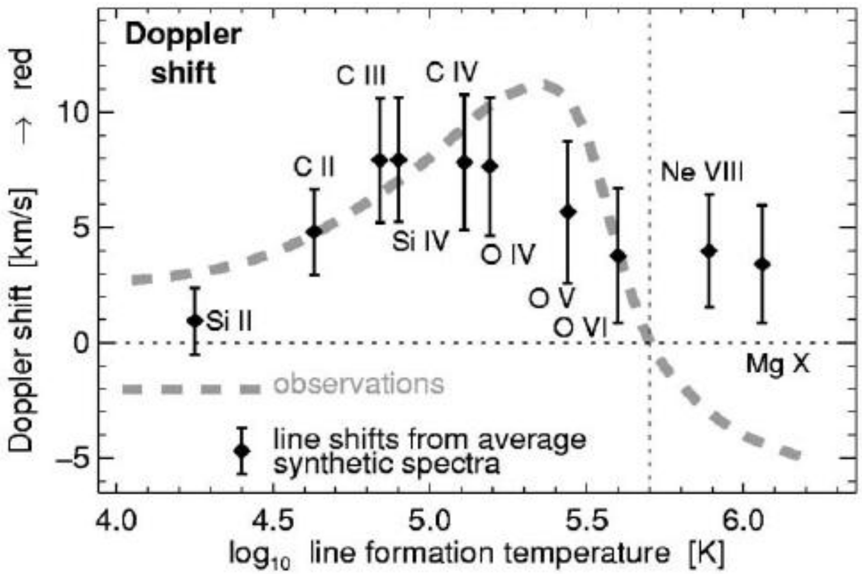
Synthetic spectra

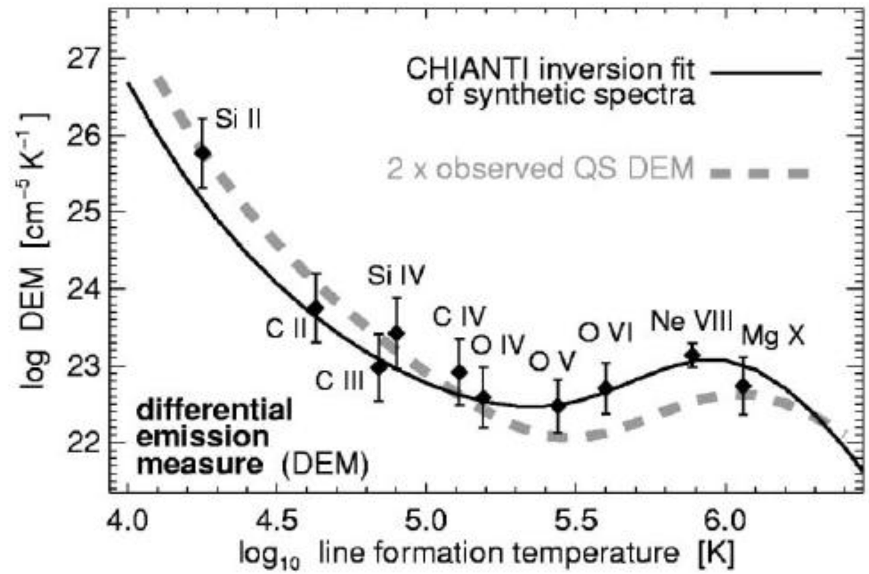


Peter, Gudiksen, and Nordlund (2004)

- 3D simulation of coronal braiding (current dissipation)

Statistical properties





Peter, Gudiksen, and Nordlund (2004)

- Statistical properties (e.g. average, deviation) are good tests for the theory.
- Coronal heating model must explain the persistent red shift in the transition region
- Solar-stellar connection

Temperature and ionization

- Wide temperature range can be studied by using different emission lines.

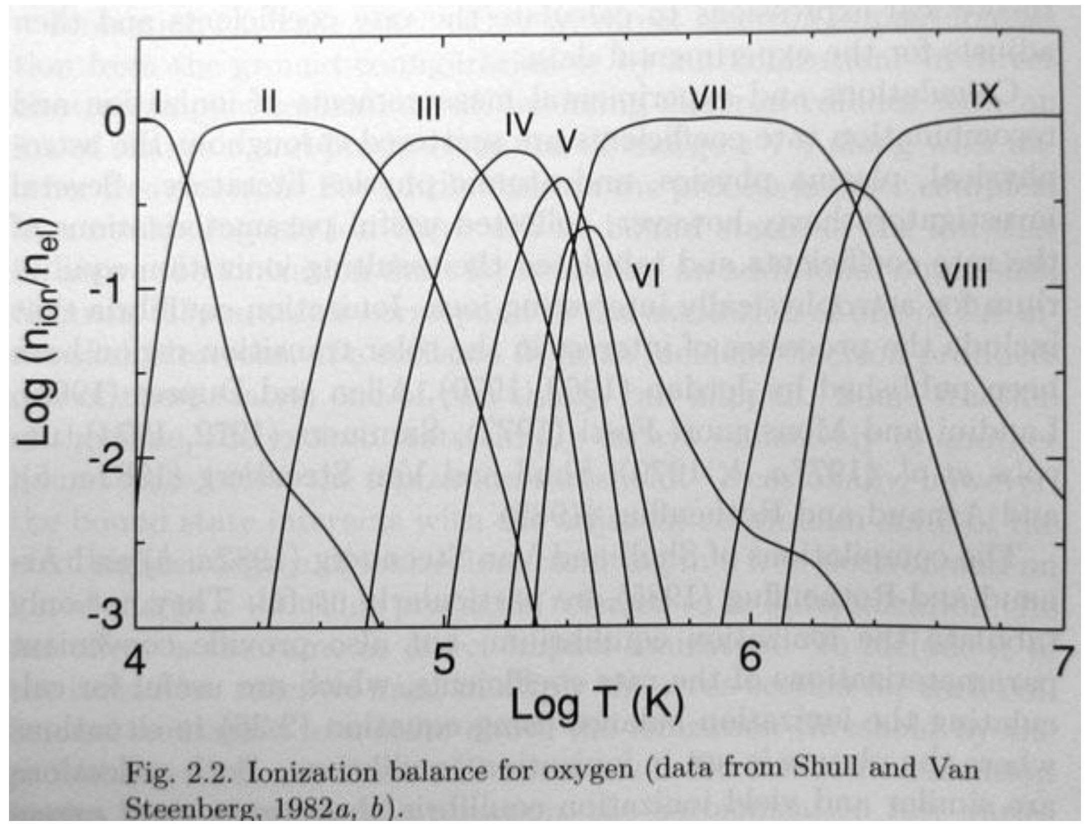


Fig. 2.2. Ionization balance for oxygen (data from Shull and Van Steenberg, 1982*a*, *b*).

Temperature and ionization of oxygen
Mariska *The solar transition region*

SOHO/SUMER

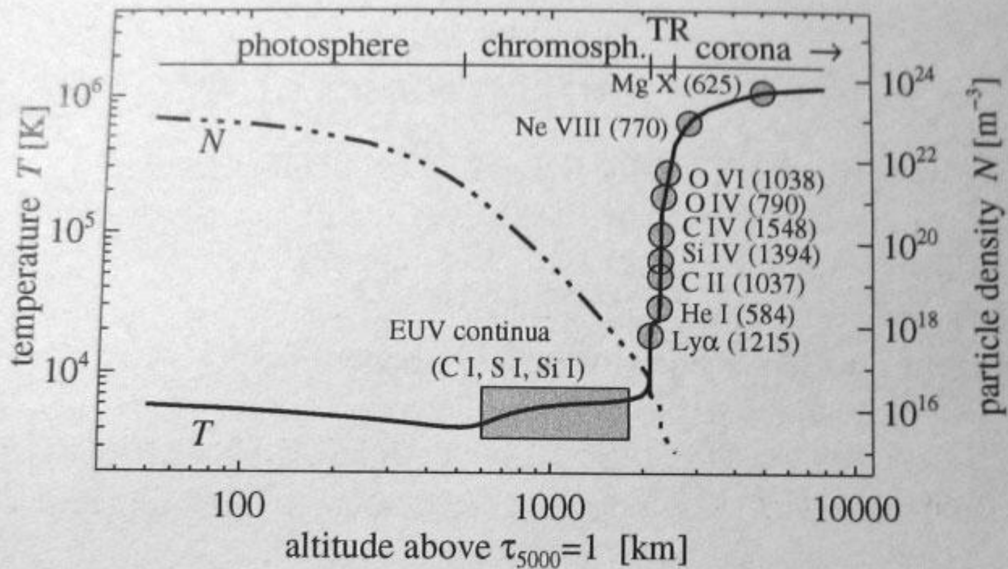
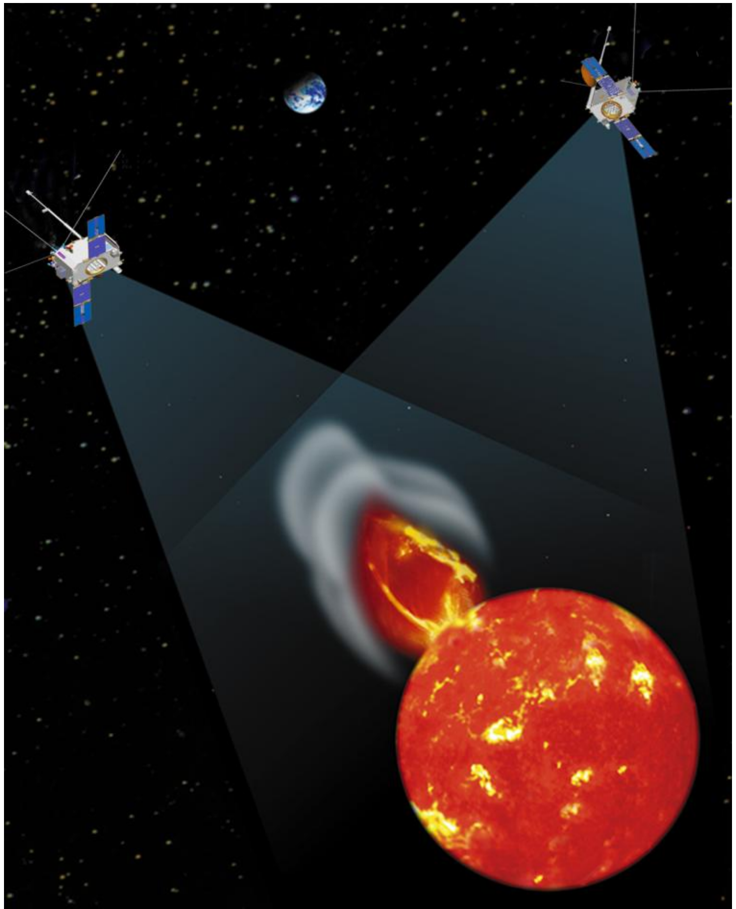


Figure 1: Temperature and density stratification in a 1D atmosphere following the semi-empirical model of Vernazza et al. (1981). The dots denote the approximate formation temperature of some prominent lines from the transition region and low corona (wavelengths in Å). Also indicated is the origin of the EUV continua in the low chromosphere. Both lines and continua are observable with SUMER.

- Good diagnostics in the chromosphere and the transition region (10^4 – 10^6 K)

STEREO (Solar TErrestrial RElations Observatory)

- Observe 3D structure of the Earth-directed CME (A pair of spacecraft)
- Launch 2006
- EUV Imager (1.6”/pixel)
  Full Sun in 171Å, 195Å, 284Å, 304Å
- Coronagraph
  COR1 1.1 - 3.0$R_{\odot}$
  COR2 2 - 15$R_{\odot}$
- Heliospheric Imager
  Interplanetary CME



http://stereo.gsfc.nasa.gov/

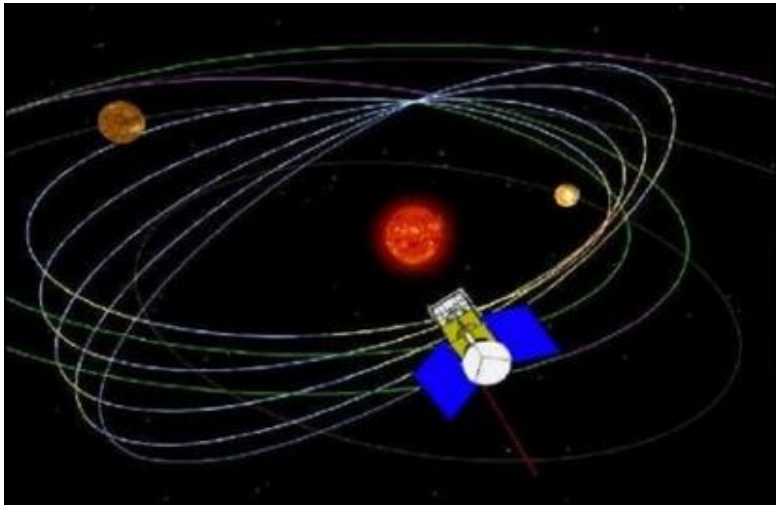
SDO (Solar Dynamics Observatory)

- Observe fine magnetic structures
- Launch 2008
- HMI (Helioseismic and Magnetic Imager)
  Full Sun Doppler velocity (1” resolution)
  Vector magnetic field measurement
- High resolution imager (0.6”/pixel)
  7 EUV and 3 UV bands
  Full Sun (FOV 41’)
- EUV irradiance measurement

http://sdo.gsfc.nasa.gov/

Solar Orbiter

- Getting close to the Sun (45$R_{\odot}$ or 0.2AU)
- Launch 2013 ?
- Instruments (TBD)
  soft X-ray, visible light
  EUV imager/spectrometer
- High resolution
  0.5" = 70km (at 0.2AU)
- Polar region observation
  Latitude up to 33 degree



http://www.orbiter.rl.ac.uk/

Future solar missions

- Demands for better spatial and temporal resolution (in terms of coronal heating)
  - small scale magnetic structures
  - wave or oscillation
- "Golden age" continues

  Solar-B (2006)
  STEREO (2006)
  Solar Dynamics Observatory (2008)
  Solar Orbiter (2013 ?)
  Solar-C ?
- We should understand their capabilities and limitations to make a suitable observational plan

Template

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