Chromospheric dynamics as observed in Lyman-α

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Outline:

- Motivation
- Net redshift of TR emission
- Ly-α and Ly-β profiles of
  - the average quiet Sun
  - the coronal hole
  - prominences
- The network and the role of the magnetic field
- Coronal loop models
- Ly-α profiles above a sunspot
- Conclusion
Ne VIII 770 Å

Curdt et al. 2008
Fe VIII 185 Å

Del Zanna 2008
Dammasch et al. 2008

C IV

Chae et al. 1998

redshift-radiance-relationship
Ly-α profiles, bins sorted by downflow

Curdt et al. 2008
cotemporal profiles:

Ly-\(\alpha\)

Ly-\(\beta\)
5-Gaussian decomposition of Ly-β
cotemporal profiles:

Ly-\(\alpha\): Absorption by downflowing material

Ly-\(\beta\): Emission of downflowing material
Density (arbitrary unit)

0.01  0.50  0.98

Corona

Transition region

Chromosphere

Photosphere

Internetwork  |  Network  |  Internetwork

LOS

magnetic field

Tian et al. 2009
Ly-α peak separation in a polar coronal hole

In the CH the separation is wider and the reversal is deeper than in QS.

This is indication of a higher opacity.

Ly-β now behaves similar to Ly-α!

Xia 2003
Coronal hole

Solar wind origin

Quiet Sun

Solar wind origin

Mass supply to loops

Tian et al. 2010
Red branch:

- downflow occurs at BOTH loop footpoints
- downflow also shapes the Ly-α profile
- phenomenon seems to occur in all magnetically confined structures
- we assume that this is also valid for unresolved fine structures
- we can explain the net redshift of TR emission

Question: How is the material replenished?
**Blue branch:**

- Continuous upflow in magnetically open coronal funnels
  (Marsch, Tu, Xia, Hassler, Tripathi ... )
Blueshifts associated with open fields

Field lines: brown open, and yellow closed
Correlation: Field topology and plasma outflow (blue in open field)

Wiegelmann, Xia, Marsch 2005
Blue branch:

- Continuous upflow in magnetically open coronal funnels (Marsch, Tu, Xia, Hassler, Tripathi, ...)

- Transient phenomena, jets, spicular activity, mini-CMEs (Innes, McIntosh, de Pontieu, Doschek, Chifor, ...
The asymmetries are variable with time and location and are probably related to large-scale motions of the atmosphere.

Gouttebroze et al. 1978

Fig. 1a: Observed profiles at the center of the solar disk. (a) Lβ. (b) Lα.
"... ejected material falls down ... and heats the legs ... ... may be related to spicules ... "

Fontenla et al. 1988
„The orientation of the prominence axis relative to the LOS has an imprint on the reversal depth of Ly-α“

Heinzel et al. 2005
Schmieder et al. 2007
Curdt et al. 2009

Tian et al. 2011 (in progress)
AR 1124 sunspot on Nov 16, 2010 in various AIA channels

SUMER slit during drift scan
Ly-α profiles in QS and sunspot umbra/penumbra

sunspot 18 Nov

black: umbra
orange: penumbra
red: quiet Sun

radiance / W/(sr m A)

lambda / px
normalized Ly-\(\alpha\) profiles in QS and sunspot
Gunar 2011, ongoing work
The coronal convection