Coronal loop footpoints threaded with small-scale mixed polarity surface magnetic fields

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in collaboration with

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Thanks to Sunrise-II Team
Scope of this talk

How the hot plasma structures outlining magnetic field lines in the corona are dynamically connected to fragmented surface magnetic field in the photosphere?
Numerical models of coronal loops

Parker (1972)
Numerical models of coronal loops

van Ballegooijen et al. (2011)

Reale et al. (2016)
Numerical models of coronal loops

Observations: Porter et al. (1994); De Pontieu et al. (2003); Aschwanden & Title (2004); Peter et al. (2013); Régnier et al. (2014); Wang (2016)

Flux-tube tectonics model of Priest et al. (2002)

van Ballegooijen et al. (1998)
A more detailed picture of coronal loop footpoints with Sunrise Observations

IMaX + SuFI covering solar lower atmosphere
Sunrise observations — context
Sunrise observations — context

Sunrise/IMaX

SDO/AIA

Sunrise observations — context
Magnetic connection: photosphere to corona

3.70
3.75
3.80
3.85
3.90

Magnetic flux \(10^{19}\) Mx

(a) dominant polarity (negative)

Start Time (12 Jun 2013 23:39:00)

0 5 10 15
Time (minutes)

Magnetic flux \(10^{19}\) Mx

(b) minor polarity (positive)

Magnetic connection: photosphere to corona

Sunrise/MeX
Sunrise/SuFI 3968 Å
SDO/HMI
Sunrise/SuFI 3968 Å
SDO/AIA 171 Å
Unsharp masked map from (e)

10^{15} Mx s^{-1}

Start Time (12–Jun–2013 23:39:00)
Magnetic connection: photosphere to corona

Sunrise/IMaX

SDO/AIA

10.9 min

Magnetic connection: photosphere to corona
A cartoon of the observed scenario

Heating scale height : Magnetic energy decay with height : close down of magnetic loops
Interpretation of heating scale height

4—6 orders of magnitude drop in the heating rate

Heating scale height $\approx 500$ km
Average magnetic energy flux $\approx 10^9$ erg cm$^{-2}$ s$^{-1}$

Photospheric Poynting flux due to convective motions
$\approx 5 \times 10^7$ erg cm$^{-2}$ s$^{-1}$

Flux cancellation ($10^{15}$ Mx s$^{-1}$)

Heating scale height of 500 km

A cartoon of the observed scenario (e.g. Welsch 2015)
Indirect evidence for the mixed polarity?

Peter et al. (2013)

Régnier et al. (2014)
Illustration of a coronal loop

arXiv:1610.07484
Conclusions

• Sunrise observations revealed presence of small-scale mixed polarity field at coronal loop footpoints

• A flux cancellation rate of $10^{15}$ Mx s$^{-1}$ can provide a large reservoir of magnetic energy at the base of coronal loops

Question

• At what stage of active region evolution do this small-scale mixed polarity field will govern coronal dynamics?