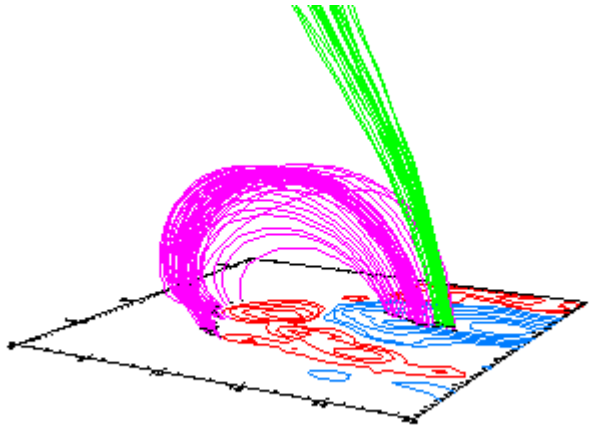
Describing Coronal Magnetic Fields by Successive Force-free Equilibria



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Based on "Evolution of Magnetic Fields and Energetics of Flares in Active Region 8210"

Motivation

- How is the magnetic configuration of an active region modified by flaring activity?
- Is there evidence of *reconnection* processes in the solar corona?
- What are the *precursors* of flares?
- How are the *magnetic energy* and the magnetic helicity stored and released?

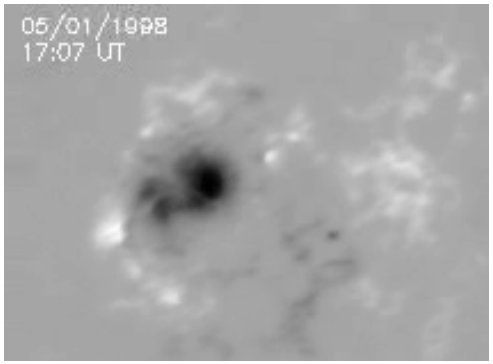
Method

1) *To find a time series of vector magnetograms*: entire active region in the fov, good seeing, low noise on the transverse components, balance of the magnetic flux, balance of the electric current density
2) *To determine the 3D magnetic configurations*: nonlinear force-free modelling with vector magnetic field as boundary conditions
3) *To analyse the magnetic configurations*: geometry and topology, magnetic energy, magnetic helicity

Main assumption: evolution of the active region sufficiently slow

Description of the flaring activity in AR 8210

Photospheric Magnetic Field



On the left, movie of the vertical distribution of the magnetic field in AR 8210 as observed on May 1st 1998

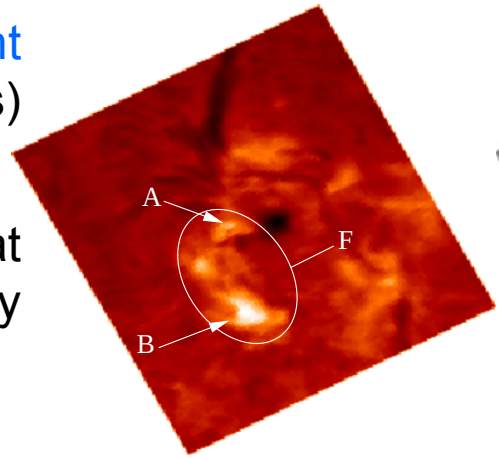
Main horizontal motions: slow rotation of the sunspot (clockwise), displacement of the South-East positive polarity towards the South

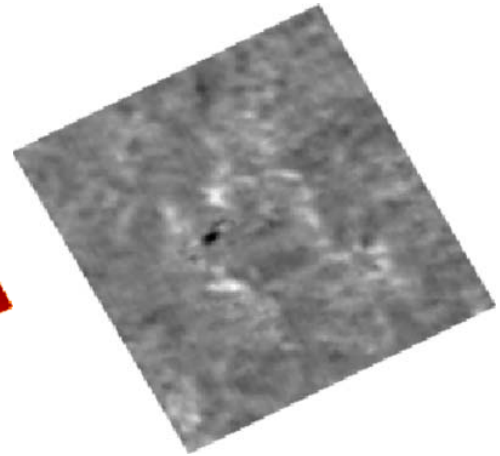
Then increase of the shear of the field line in this part of the active region

Chromospheric Response

Observation of the intensity enhancement in Hα as well as blueshift events (BSEs) related to the flare activity in AR 8210

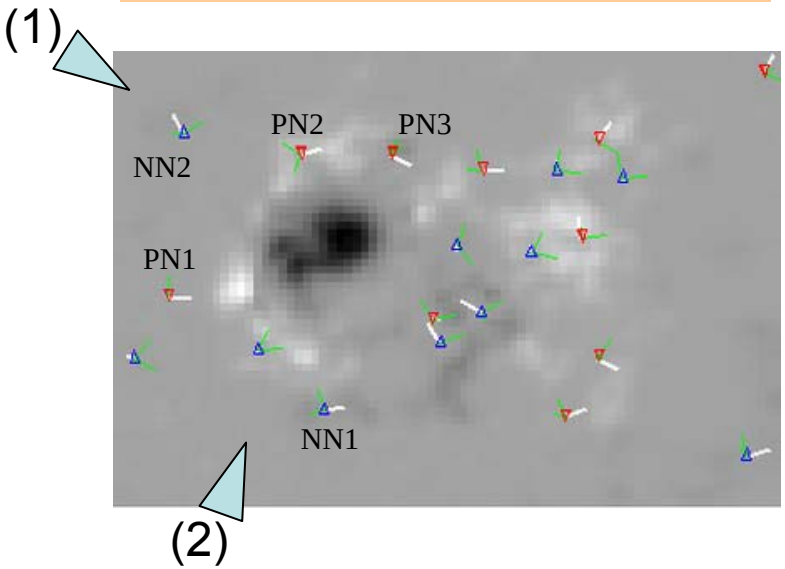
BSEs mainly appear before the flare at location A and also during the decay phase of the same flare at location A

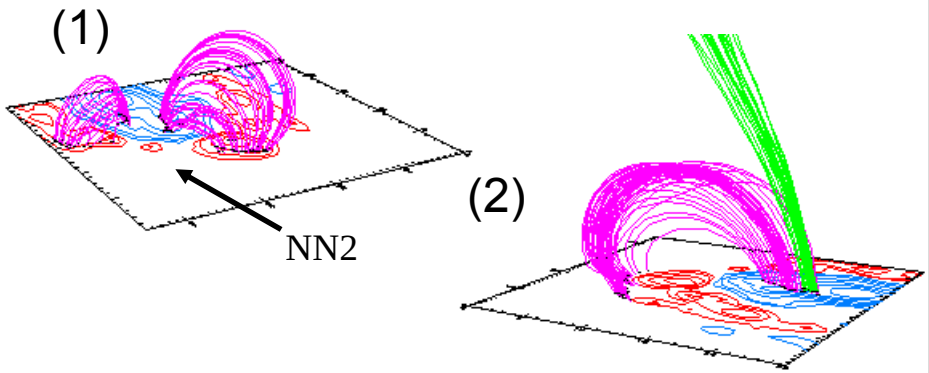




Evolution of the coronal field

Topology

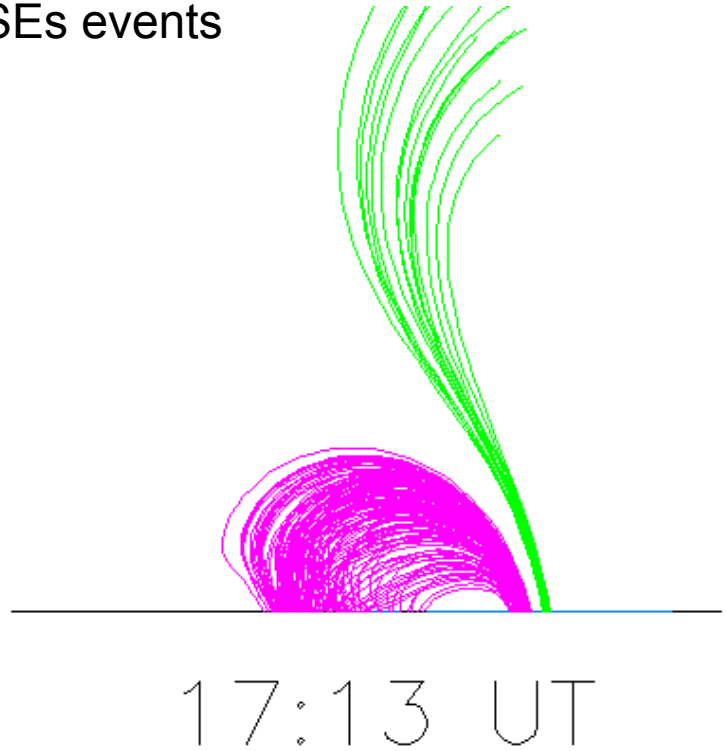




Dynamic Evolution

Modification of the connectivity of field lines during the observed time series

Evidence of reconnection at the site of BSEs events



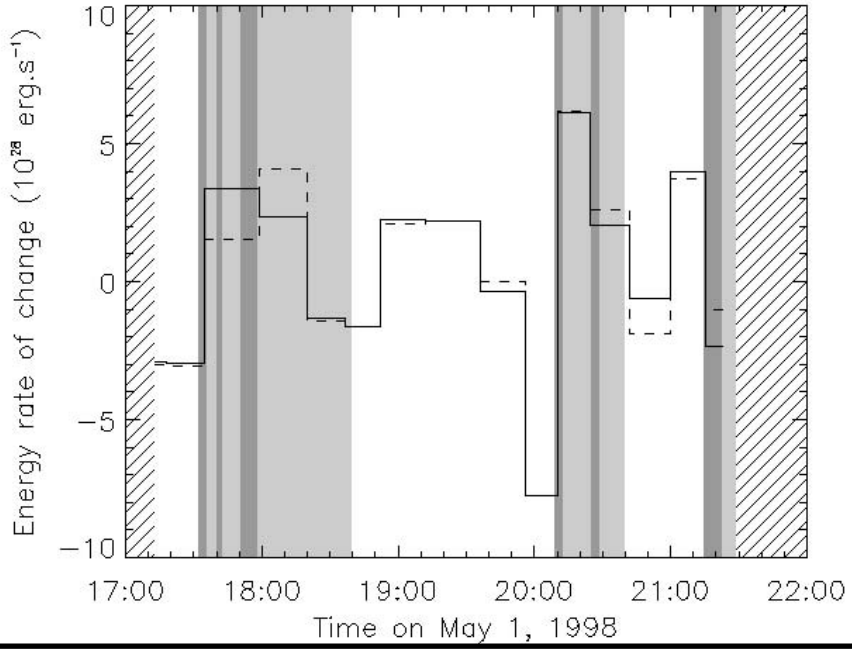
Evolution of the magnetic energy

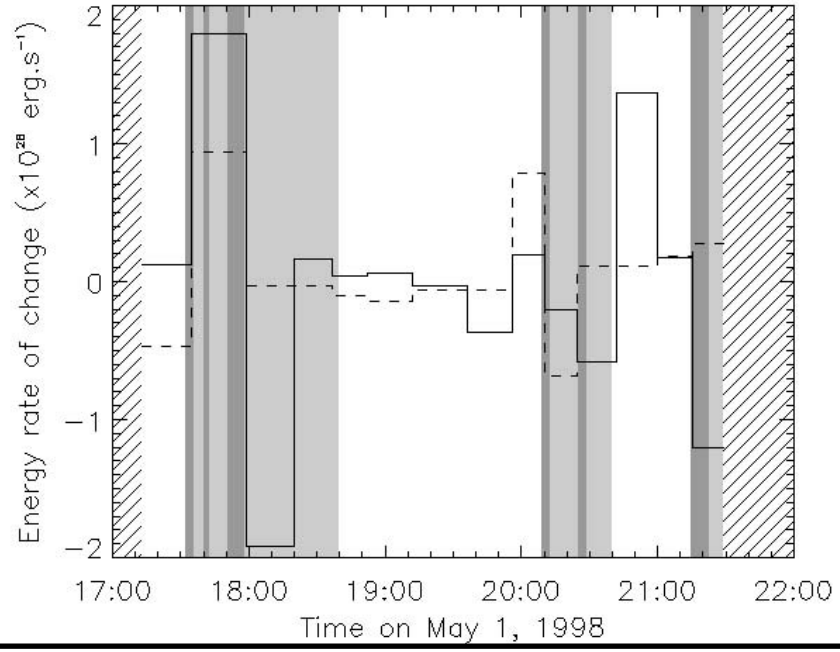
- Similar evolution of the potential and the nonlinear force-free magnetic energy (same sign of the rate of change)
- Decrease of the free magnetic energy budget after a flare

- Increase of free energy budget associated with the increase of magnetic energy due to transverse motions

On the left: time evolution of the magnetic energy rate for the potential field configurations (*dashed line*) and for the nonlinear force-free configurations (*solid line*)

On the right: time evolution of the rate of change of the free magnetic energy budget (*solid line*) and of the energy rate due to transverse photospheric motions (*dashed line*)





Conclusions

On the evolution of the magnetic field using successive force-free equilibria:

- smooth evolution of the field mostly related to the motions of photospheric elements

- consistency of the topology from one equilibrium to an other

- possibility to determine the magnetic energy content of the active region to know where the magnetic energy is stored or released

On the evolution of flaring activity in AR 8210:

- evidence of reconnection given by the connectivity change of field lines near the separatrix surface, at the same location as Hα blueshift events

- release of magnetic energy during or after the flare sufficient to trigger a C-class flare

- photospheric motions and the complex topology are precursors of the flaring activity