Onset of the Evershed flow during the formation of a sunspot penumbra

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Ground and space-based instruments for future research in Solar-Terrestrial physics- June 2016

IBIS and SDO/HMI data sets

IBIS DATA SET

- on 2012 ***May 28***, from 13:39 UT to 14:38 UT (30 scans)
- on 2012 ***May 29***, from 13:58 UT to 16:57 UT (30 scans)

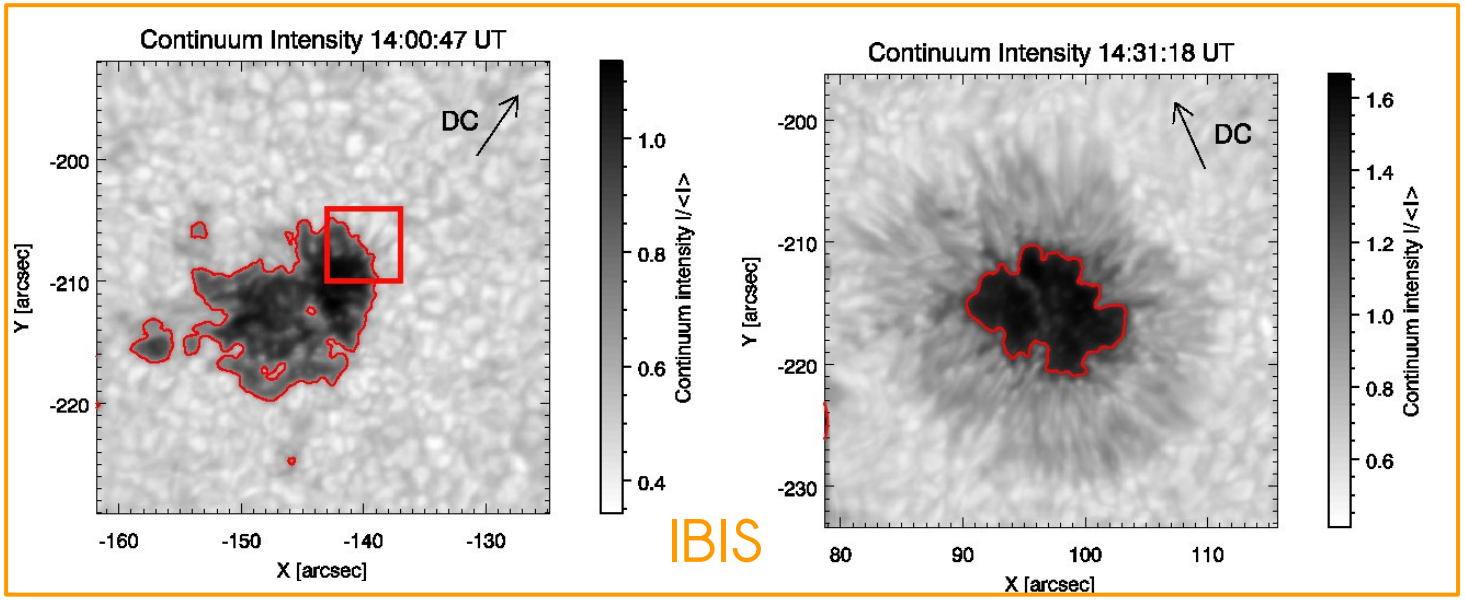
The scans with 67 s cadence contain:

- **Fe I 617.3 nm**
  sampled with 24 λ in spectropolarimetric mode
  six modulation states (I + S with S = [+Q,+V,-Q,-V,-U,+U])
- **Fe I 630.25 nm**
  sampled with 30 λ in spectropolarimetric mode
  six modulation states (I + S with S = [+Q,+V,-Q,-V,-U,+U])
- **Ca II 854.2 nm**
  sampled with 25 λ without polarimetric measurements
- Simultaneous **broad band** images (633.32 ± 5 nm)
- **G-band** filtergrams (430.5 ± 0.5 nm)

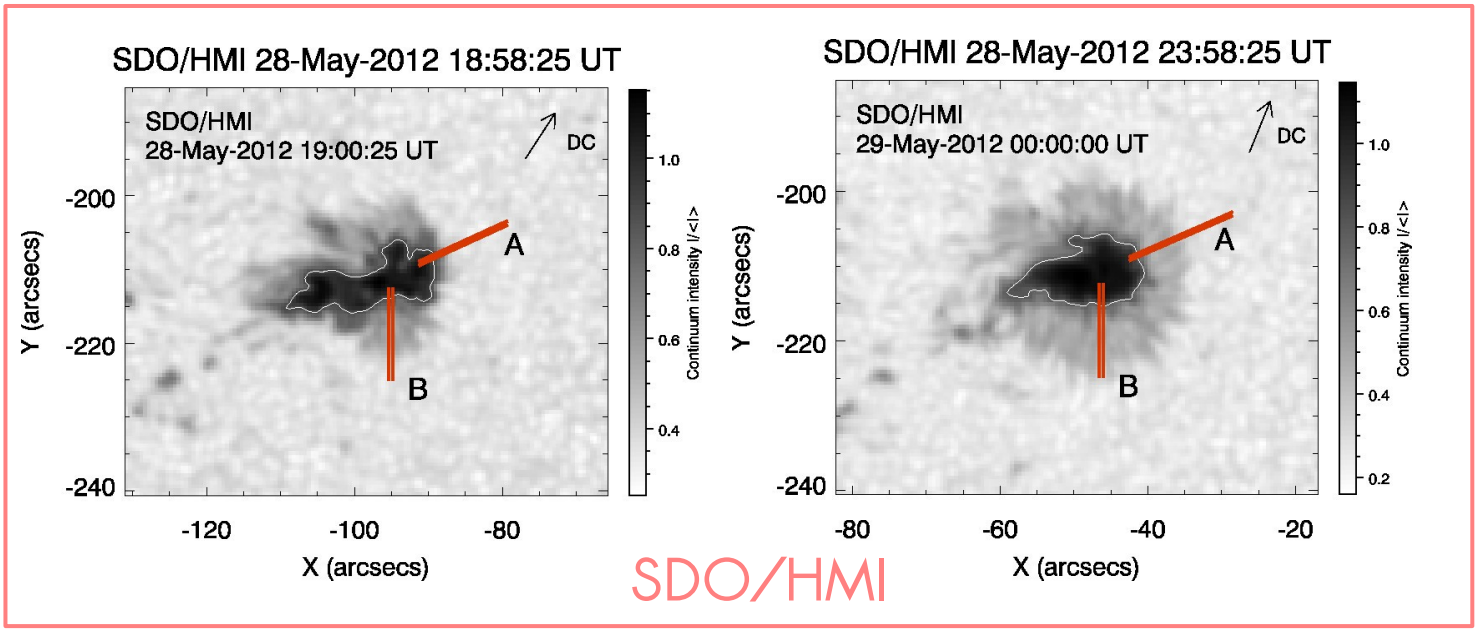
SDO/HMI SHARPs DATA SET

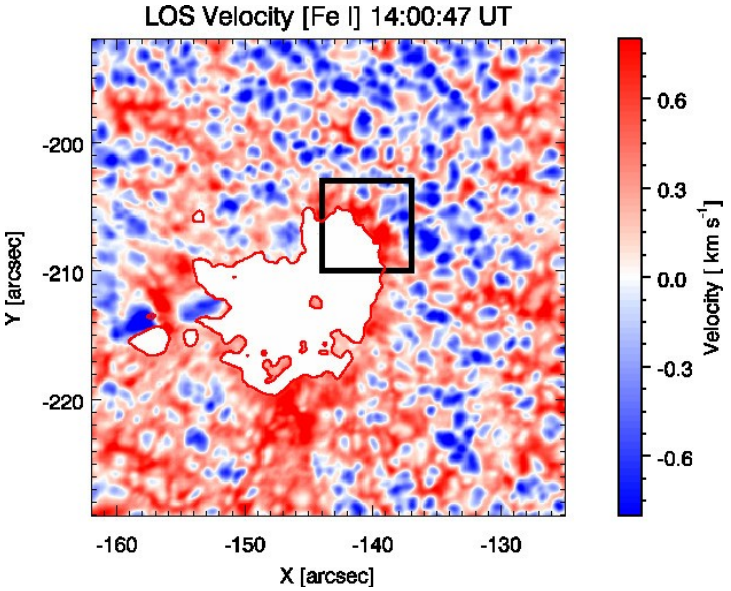
-Continuum filtergrams and Dopplergrams in the Fe I 617.3 nm line from May 28 at 14:58 UT to May 29 at 14:58 UT with 12 minutes of cadence and a resolution of 1”
-The components Br, Bφ, Bθ of the vector magnetic field B.

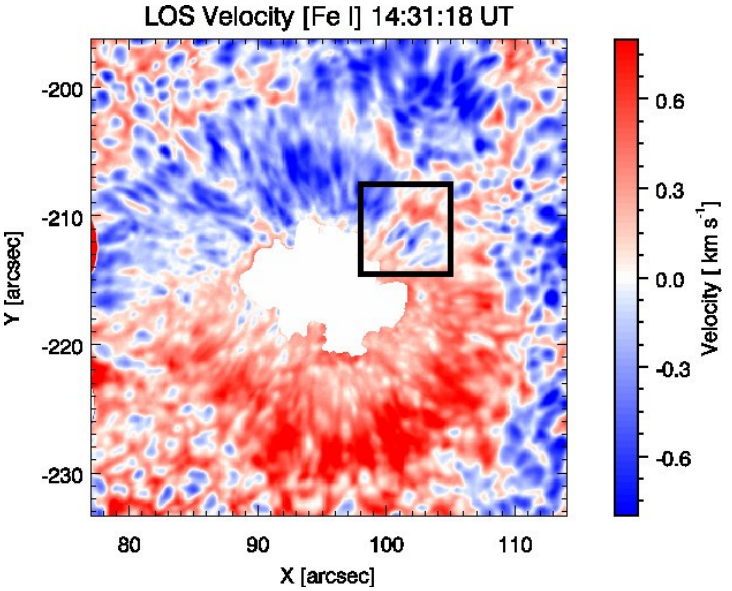
Formation of the penumbra

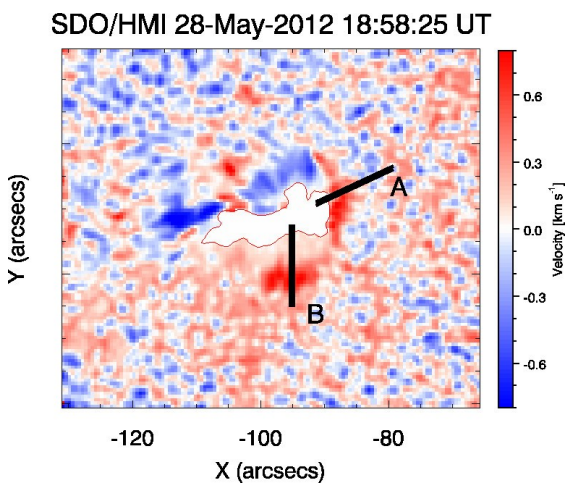


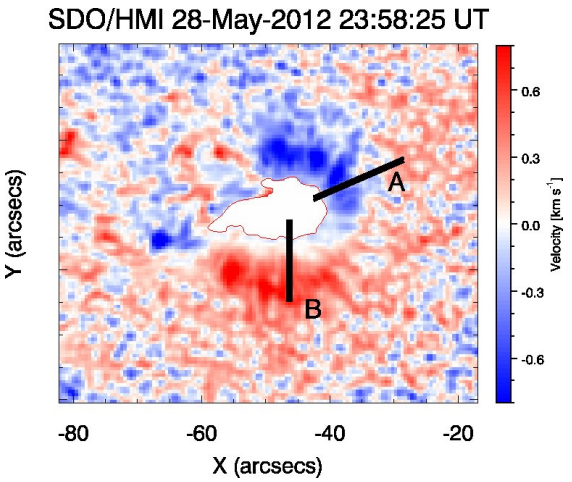
In Particular...



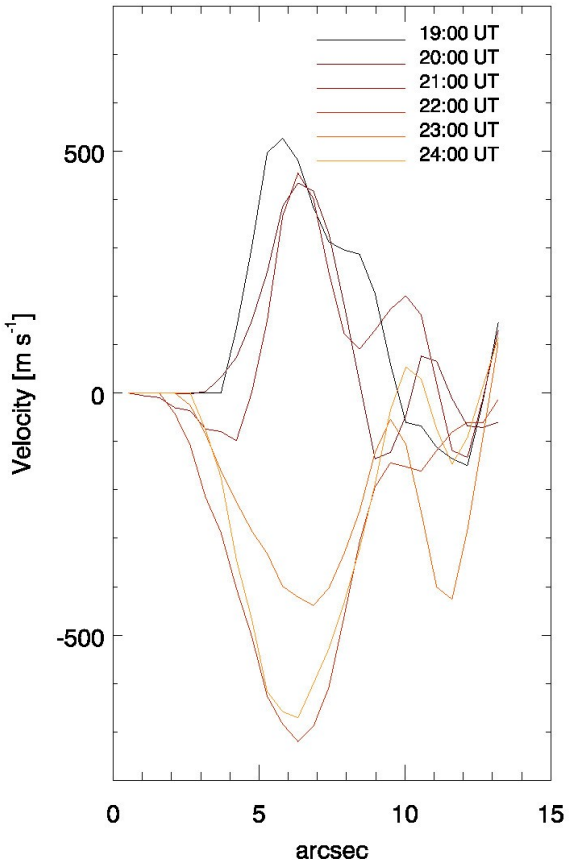

LOS Velocity [Fe I] 14:00:47 UT
-200
-210
-220
Y [arcsec]
-160
-150
-140
-130
X [arcsec]
0.6
0.3
0.0
-0.3
-0.6
Velocity [km s-1]

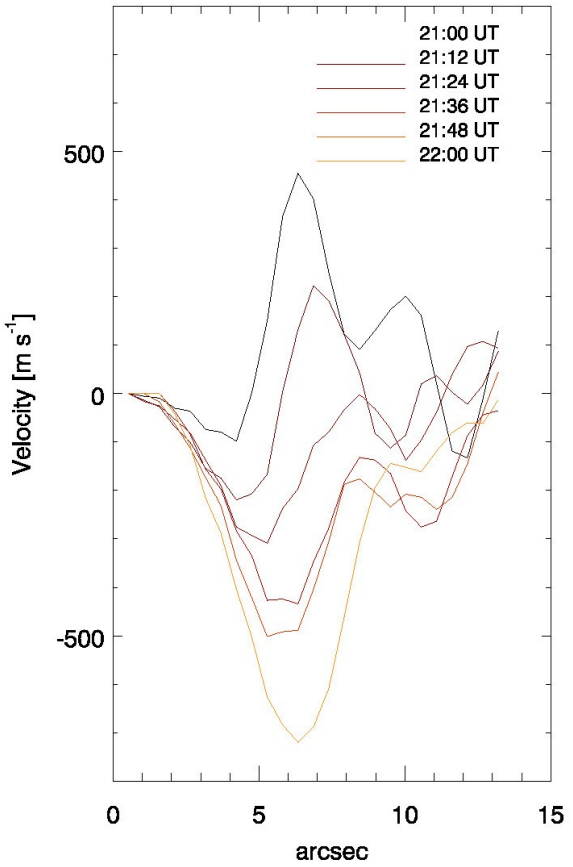

LOS Velocity [Fe I] 14:31:18 UT
-200
-210
-220
-230
Y [arcsec]
80
90
100
110
X [arcsec]
0.6
0.3
0.0
-0.3
-0.6
Velocity [km s-1]


SDO/HMI 28-May-2012 18:58:25 UT
A
B
Y (arcsecs)
-120
-100
-80
X (arcsecs)
0.6
0.3
0.0
-0.3
-0.6
Velocity [km s-1]


SDO/HMI 28-May-2012 23:58:25 UT
A
B
Y (arcsecs)
-80
-60
-40
-20
X (arcsecs)
0.6
0.3
0.0
-0.3
-0.6
Velocity [km s-1]

Fundamental Result: Redshift →Blueshift





Conclusions

- Flow of **opposity sign** respect to that the classic Evershed flow
- The **transition** to classic Evershed flow occurs in about **1 hr**
- The proposed scenario includes the presence of small **U-loop** whose inner footpoint has the **magnetic polarity opposite** to that of the pore. This footpoint is also the outher footpoint of an **inverted U-loop** connecting it to the pore → **Counter Evershed Flow**. With time more and more flux is dragged down, increasing the flux in the external footpoint of the inverted U-loop → **magneto-convection starts** and also the Evershed flow is set up as part of the magneto-convective process.