High resolution observations of a light bridge in a decaying sunspot

M. Falco, S. Criscuoli, A. Cristaldi, J. De la Cruz Rodriguez, I. Ermolli, S.L. Guglielmino, P. Romano, L. Rouppe Van Der Voort, F. Zuccarello
What is a Light Bridge?

A bright and elongated structure delineating the borders between dark umbral fragments.

- Observed during:
  - the assembly process of a sunspot
  - the decay phase of a sunspot

- Classification:
  - **LBs segmented** along their length by tiny granules separated by narrow dark lanes oriented perpendicular to the axis of the bridges
  - **LBs unsegmented** more resembling the elongated bright filaments seen in the penumbra
Properties of the LBs

**Magnetic Field**: field strength lower and more horizontal than in the umbra. LBs are a discontinuity in the regular umbral field.

**Plasma motions**: old observations showed evidence of sinking plasma in the axial channel. Convective origin of the LBs.

Rimmele (2008): upflows in the dark lane and downflows on both sides of it.

**Magnetoconvection origin** vs

Convection penetrating from the sub-photospheric layers into a field-free gap.
Dark Lane in LBs

Central dark lane observed in LBs interpreted as a sequence of high points of a ridge elevated over the dark umbra (see, e.g. Lites et al. 2004 and Rimmele 2008)

The dark lane can be explained due to:

- an increased temperature that provokes an increased opacity
- an increased gas pressure related with a reduced magnetic field strength in the bridge
Observational Campaign at the Swedish Solar Telescope (SST)

6-19 August 2011, La Palma (Canary Islands)

S. Criscuoli (PI), I. Ermolli, S. L. Guglielmino, A. Cristaldi, M. Falco, F. Zuccarello

1st SOLARNET - 3rd EAST/ATST meeting. Oslo, 5-8 August 2013
### Observational Campaign data-set

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Wavelength</th>
<th>Spectral points</th>
<th>Pixel size (arcsec)</th>
<th>Time Resolution (sec)</th>
<th>Observation days</th>
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<tbody>
<tr>
<td>SST</td>
<td>Fe I 5576 Å</td>
<td>20</td>
<td>0.0592</td>
<td>28</td>
<td>6 - 19 Aug 2011</td>
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<tr>
<td></td>
<td>Fe I pair 6302 Å</td>
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<td>Hα</td>
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<td>0.109</td>
<td>30</td>
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</tbody>
</table>
HMI/SDO on August 6, 2011

NOAA 11263
Coord: N16 W43 (621", 188")
NOAA 11263 evolution: HMI continuum

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Hinode filtergrams

NOAA 11263, Ca II H line

NOAA 11263, G-band

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CRISP Continuum - Fe I 5576 Line
Ca II H core
NOAA 11263: SST data

Wide Band 5576 Å with FOV 57.5 x 57.8 arc seconds (41700 x 41900 Km)
CRISP observations confirm that the magnetic field strength in the LB is lower than in the umbra and is comparable with the penumbra.
Hinode: Magnetic components

Longitudinal Magnetic Field 08:55:05 UT

Horizontal Magnetic Field 08:55:05 UT
Hinode: Azimuth and Inclination angles
CRISP: Velocity maps

Plasma velocity map deduced from the SIR inversion

Plasma velocity map deduced from Gaussian fit of the Fe I line at 5576 Å
LB granulation vs Quiet Sun granulation
Dark Lane analysis

DL of the penumbral zone

DL of the umbral zone
Dark Lane intensity

Fe I 5576 Å

The intensity of the DL is lower in the penumbral region than in the umbral one.
Intensity of LB’s grains of the penumbral side
Intensity of LB’s grains of the umbral side
Dark Lane velocity

Fe I 5576 Å

There are upflow motions along the DL in the umbral region.

In the penumbral region the plasma motions of the DL are more variable.
Velocity of LB’s grains in the penumbral side

![Graphs showing velocity of LB’s grains in the penumbral side with X-axis in arcsec and velocity in km/s.]

B1

C1

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Velocity of LB’s grains in the umbral side
Dark Lane intensity

Fe I 6302 Å

The intensity of the DL is lower in the penumbral region than in the umbral one as for the Fe I 5576 Å
Dark Lane magnetic Field along the LB

Fe I 6302 Å

The magnetic field in the DL is higher in the penumbral region than in the umbral one.
Dark Lane Analysis

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Dark Lane between umbrae</th>
<th>Dark Lane between penumbrae</th>
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</thead>
<tbody>
<tr>
<td>Intensity (Fe I 5576 Å)</td>
<td>0.76</td>
<td>0.64</td>
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<tr>
<td>Velocity (Fe I 5576 Å)</td>
<td>-0.10 (Km/s)</td>
<td>+0.17 (Km/s)</td>
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<tr>
<td>Magnetic Field (Fe I 6302 Å)</td>
<td>1000 G</td>
<td>1300 G</td>
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</table>

There are differences in intensity, velocity, and magnetic field between the DL of the penumbral region and the DL of the umbral one.
Conclusions

1) The DL of the umbral zone is characterized by upflows.
2) The DL of the penumbral zone shows both downflows and upflows.
3) The magnetic field of the DL in the umbral zone is lower than in the penumbral zone.

These results confirm that where the magnetic field is lower, convection is more effective, the intensity of the DL is higher and there are upflow motions.

Convection penetrating from the sub-photospheric layers into a field-free gap.