SMALL-SCALE CHROMOSPHERIC JETS ABOVE A SUNSPOT LIGHT BRIDGE

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Introduction

- Chromosphere above sunspots → highly dynamic phenomena
  - Umbral flashes (Wittmann, 1969, Rouppe van der Voort et al. 2003)
  - Penumbral microjets (Katsukawa et al. 2007, Duvall et al. 2010)

- Perturbation in the sunspot magnetic field → Chromospheric Heating
- Convective disruption most apparent in light bridges – transition from $\beta>1$ to $\beta<1$ rapid
Hα Surges above LBs

- 80% of surges on edge of LB adjacent to strongest umbral core

Roy (1973)
Hα Surges & EUV Brightenings

- Recurrent and intermittent surges, Speeds of 50 km/s
- Coincide with TRACE 171Å brightenings

Asai et al. (2001)

Hα -5.0 Å
May 1, 22:47:47(UT)

Hα -0.6 Å
May 2, (3) 02:50:56(UT)

(1) 00:40:36(UT)
(2) 02:38:56(UT)
(3) 02:50:56(UT)
(4) 03:19:29(UT)
(5) 03:57:08(UT)
Flaring activity in LBs

- Overturning motions in LB, constant brightness enhancement in TR
- C2.0 flare 4 hrs later, ribbon over LB

HINODE sheds light !!!

Louis et al. 2008, 2009

- Persistent, recurrent brightenings over penumbral LB in Ca II H
- Jets along LB & arch-shaped brightenings across the LB extending to QS
Underlying photospheric conditions

- Anomalous profiles in LB, supersonic downflows co-spatial, temporal with chromospheric brightenings
- Similar obs. at umbra-penumbra border – Louis et al. 2011

CAUSE AND EFFECT ????
Small-scale chromospheric jets in light bridges

Detection of jets

- Base of jets: Triangular-shaped blob
- Spike-like jets launched towards UC

Louis et al. 2014
Properties of jets

Louis et al. 2014
Timeline of the small-scale jets

- Frequent transition formation and fragmentation over 3 days
- LB intact from latter half of Aug 18 till end of Aug 19
- No jets observed during early phase of LB, but soon after formation
Small-scale velocity & magnetic anomalies

Louis (2015)
Small-scale velocity & magnetic anomalies

Louis (2015)
Two-component inversion

Strong Doppler shifts of either sign with opposite polarity!!!

Louis (2015)
Two-component inversion

<table>
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<th>BP</th>
<th>RP</th>
<th>LB</th>
<th>Umb</th>
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<td><strong>Field Strength [G]</strong></td>
<td>1554</td>
<td>1581</td>
<td>1688</td>
<td>2611</td>
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<td>1747</td>
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<tr>
<td><strong>Field Inclination [deg]</strong></td>
<td>150</td>
<td>145</td>
<td>156</td>
<td>164</td>
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<td></td>
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<td>54</td>
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<tr>
<td><strong>LOS Velocity [km s(^{-1})]</strong></td>
<td>0.6</td>
<td>0.3</td>
<td>0.2</td>
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<td></td>
<td>-5.2</td>
<td>6.7</td>
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<td><strong>Fill Fraction</strong></td>
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<td>0.04</td>
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</table>
Chromospheric activity in LBs

Louis (2010)
Summary & Conclusion

- One-to-one (spatial & temporal) correspondence between photospheric inhomogeneities (velocity & magnetic) & chromopsheric jets → causal relationship
- Strong/supersonic velocities imply strong pressure gradients, capable of producing Doppler shifts of either sign & in close spatial proximity
- Jets associated with LBs at different epochs of sunspot evolution, recurrent and long-lived

- Small-scale inhomogeneities likely driven by magneto-convection
- Evidence for small-scale flux emergence in LBs (Louis et al. 2015)
- LB associated large-scale convective flows in EARs (Toriumi et al. 2015a, 2015b)
- Magnetic reconnection with overlying sunspot field → jets/surges?
THANK YOU