SDO/AIA observations of EUV sunspot jets and associated interplanetary electron streams

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AIA: Full Sun - 7 EUV channels, 2 UV, 1 Optical - 12s cadence/channel – 0.6” pixels
HMI: Full Sun – Optical continuum – Magnetograms – Dopplergrams - 45s – 0.6” pixels

Overwhelming amount of fantastic data – Where do you start?

3 color images and movies from the Sun Today web site

171 blue
193 green
211 red
304 red
171 blue
193 green
yellow 171
orange +ve
blue -ve
M1 Flare –

EUV relates to photospheric footpoints. Initial loop brightening over sunspot

main arcade off-set from sunspot

Red LOS magnetic field
Blue 171A Fe IX
Green 131 FeXXI

movement along field
Type III radio bursts

The most frequently observed solar radio burst by WAVES/WIND and SWAVES/STEREO (Freq 0.1-13 MHz).

Emission drift from high to low frequency.

Produced when suprathermal electrons (velocity ~ 0.1 c) travel outward along open magnetic field lines through the corona and interplanetary medium.

Electrons excite Langmuir waves at the electron plasma frequency that are converted into radio waves.

f ~ √ne  

frequency proportional to square root electron density

Estimated distance from the Sun for 13 MHz emission is 2 Rsun. It takes 17s.
Radio Bursts on 3 Aug 2010

Quasi-periodic bursts seen simultaneously on STEREO-A, -B and Wind (Earth)
Source close to the central meridian as seen from Earth

quasi-periodic type III bursts
AR 11092 at disk center on 3 Aug 2010

strong negative polarity spot with trailing plage
EUV jets

image cadence 12s

red – magnetic field
blue – 304 (He II)
green – 211 (Fe XIV)

211 A base difference
Where do the jets start?

sunspot
footpoint
loops
jet

211A base difference
211A Light curves and cross-correlations

- Good correlation of footpoint and jet. Jet lags footpoint by 30s.
- No correlation between sunspot waves and footpoint correlation over 2.5 hours.
211A Light curves and cross-correlations

footpoint-sunspot has a correlation 0.4 during two periods of strong bursts

Footpoint brightening with period about 3-min, like sunspot waves
Radio and 211 cross-correlations

Radio has good correlation with jets and footpoint. Jets EUV lag radio by 1 min.
Reconnection triggered by waves

Microwave bursts and soft X-ray bursts above sunspots

(Sych et al 2010)

3-min period seen before, during and after soft X-ray flare. 3-min period in GOES
EUV jets - YOHKOH


movement of satellite flux into unipolar field

Shibata et al. PASJ, 1992
Emerging flux into unipolar field
Extrapolation of 3 Aug 2010

No sign of flux emergence in previous 24 hours

Red – closed field
Black- Open field

No open flux near the base of the jet except from sunspot.
All negative flux outside is balanced by this positive polarity region.
Need open flux to produce type IIIs =>
the jet must start in the strong fields above sunspot.
Possible acceleration mechanism

Reconnection along quasi-separatrix layers – regions with change in magnetic connectivity (red contours) and therefore sites of strong currents.

eg source of slow solar wind
Baker et al 2009

velocity FeXII
Summary

• Interplanetary electron streams (Type IIIs) and EUV jets originate on the edge of the sunspot umbra.
• They form along a current sheet between the sunspot open field and the closed field of satellite flux.
• Sunspot waves modify and possibly trigger the jets

Thank You
Next Project -
Solar radio emission 13-15 Feb

Type III’s start on 13 Feb

M-flare  C-flare  M-flare  X-flare