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BURSTS, BOMBS, AND EXPLOSIVE EVENTS: MAGNETIC RECONNECTION IN THE LOWER SOLAR ATMOSPHERE

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ABSTRACT

Write an abstract.

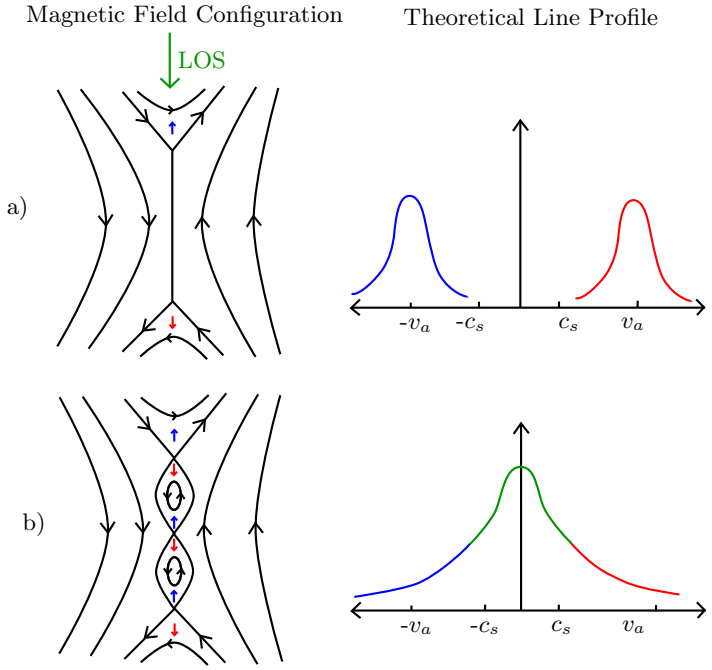
1. BACKGROUND

1.1. *Transient Brightenings in the Lower Solar Atmosphere*

From the photosphere to the upper reaches of the transition region the solar atmosphere changes three orders of magnitude in temperature over only a few thousand kilometers. This thin layer of the Sun, while often less grand in appearance than the corona, plays an important role in the energy transport required to heat the corona to mega-Kelvin temperatures. Like the flickering coals of a camp fire the photosphere, chromosphere, and transition region are littered with small, short lived, brightenings. Brightenings give us clues as to how often, where, and when energy produced in the solar interior is deposited beyond the photosphere.

Many of these small brightenings are also accompanied by fast motion. Spectroscopic observations reveal many events, over a range of heights and temperatures, that have Doppler velocities exceeding the local thermal speed. In order for plasma velocities to exceed thermal speeds there must be a conversion of some

Figure 1. Here we present a cartoon representing an ideal presentation of magnetic reconnection and corresponding spectral observation. Panel a shows Petscheck reconnection with bi-directional outflow jets at the Alfvén Speed, v_a. Plotted along side is a theoretical line profile, for the labeled *Line Of Sight* (LOS), showing two seperate peaks in intensity at $\pm v_a$. Panel b shows the developement of magnetic islands during the onset of the tearing mode instability. The addition of stationary emitting material will fill out line center and result in a broadened, mostly centered line profile. The blue, green, red coloring on the line profiles demonstrated how line intensity is binned in Figure **??**.



other energy source to kinetic energy. It is becoming widely accepted that this extra energy comes from the solar magnetic field. Through magnetic reconnection the Sun's magnetic field eliminates high energy discontinuities and converts that energy in to the heating and motion of local plasma. While repeated observations of non-thermal plasma motion within regions of complicated magnetic field has the solar physics community leaning toward magnetic reconnection as the cause of solar atmospheric heating the details are still the subject of much debate.

1.2. *Ellerman Bombs and Explosive Events*

Two commonly observed events in the Sun's lower atmosphere are Ellerman Bombs (EBs) and Explosive Events (EEs). EBs (Ellerman 1917) are commonly observed as intense brightenings in the wings of Hα $\lambda 6563 \mathring{A}$ are characterized by small spatial scales (arcsecond or smaller) and short life times (a few minutes). Hα has a peak formation temperature of $\approx$ 10000 K placing EBs very low in the solar atmosphere near the photosphere. EBs are observed in regions of opposing magnetic polarity and, until recently (Nelson et al. 2017), exclusively within active regions. EBs are believed to be the result of magnetic reconnection as new flux emerges through the photosphere and reconnects with the preexisting photopsheric magnetic field. High resolution instruments such as the Crisp Imaging Spectropolarimeter (CHRISP; Scharmer et al. 2008) on the Swedish Solar Telescope (SST; Scharmer et al. 2003) and the Interface Region Imaging Spectrometer (IRIS; De Pontieu et al. 2014) have helped discover more details about EBs. They often originate between granules deep in the photosphere, they often have an upward extending flow or "jet", and they demonstrate very fast variations (on second timescales) coupled with repeated eruptions (Watanabe et al. 2011; Vissers et al. 2013, 2015)

EEs were first analyzed by Brueckner & Bartoe (1983) using data from the High Resolution Telescope and Spectrograph (HRTS) sounding rocket. EEs are typically characterized by Doppler shifts on order 100 km s^{-1} and spatial scales of a few arcseconds (Dere et al. 1989; Dere 1994). Si IV λ1393 Årasters taken by the Solar Ultraviolet Measurement of Emitted Radiation (SUMER) revealed an EE with bi-directional jets near small magnetic bi-poles on the solar surface (Innes et al. 1997). This presentation was said to match the classic magneto-hydrodynamic (MHD) model of reconnection (Petschek 1964) quite well and is illustrated in Figure 1(a)

Explosive events as viewed by MOSES, Lewis' event (Possible Tearing Mode), Tom's thesis and the discovery of symmetric, fast, bi-directional flows in He II

1.3. *IRIS Bombs and UV Bursts*

With IRIS many Bomb/Burst events have been observed and modeled (stack of sources here). Most agree these are the result of reconnection, others (Phil Judge) do not.

Often these events are seen as non-gaussian triangular line profiles (Lidja and more recent study including Bart), sometimes they have absorption features sometimes not, sometimes they even show self absorption (One paper to dig up)

1.4. *Problem Statement*

Come up with a really good, concise question.

2. TECHNICAL APPROACH

2.1. *Initial Survey and Event Selection*

Why IRIS, Si IV, OBS selection criterion Why the medium or large line list? What is an "event" How many, what size, how long, where? (Dig through Allison's work) Maybe show a few particularly interesting events.

Specific Questions brought up in initial survey?

2.2. *Spectral Diagnostic IRIS*

Identifying events with optical depth effects (Si IV line ratios). This will help us distinguish between bi-directional flows and absorption.

Doppler maps of events, possible human sorting?

Eventually I would also like to examine HMI context for various types of events. Also look for evidence or lack there of in other IRIS lines (mostly C II)

Whole purpose is to get a handle on the types and frequency of different kinds of events.

2.3. *ESIS and MOSES-3*

While IRIS provides high resolution spectral data in a few lines it fails in a few different areas. Small field of view, a compromise between high cadence(sit-and-stare) and spatial resolution (rasters).

MOSES/ESIS proved the right lines for comparison, a larger FOV, and spectral data in a snapshot over the full field of view. Talk about finishing up the developement of KSO and how you plan to tie in the data eventually.

3. SCIENTIFIC IMPACT

Short and sweet. Reconnection is a universal process that contributes tremendously to the variability of our sun and intern the Sun-Earth environment.

4. TIMELINE

Get a fucking degree already, and maybe some money in the meantime.

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