

# Observations of quiescent reconnection (and associated heating!, and topological energy release!, but no time!)

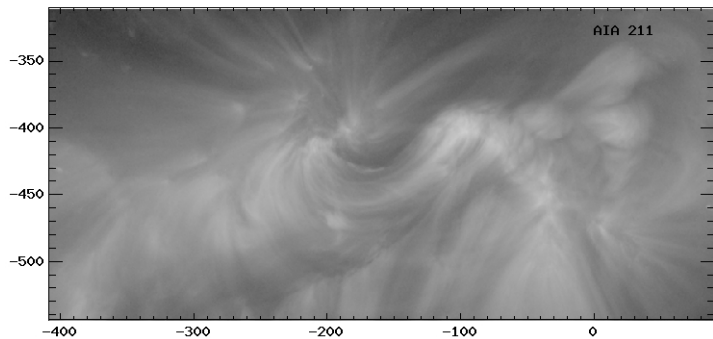
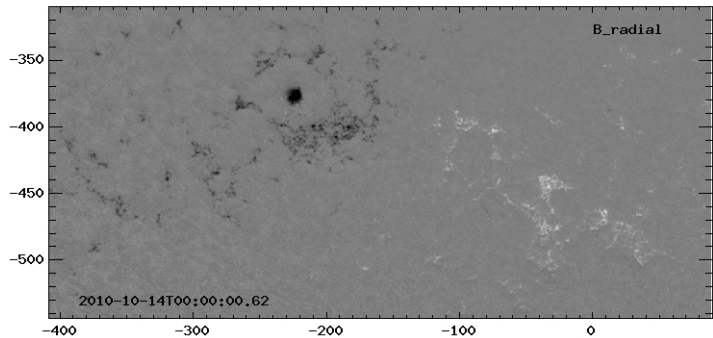
Lucas Tarr, Dana Longcope, Dave McKenzie, & Keiji  
Yoshimura



MSU Solar Physics

July 10, 2013





## Purpose and motivation

Goal: Measure the amount of reconnected flux between a small, bipolar active region and surrounding, preexisting field over the course of multiple days

## Purpose and motivation

Goal: Measure the amount of reconnected flux between a small, bipolar active region and surrounding, preexisting field over the course of multiple days

Past Observations: Similar procedure to previous studies of flares, using flare ribbons: [Qiu et al. 2010, ApJ 725] and [Kazachenko et al. 2010, ApJ 722]. FOCUS: large 2 ribbon flares,  $\sim 30$ min timescale



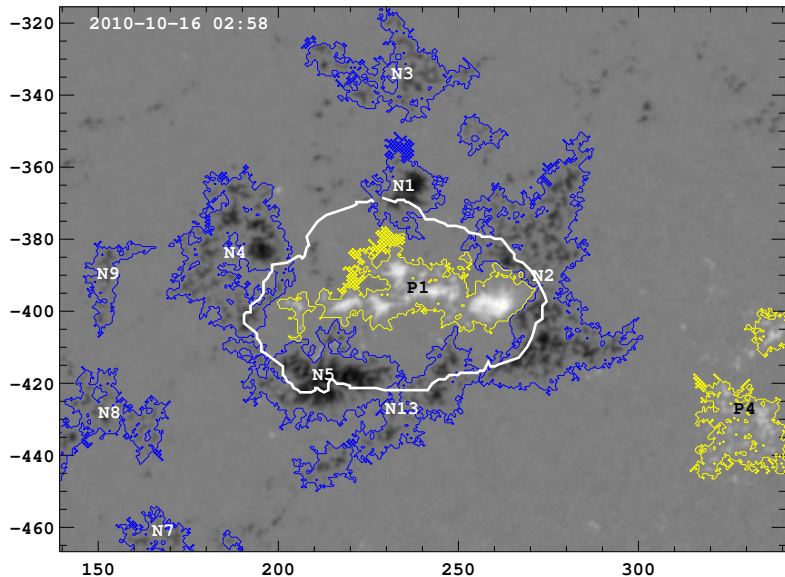
## Purpose and motivation

Goal: Measure the amount of reconnected flux between a small, bipolar active region and surrounding, preexisting field over the course of multiple days

Past Observations: Similar procedure to previous studies of flares, using flare ribbons: [Qiu et al. 2010, ApJ 725] and [Kazachenko et al. 2010, ApJ 722]. FOCUS: large 2 ribbon flares,  $\sim 30$ min timescale

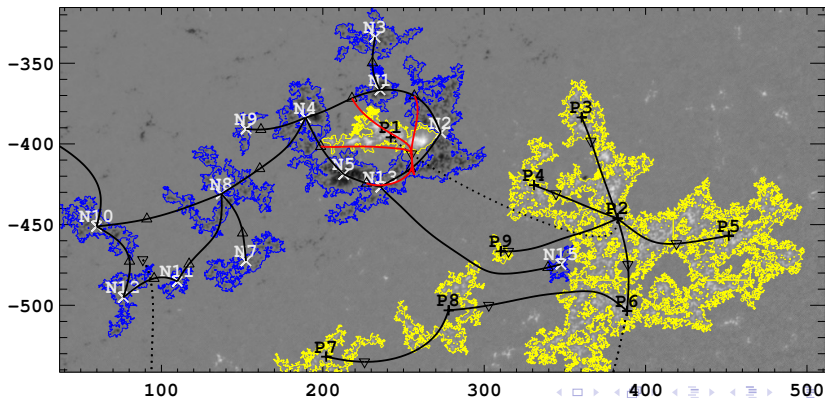
Past Simulations: See series reviewed by [Archontis 2008, JGR 113], which shows emerging flux will also continuously reconnect, with as much as 75% of emerging flux reconnecting to external fields, depending on the orientation of the overlying field. FOCUS: small, bipolar emergence associated with Xray Bright Points, Jets, etc. [eg Karpen#100.43, Fang#100.102]

See [Tarr & Longcope, 2012, ApJ 749] and [Tarr, Longcope, & Millhouse 2013, ApJ 770]



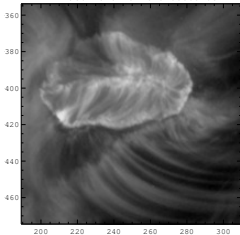
## Key points of the radial field evolution:

- ▶ Emerged positive field complete surrounded by preexisting negative flux in emergence zone: magnetic dome topology
- ▶ Emerged positive flux moves West, negative flux moves South/East
- ▶ Region N2, West of emergence contains *unambiguously preexisting* negative flux

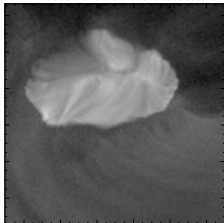


# AIA UV and EUV wavelengths:

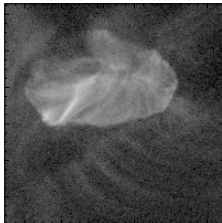
AIA 193: 2010-10-16T04:00:07.84



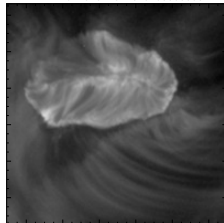
AIA 335: 2010-10-16T04:00:03.62



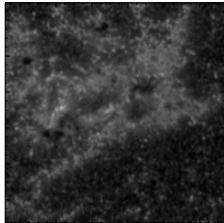
AIA 94: 2010-10-16T04:00:02.12



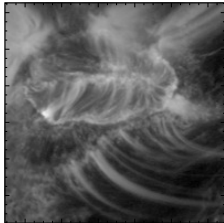
AIA 211: 2010-10-16T04:00:00.62



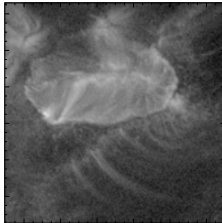
AIA 1600: 2010-10-16T03:59:53.12



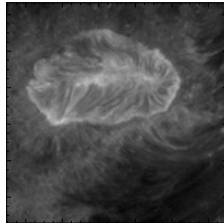
AIA 171: 2010-10-16T04:00:12.34



AIA 131: 2010-10-16T04:00:09.62

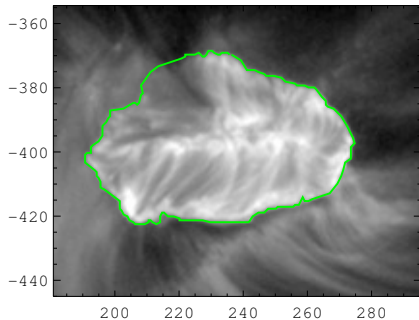


AIA 304: 2010-10-16T04:00:08.12

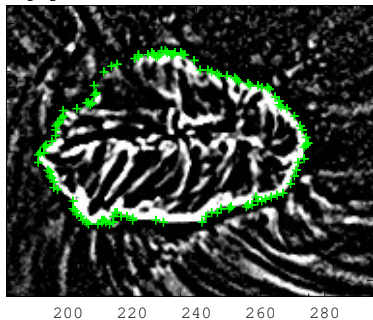


## “By eye” determination of boundary at each point:

AIA211: 2010-10-16 03:00



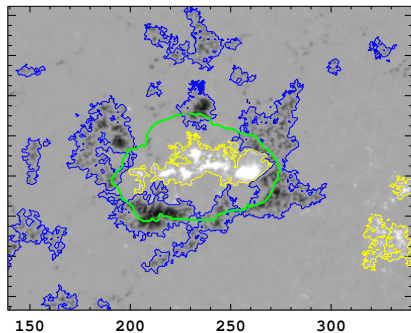
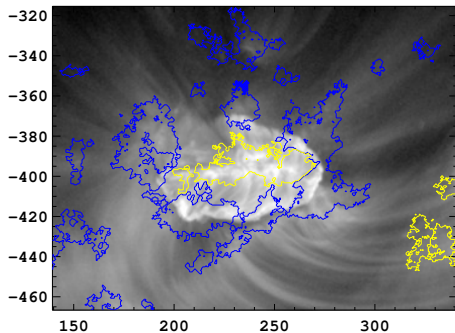
Highpass filter (Gaussian PSF)



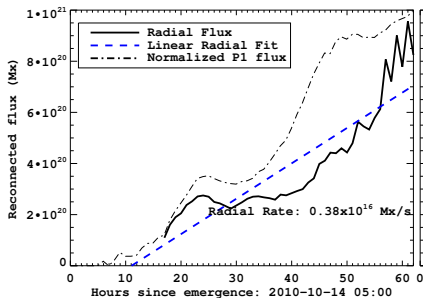
- ▶ Boundary defined by “Dark Band” - Scott et al 2013 ApJ 765
- ▶ “Procedure” performed at every timestep at a 1 hour cadence
- ▶ Should really automate to reduce hand fatigue, and also apply to statistical study the HEK Emerging Flux module.

# Both EUV and Magnetogram together:

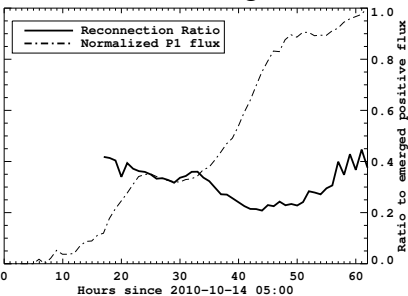
AIA 211 and HMI radial 2010-10-16 03:00



## Intersection of EUV and N2



## Ratio to emerged flux



- ▶ Linear fit:  $0.38 \times 10^{16}$  Mx/s
- ▶ 20 – 40% of emerged flux has reconnected at any given time
- ▶ First measured reconnection flux: 17 hours after emergence
- ▶ First reconnection according to fit: 11 hours after emergence

# Summary

- ▶ Track radial magnetic field over the course of several days
- ▶ Identify a region of unambiguously pre-emergence flux
- ▶ Track the boundary of emerging flux system using EUV data
- ▶ Intersection gives average reconnection rate of  $0.38 \times 10^{16}$  Mx/s for  $\sim 40$  hours.
- ▶ Reconnection lags emergence by  $\sim 12$  hours
- ▶ 40% of emerged flux eventually reconnects with preexisting field