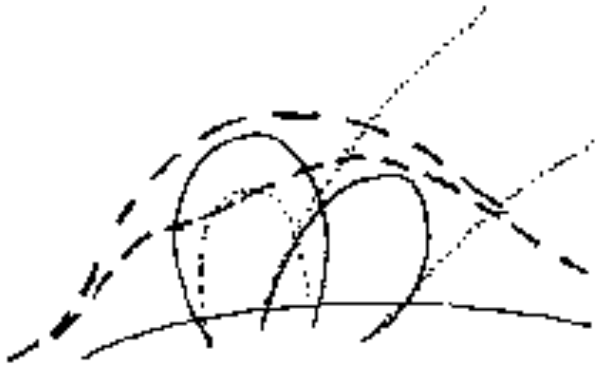
Magnetic Implosions and their Consequences

Hugh Hudson
SSL, UC Berkeley and U. Of Glasgow

The conjecture: a flare or CME must reduce $\int B^2 dV$ *in the coronal half-space. Energy is conserved.*

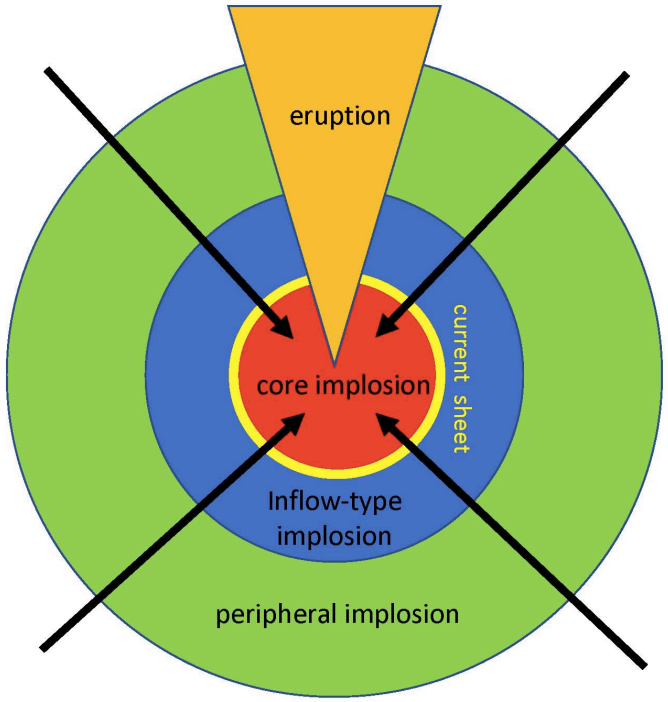
The significance: the geometry and timing of the implosion are observables that can guide us to the nature of the instability.

Key cartoons



Hudson & Cliver2001

- - - Magnetoisobar
…… Magnetic field post
___ Magnetic field prior



Wang Juntao 2018

Theoretical history

ADS search: abstracts (implosion, flare)

- Sakai, J. 1990ESASP.311....7S
- Craig, I. 1991PASAu...9..225C
- McClymont & Craig 1996ApJ...466..487M
- Hudson, H. 2000ApJ...531L..75H
- Spicer, D., 2000 **“So what? That’s in all the plasma physics textbooks!”**
- Janse & Low 2007A&A...472..957J

…

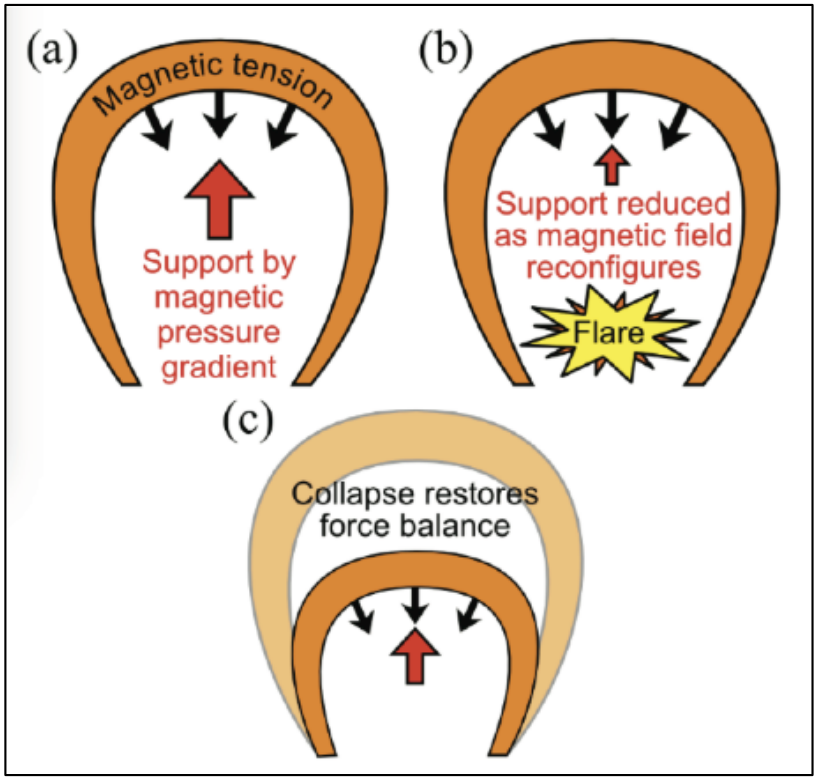
- Barczynski et al. 2019arXiv190405447B

Observational history

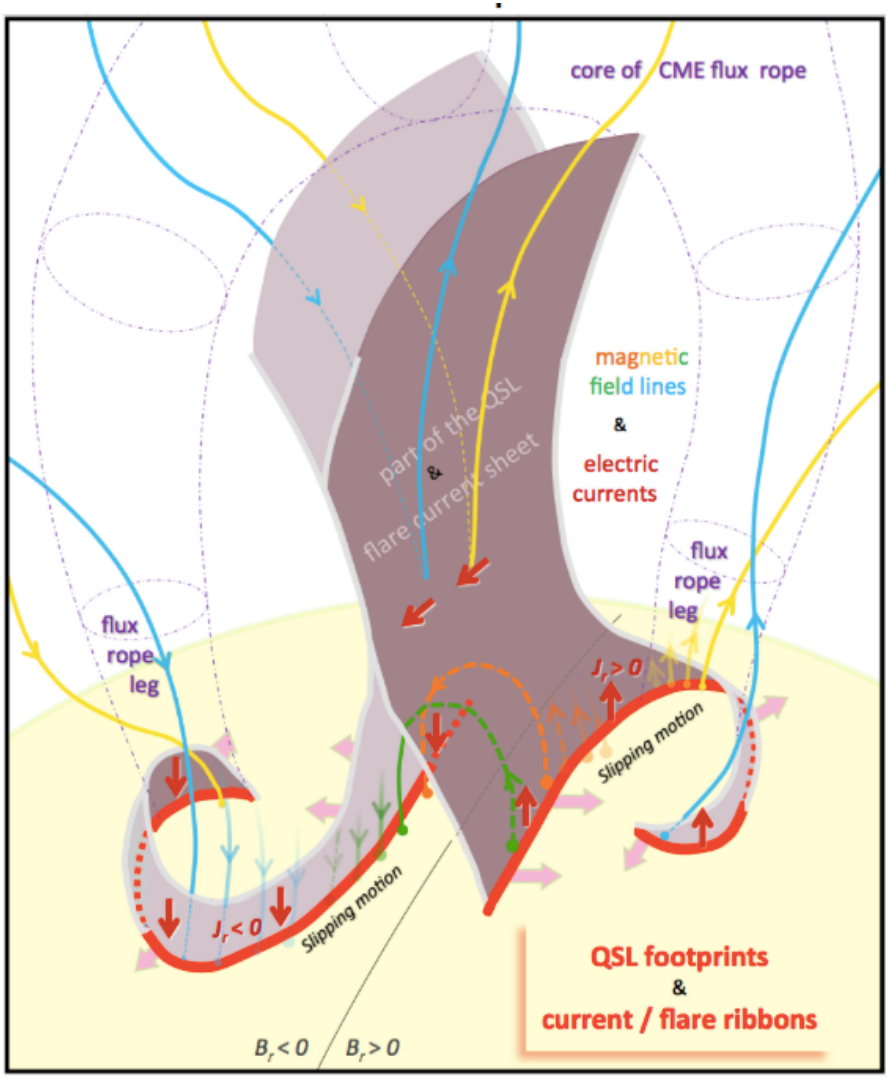
- Liu, R et al. 2009ApJ...696..121L
- Liu, R. & Wang, H. 2009ApJ...703L..23L
- Liu, R. & Wang, H. 2009ApJ...703L..23L
- Ji, H. et al. 2011ASInC...2..213J
- Ji, H et al. 2011ASInC...2..213J
- Sun, X. et al 2011sdmi.confE..63S
- Liu, C. et al. 2012ApJ...745L...4L
- Gosain, S. et al. 2012ApJ...749...85G
- Shen, Y. et al. 2012ApJ...750...12S
- Ji, H. et al. 2012EAS....55..229J
- Simões et al. 2013ApJ...777..152S
- …

- Wang, J. et al. 2018ApJ...859...25W

My new favorite cartoons

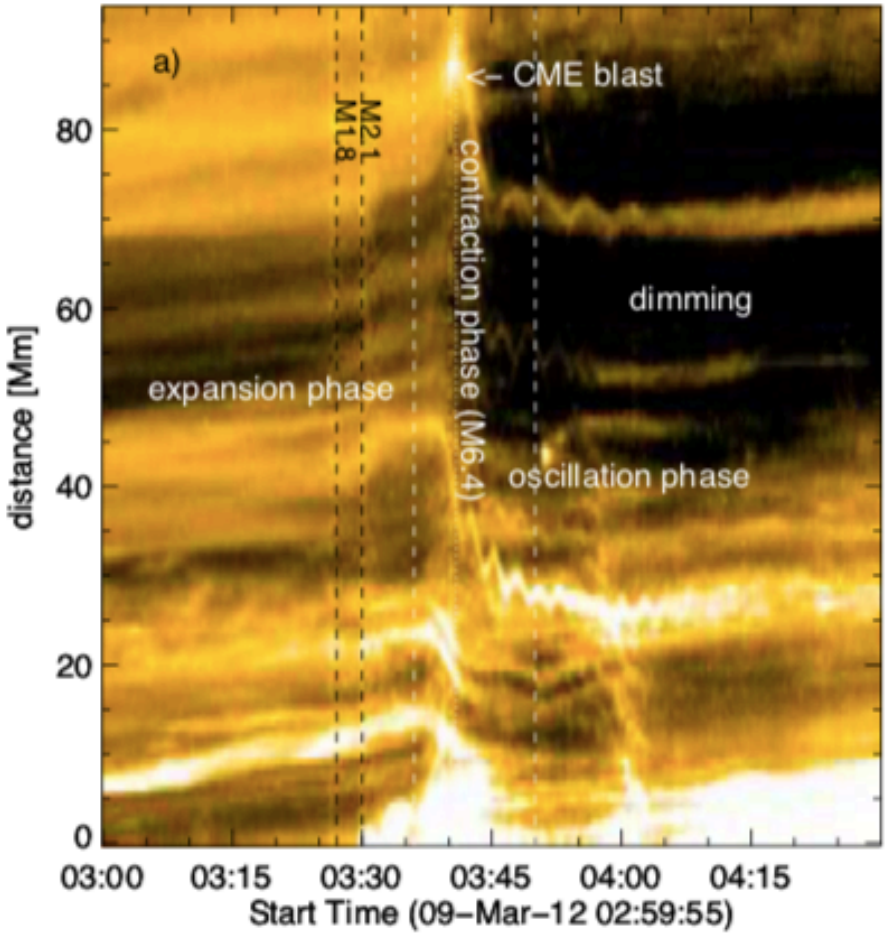


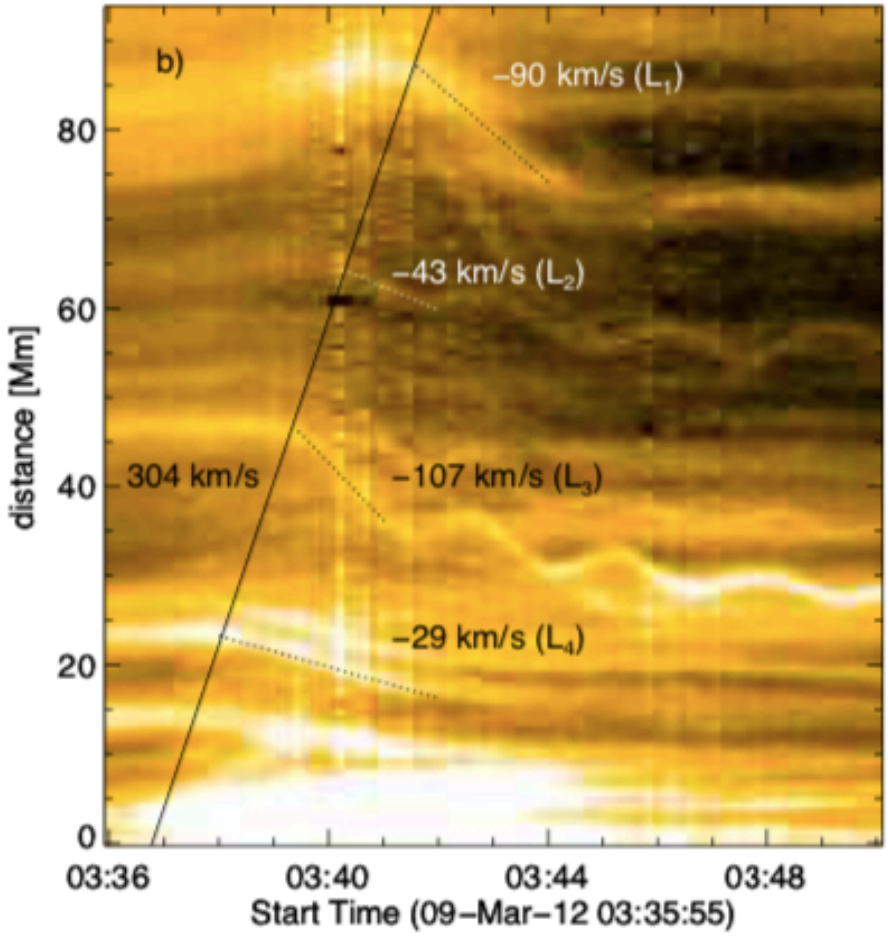
Russell et al. 2015



Janvier et al. 2013

Implosion, QPP, Dimming





Simões et al., 2013

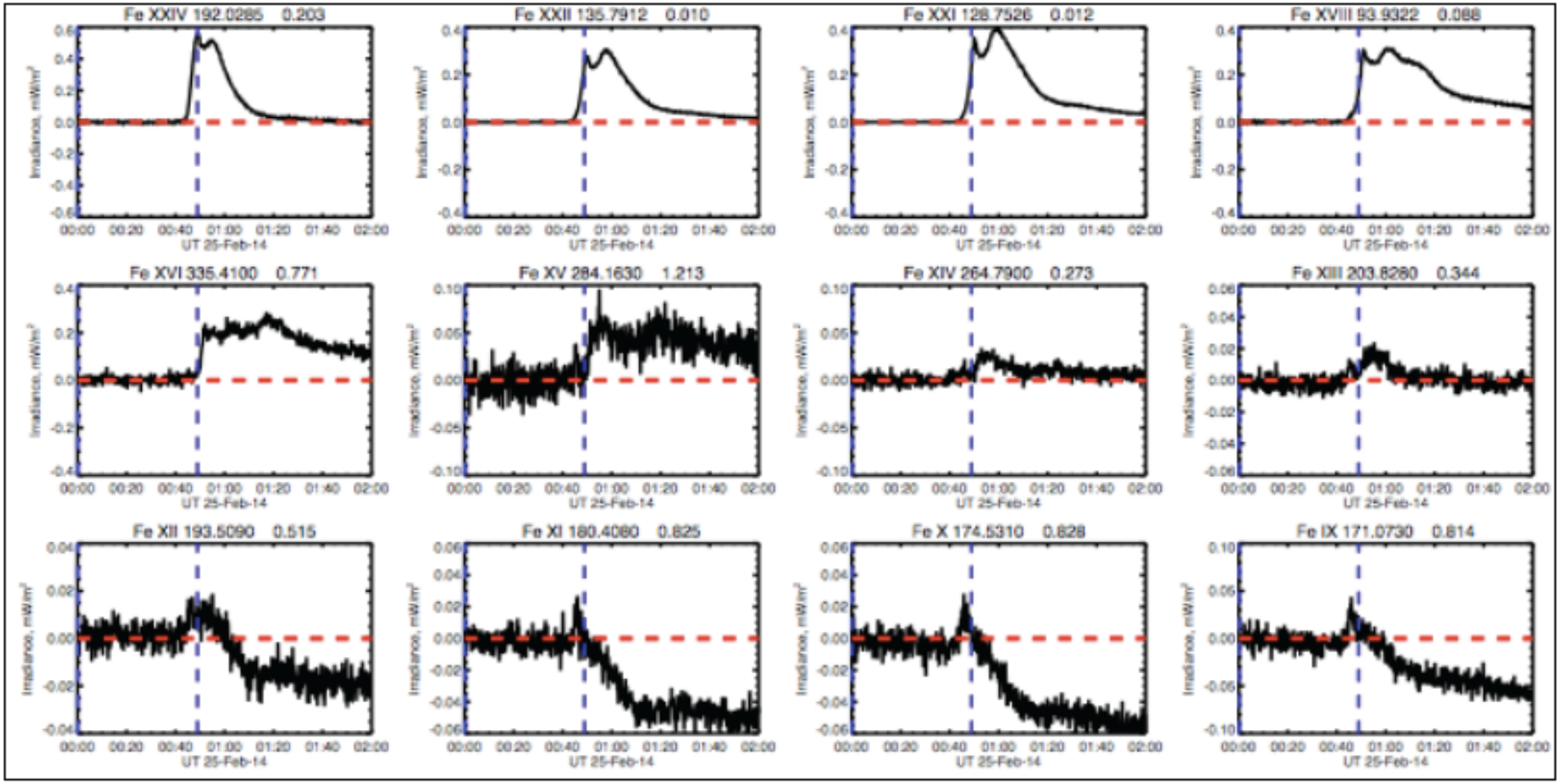
Conclusions

- A process of implosion, reducing $\int B^2 dV$ in the half-space, must supply the flare/CME energy on short time scales.
- Implosion is more fundamental than reconnection, and can be a driver.
- There are broad implications of the physical restructuring.
- Observationally it is tricky, probably because it is a process in 3 dimensions and we don't really know what the actual plasma instability is.

Challenges

- Observational: Can we detect implosions in non-eruptive flares?
- Theoretical: Does an implosion (ie, energy release) always require global magnetic reconnection?

SDO/EVE Spectroscopic Overview



An "Fe Cascade" plot, SOL2014-02-25

- Dimming (CME)

- Hot coronal sources

- Footpoint sources