



Magnetic configuration & helicity of solar filaments

P. F. Chen

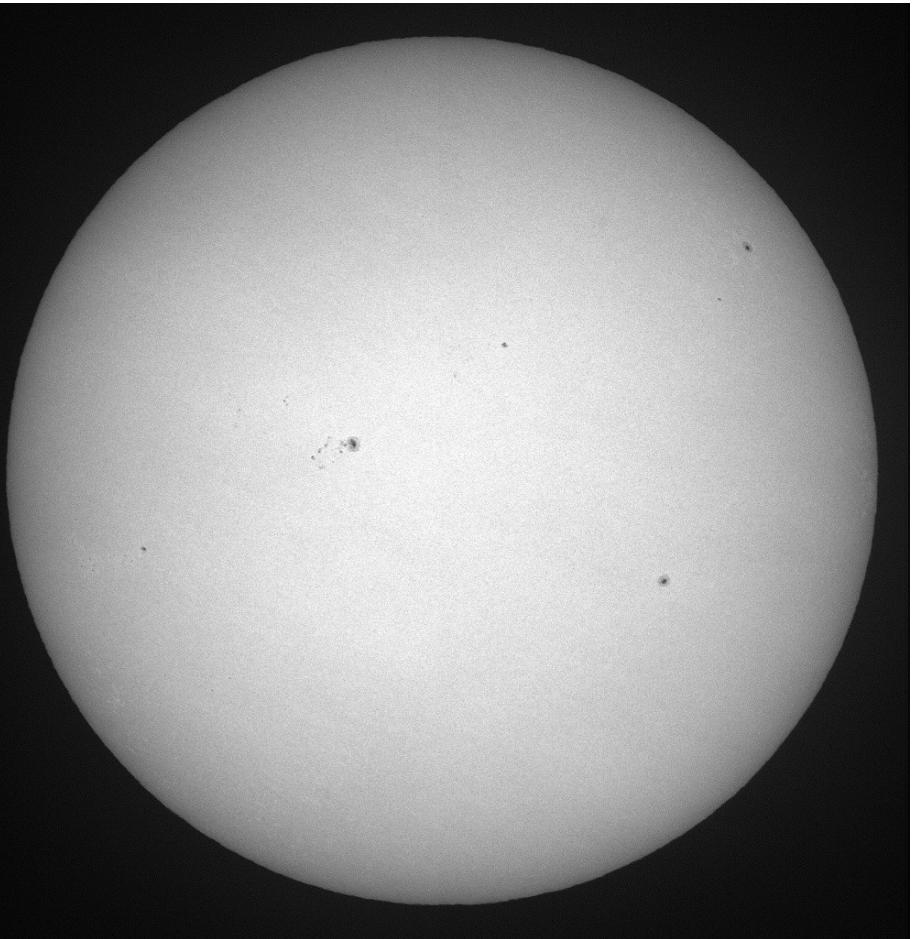
chenpf@nju.edu.cn



NANJING UNIVERSITY , Chin



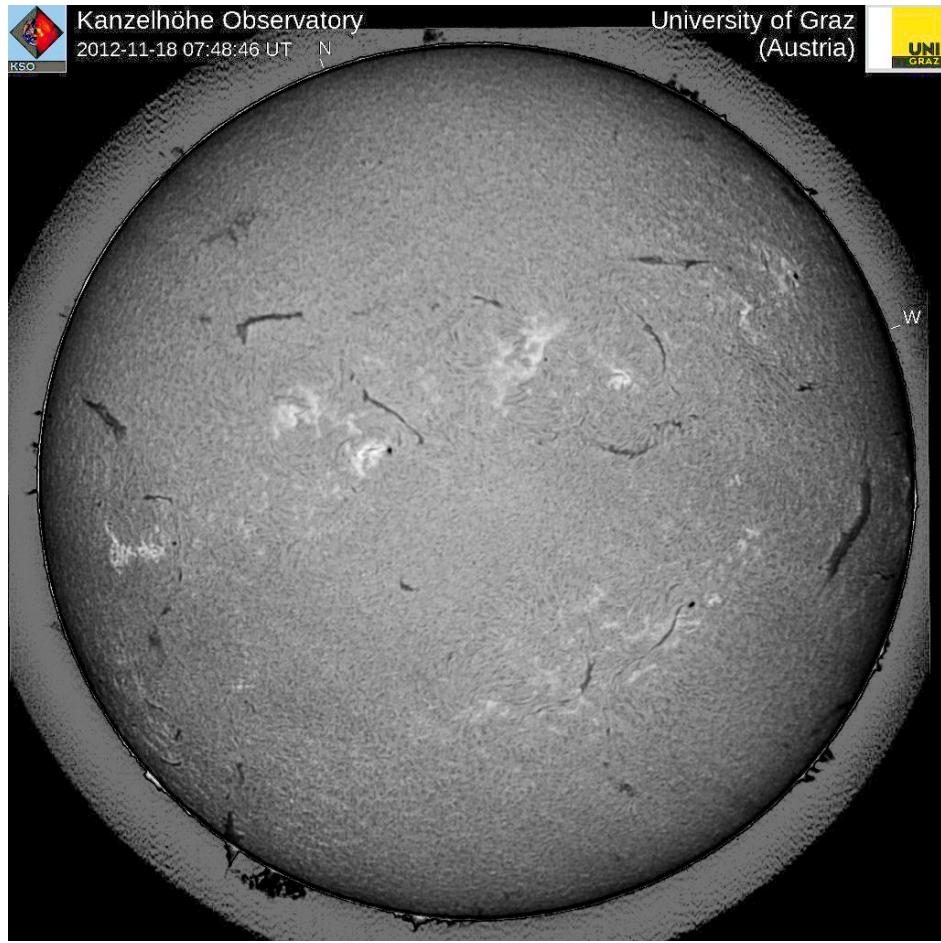
White light



H α



Kanzelhöhe Observatory
2012-11-18 07:48:46 UT N

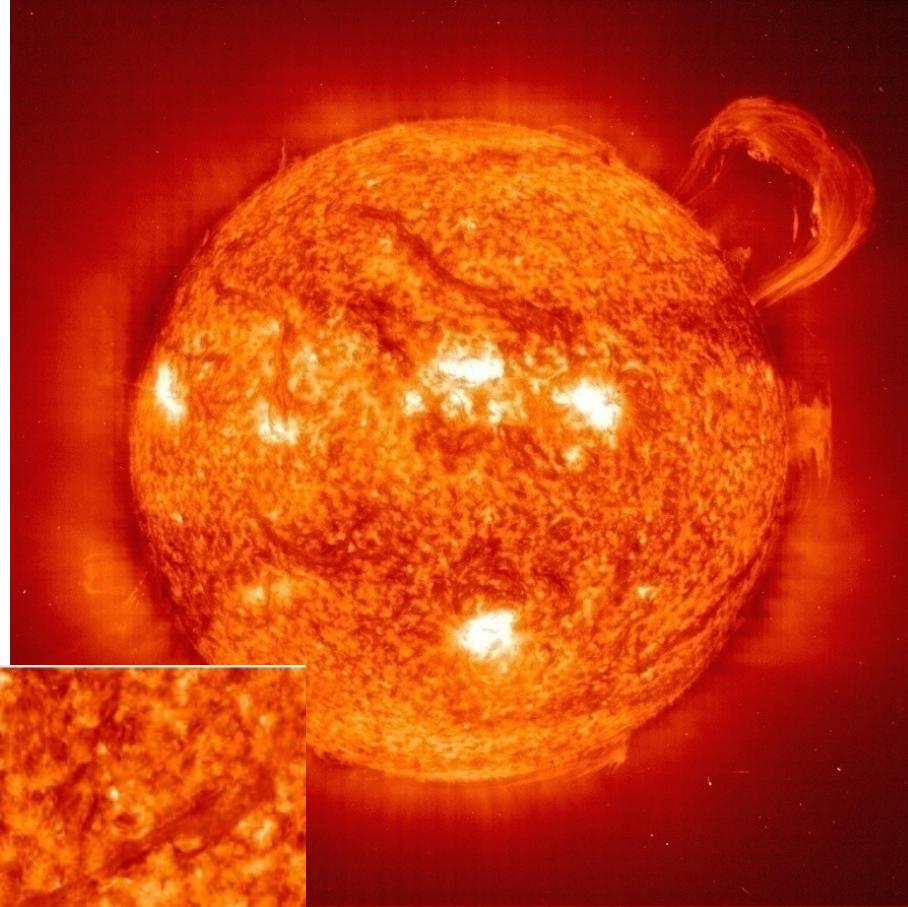
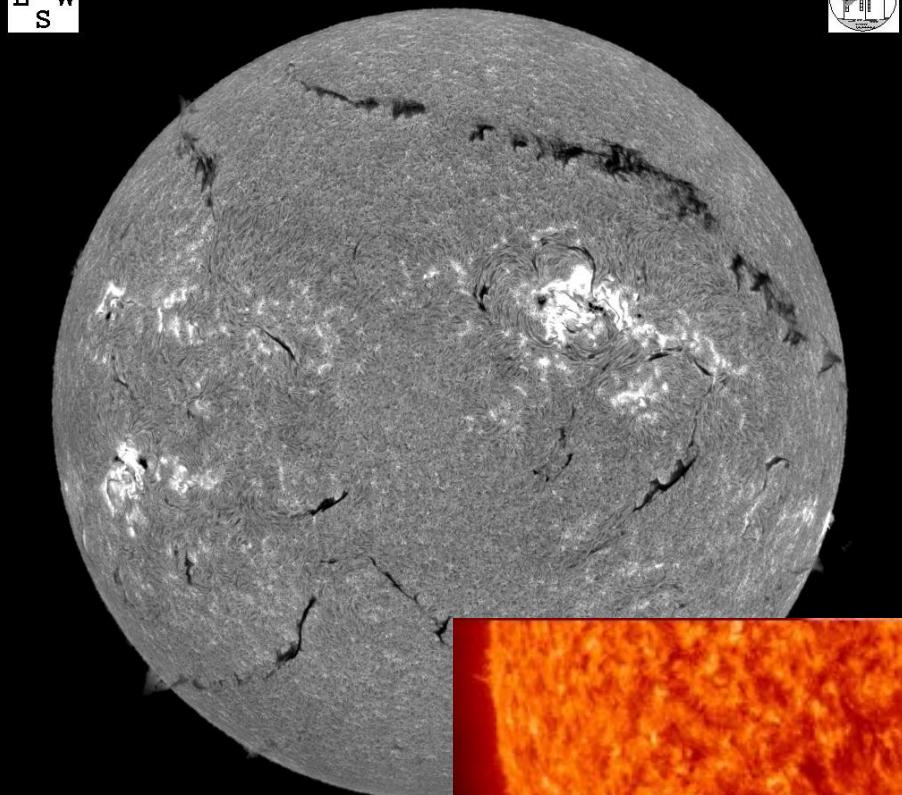


University of Graz
(Austria)

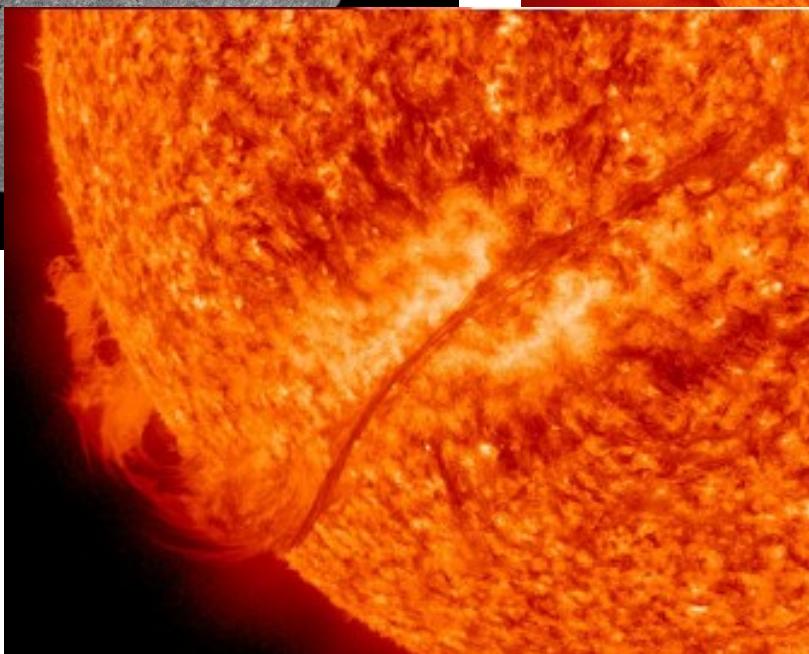


2012.11.18

N
E
W
S

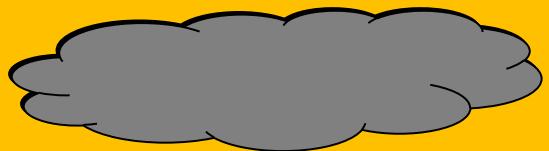


Filament



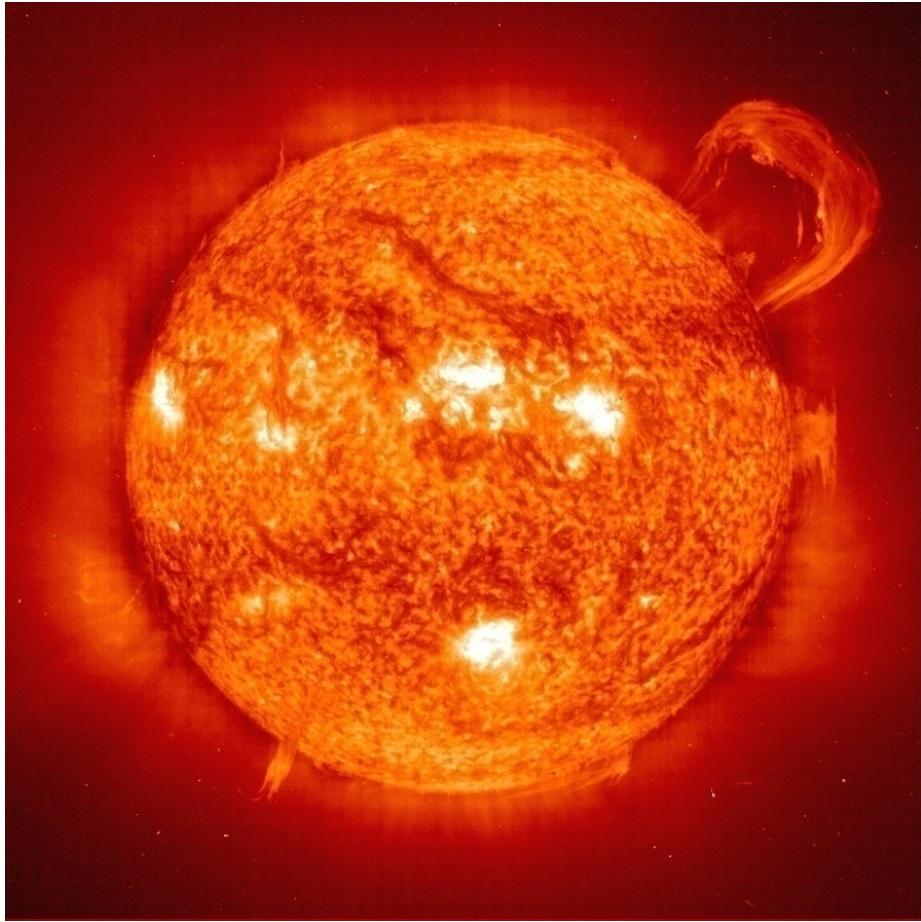
Prominence

Corona



Chromosphere

Photosphere

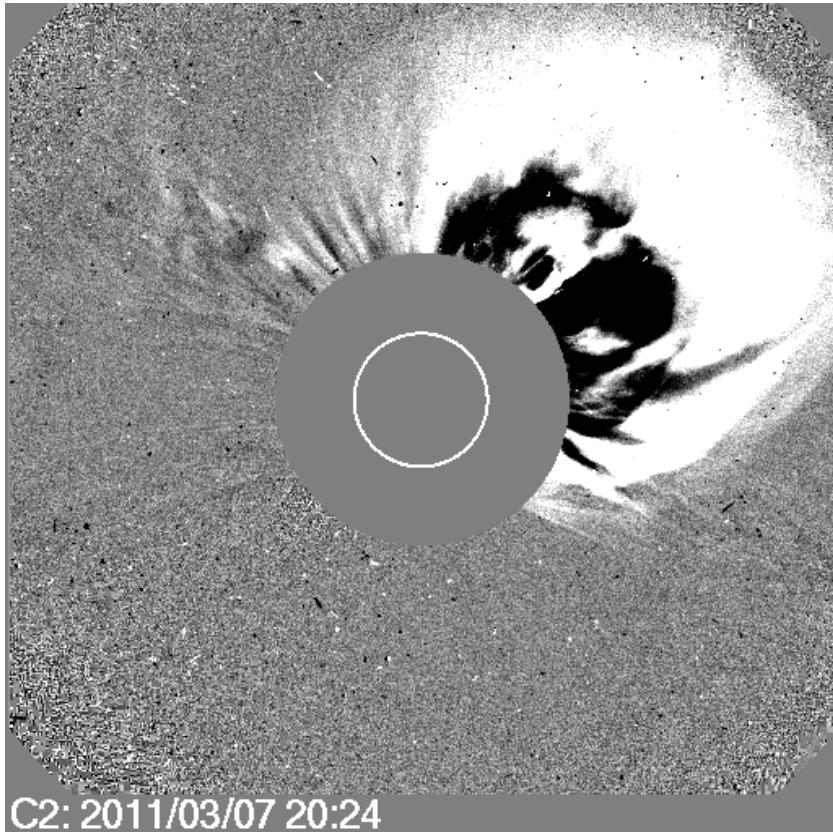


T : 1/100 of T_{corona}

ρ : 100 ρ_{corona}



Img_SDO_AIA_4_304_2011-03-07T19:32:20.12



Chen et al. (2014)
Filament is the core of CME research

Fundamental Issues

1. Formation Mechanism

2. Dynamics

3. Magnetic Structure &

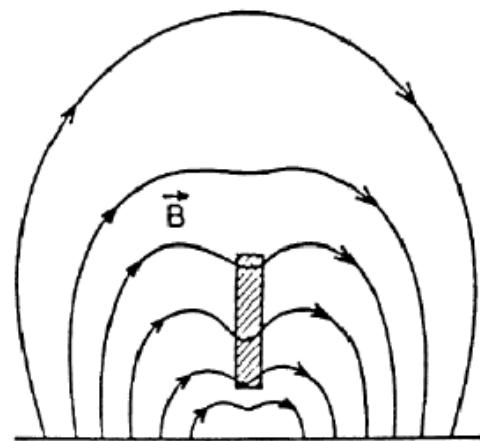
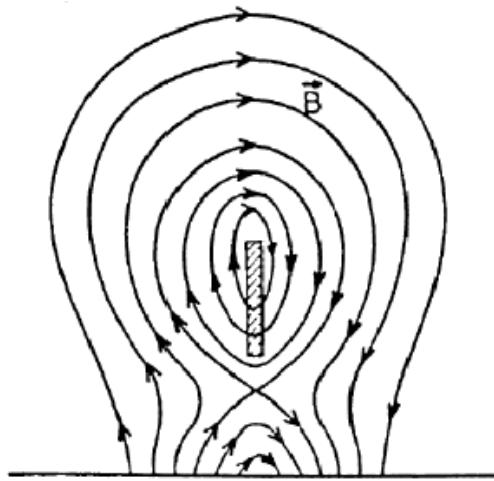
Helicity

4. Mass Maintenance

From birth to death

Inverse polarity

Normal polarity



Kuperus & Raadu (1974)
Low (1996), Aulanier + (1998)

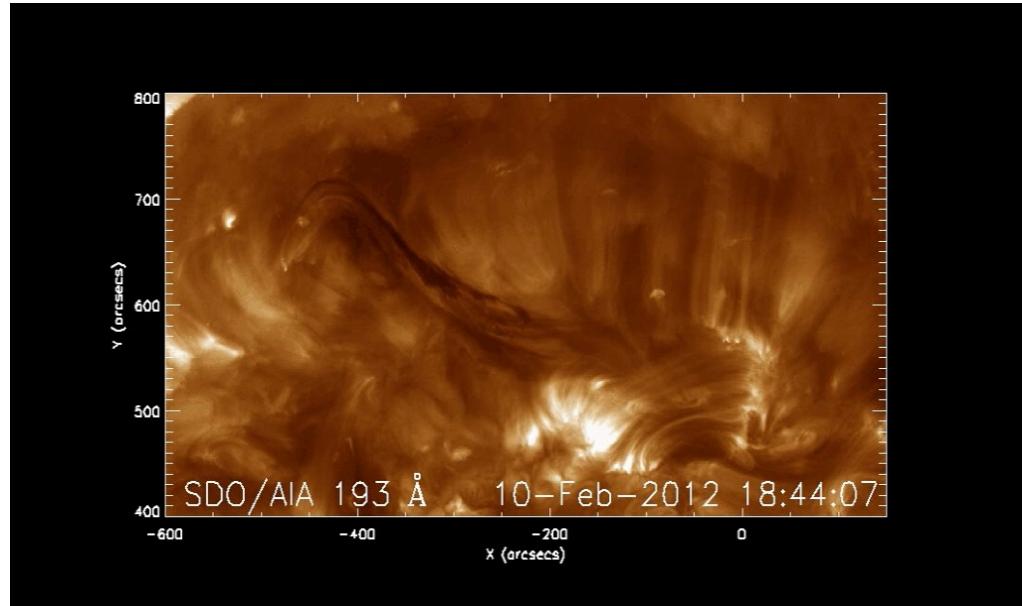
Kippenhahn &
Schluter (1957)

Flux rope

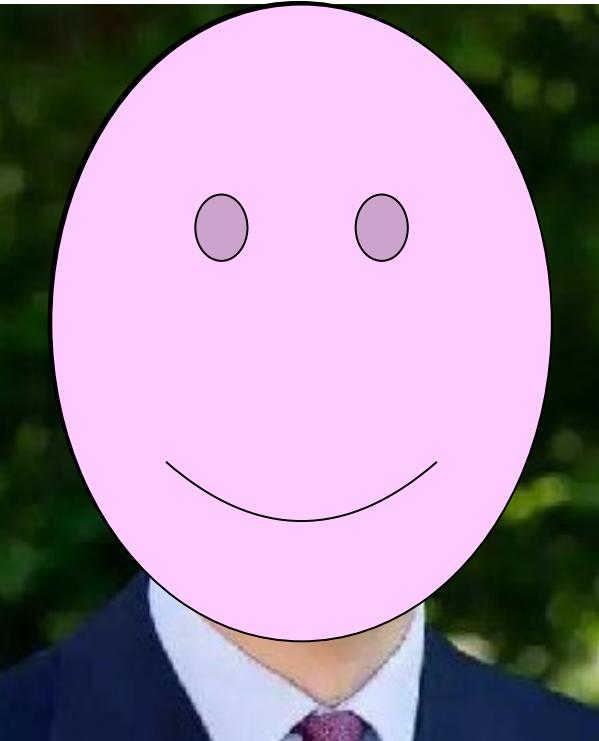
Sheared arcade

Rust (1967), Leory, Bommier (1989, 1994, 1998)

Can we distinguish between a flux rope and a sheared arcade based on images?

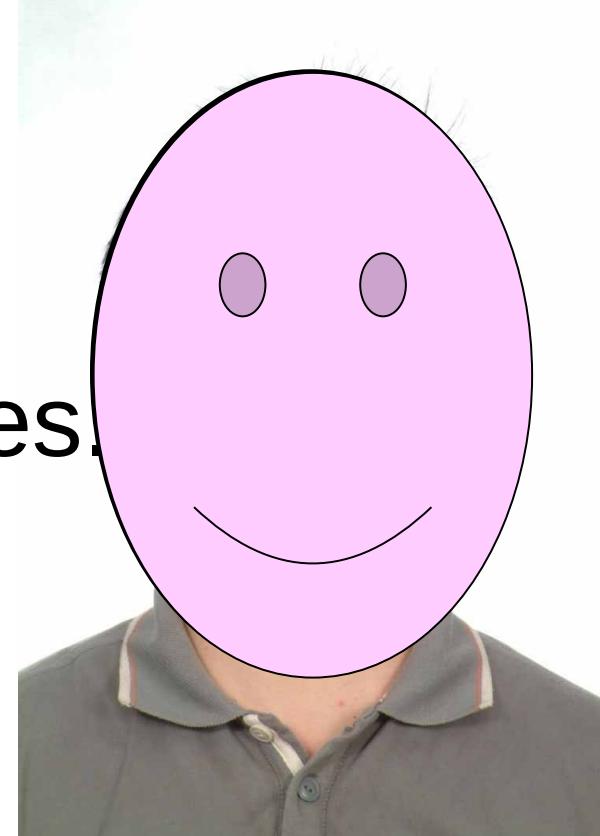


Can we distinguish between
a British and a Chinese
based on images?



Yes!

Look at the faces.



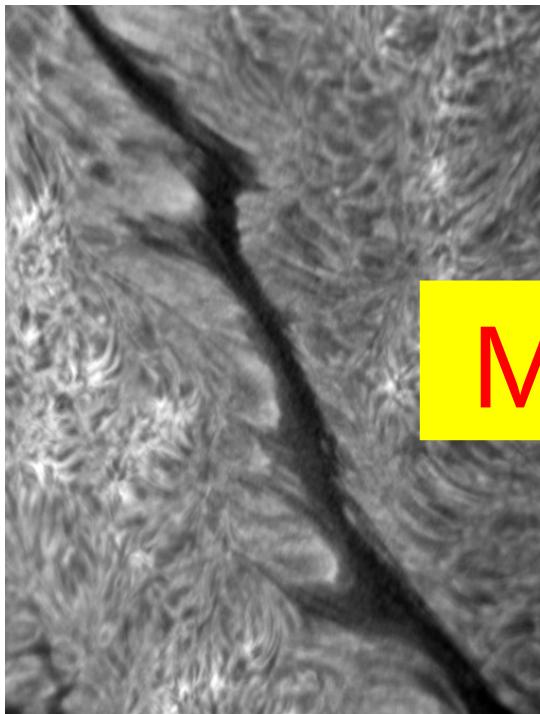
Can we distinguish between
a flux rope and a sheared arcade
based on images?

Yes!

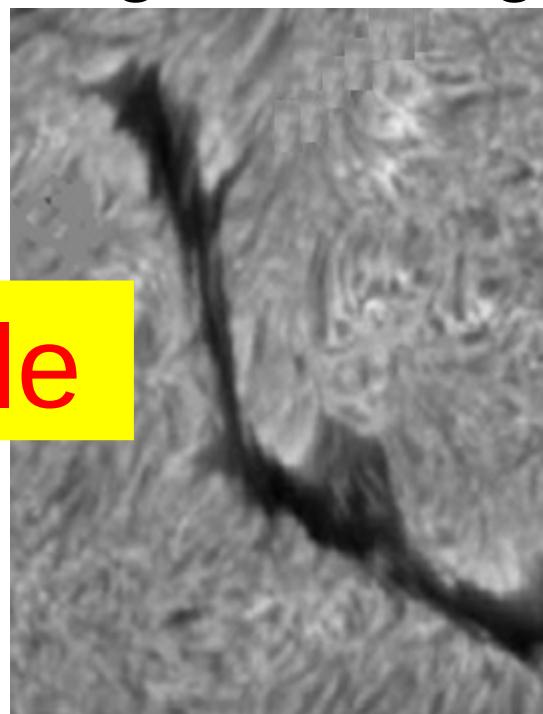
Look at the filaments.



Left bearing



Right bearing



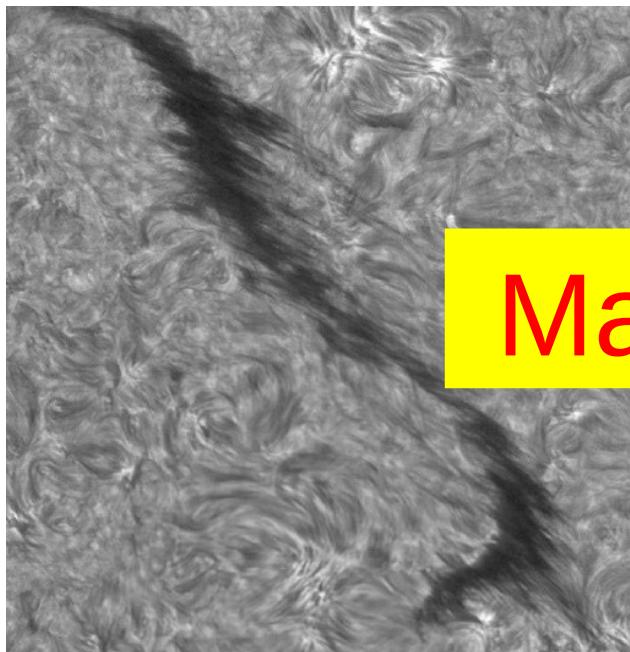
Martin's Rule

+ helicity

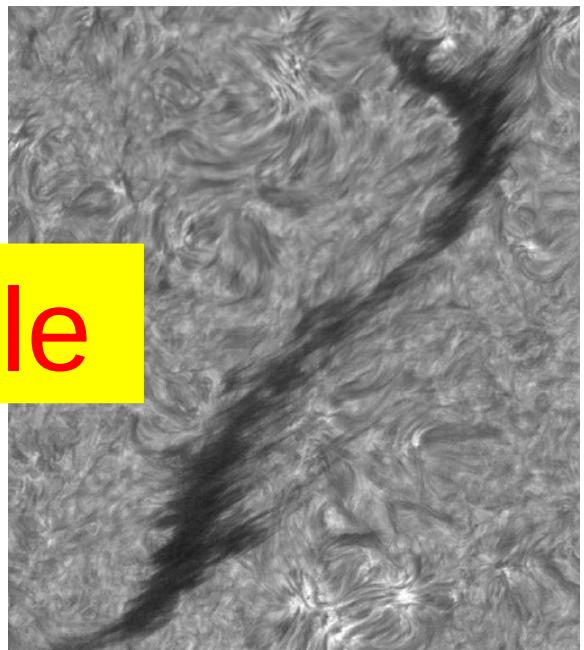
— helicity

Martin (1994)

Left bearing



Right bearing

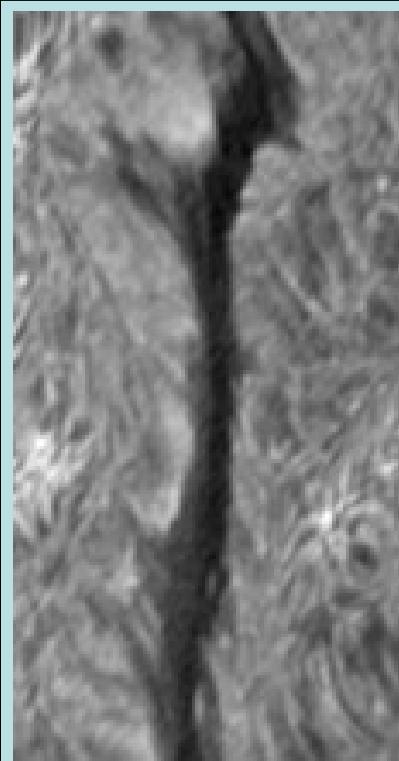


Martin's Rule

+ helicity

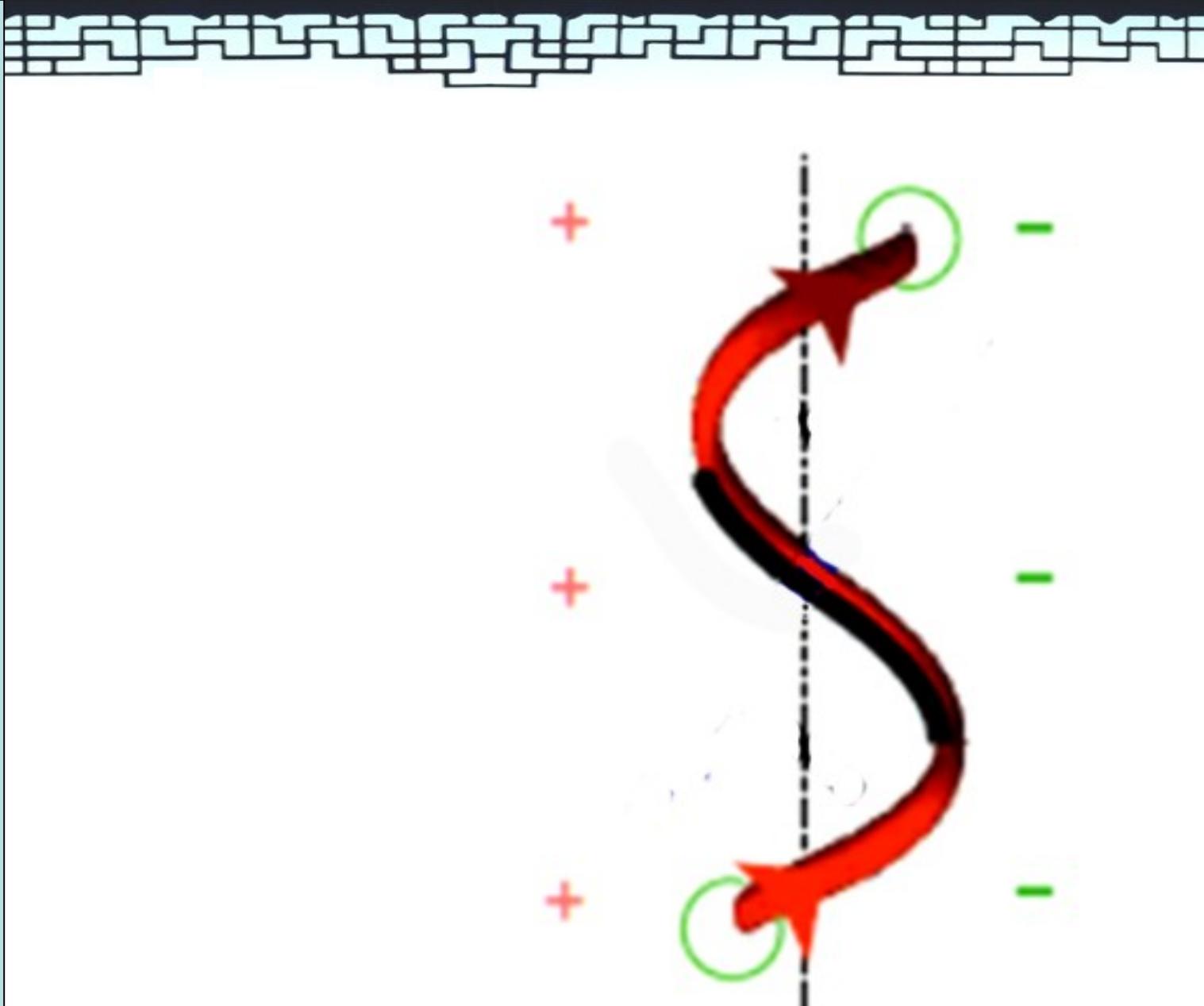
- helicity

Martin (2008)



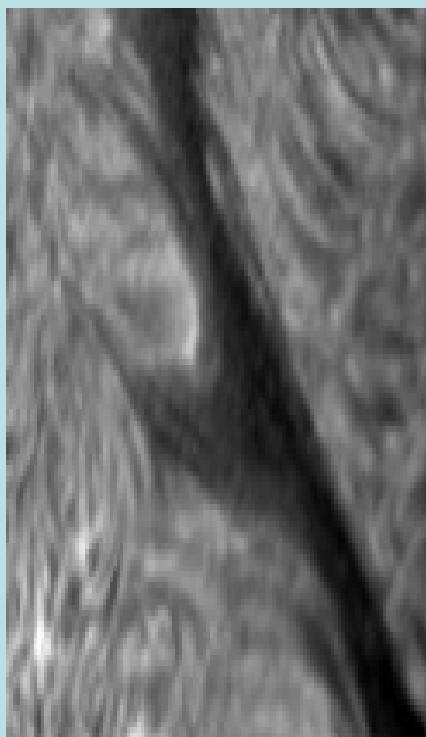
+ helicity

$$H_c = \mathbf{J} \bullet \mathbf{B}$$

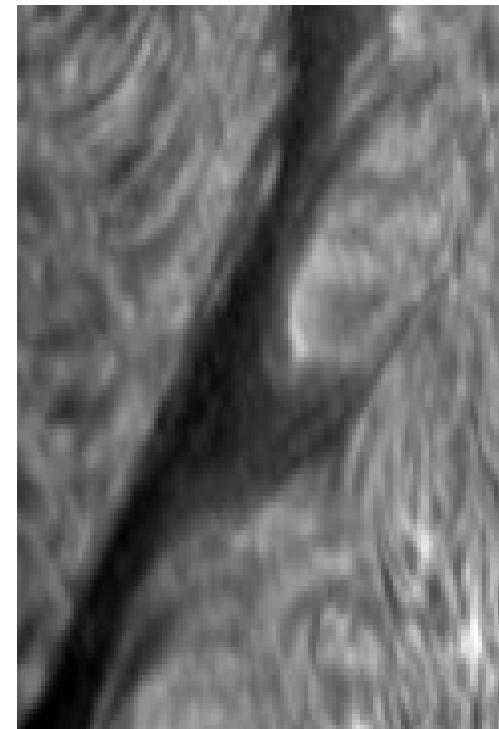


However,

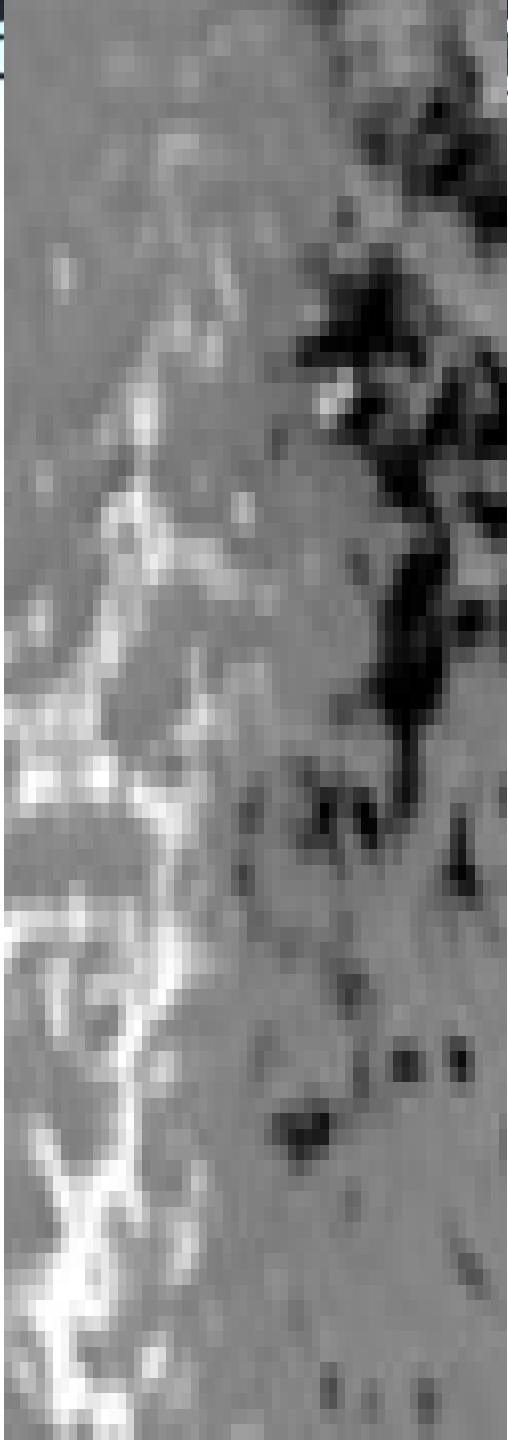
Martin's Rule



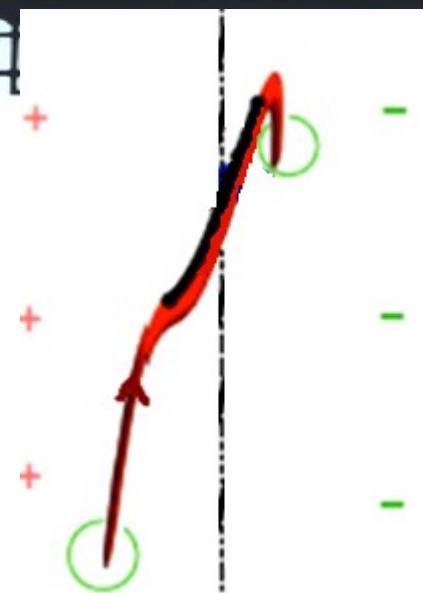
+ helicity



Guo, Y. et al. (2010, ApJ)



Sheared arcade



Flux rope



Bad news:

Martin's rule is not universal!

— helicity

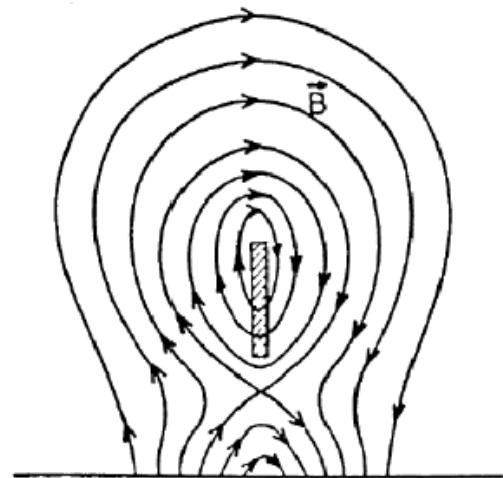


+ helicity

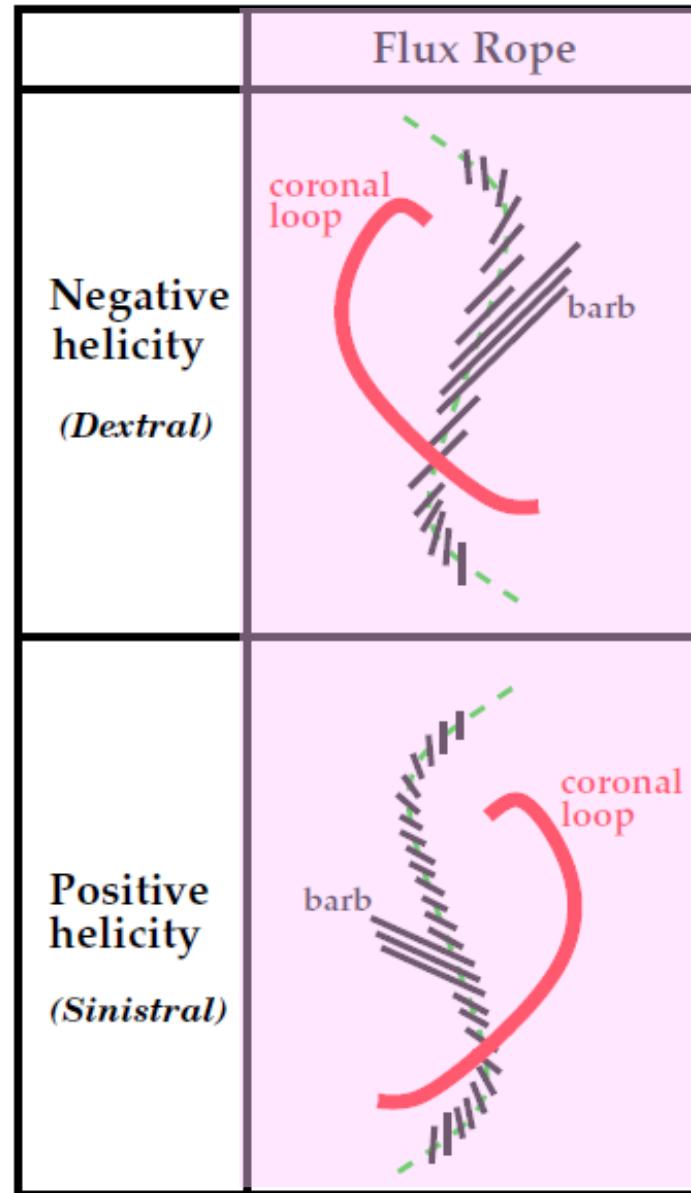


Valid only for

Inverse polarity

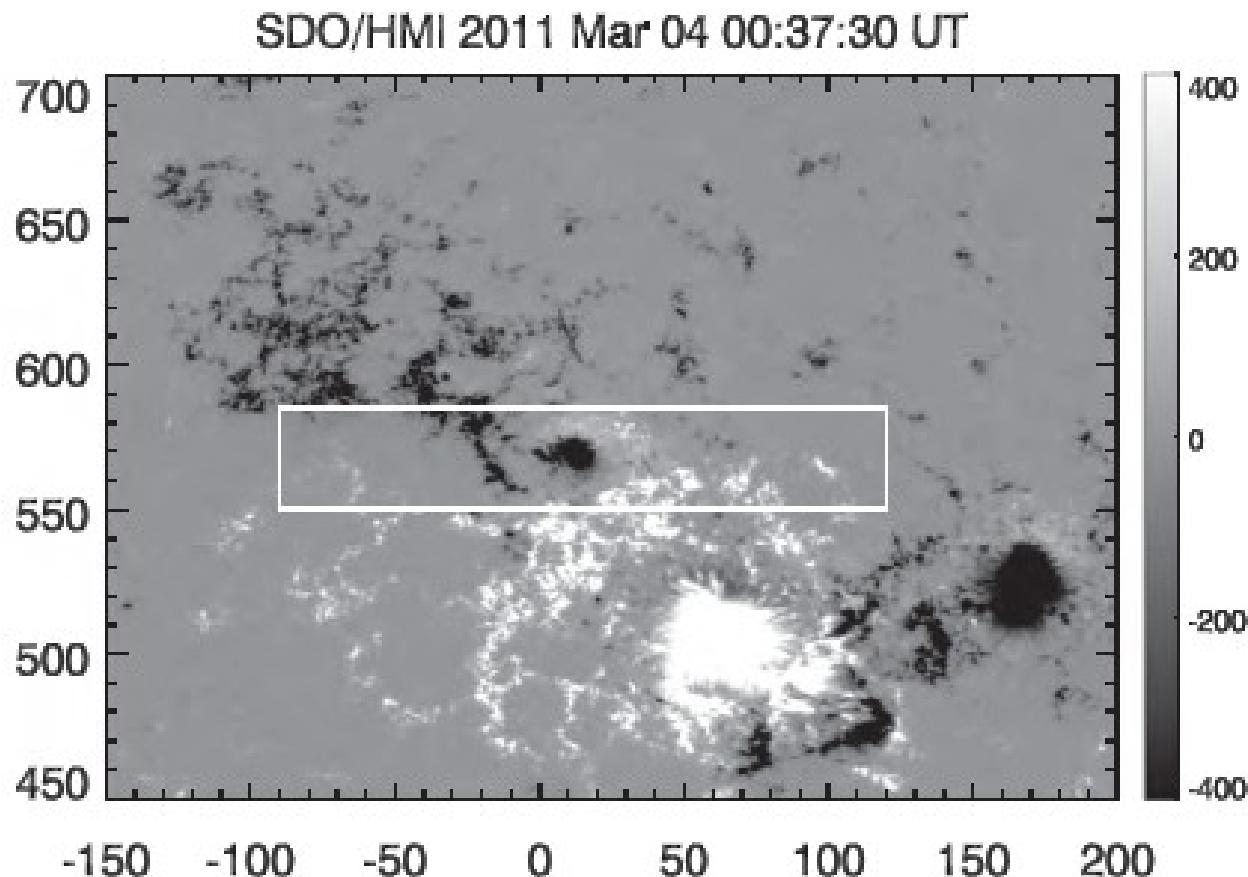


Good news



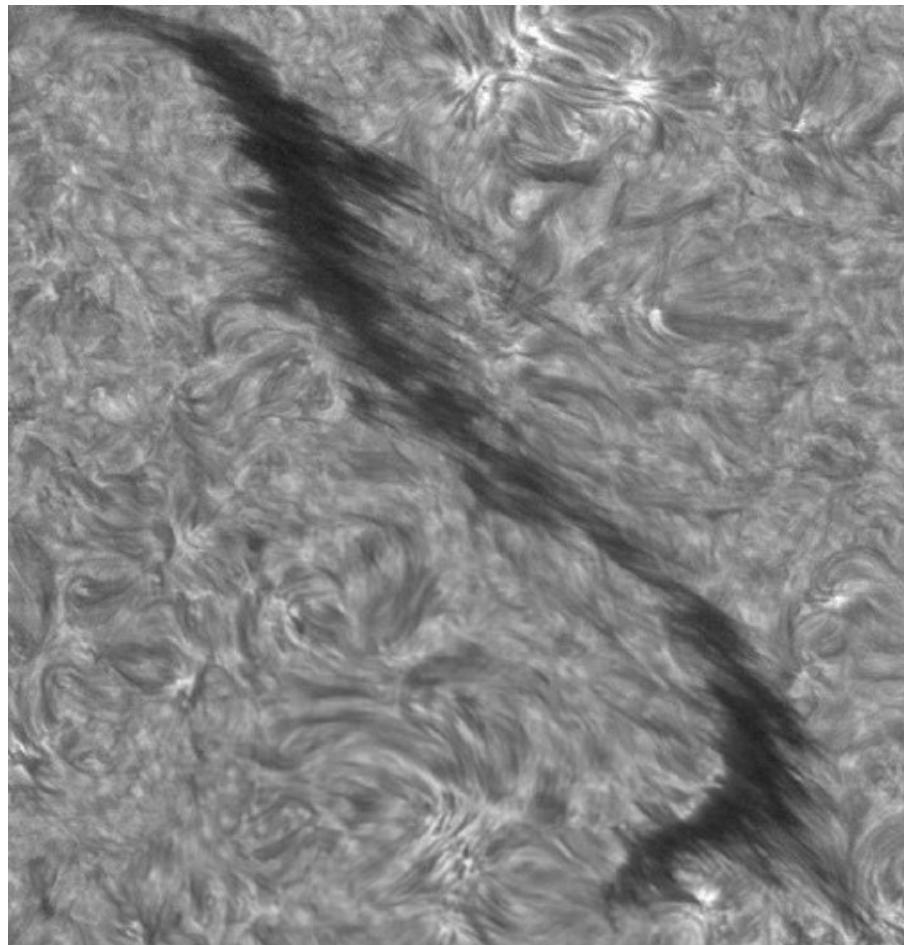
How to do it?

Step 1: Sign of helicity

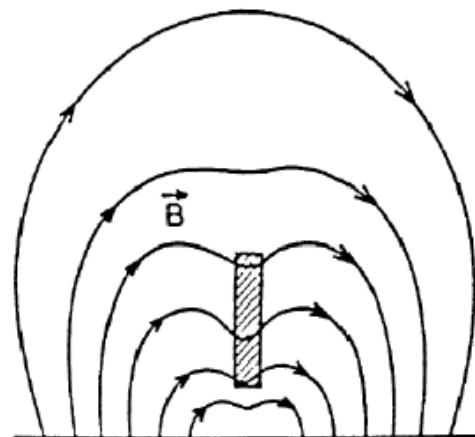
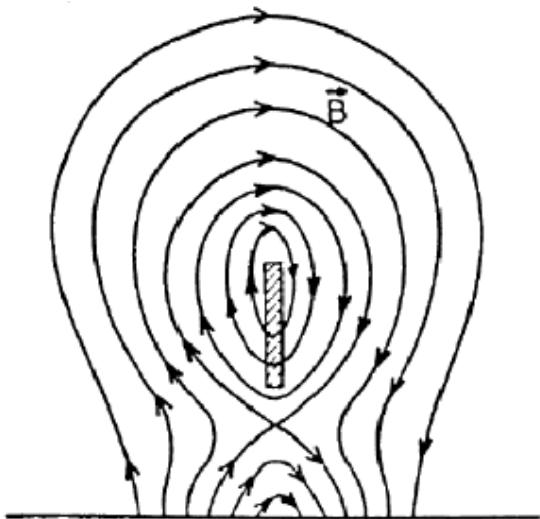


How to do it?

Step 2: Barbs (or filament threads)



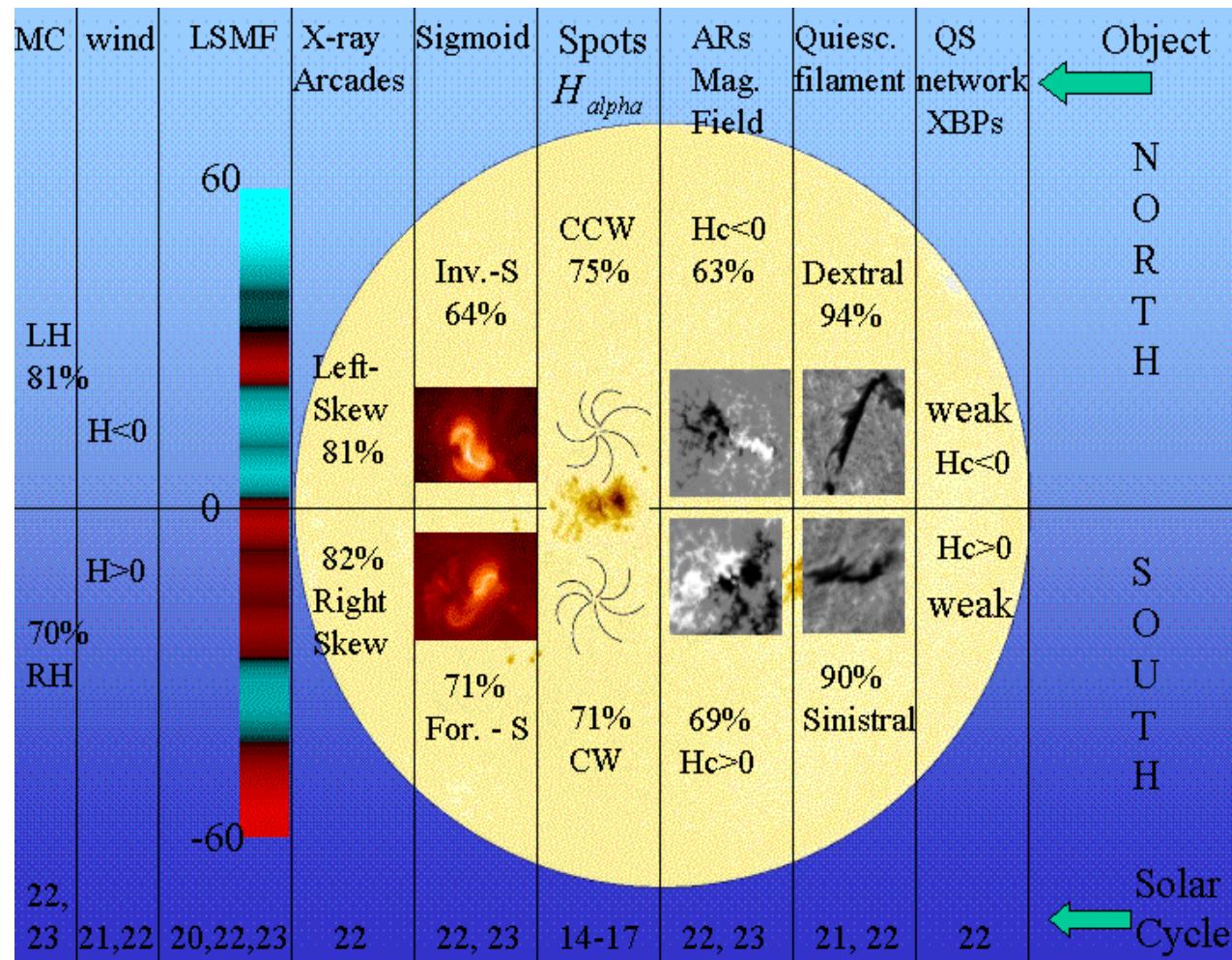
Ouyang et al. (2017, ApJ, 835, 94)



89%

11%

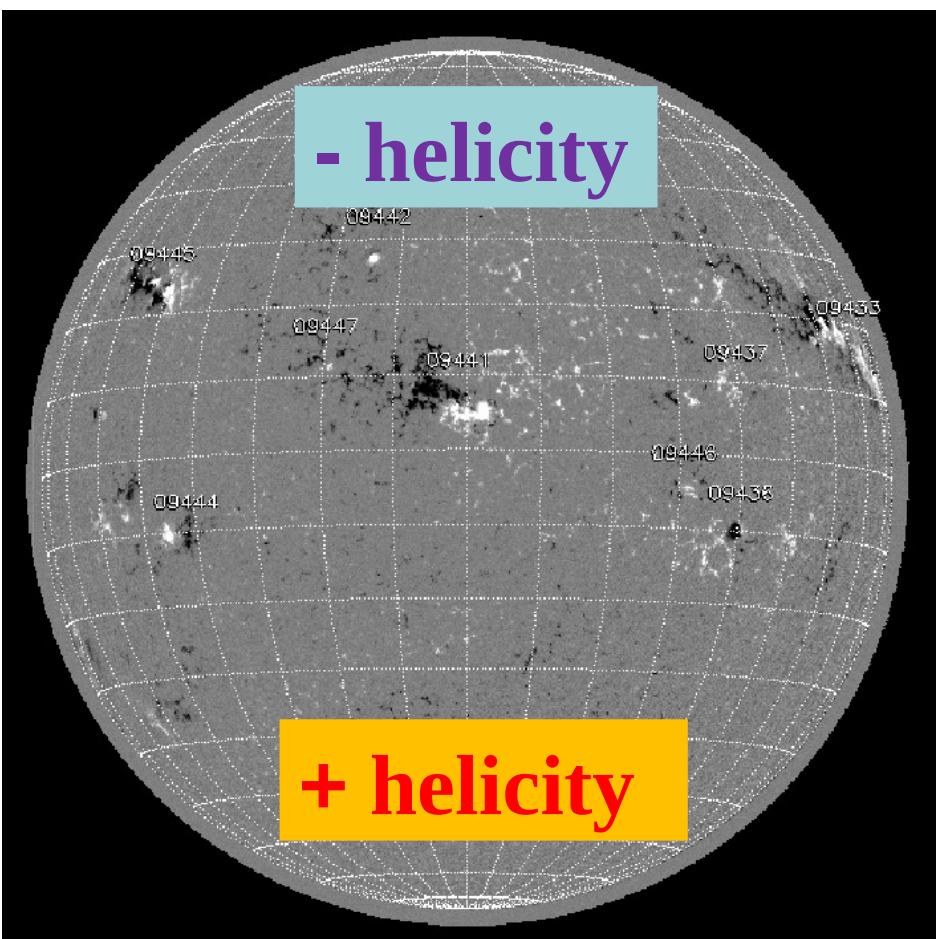
Hemispheric Preference



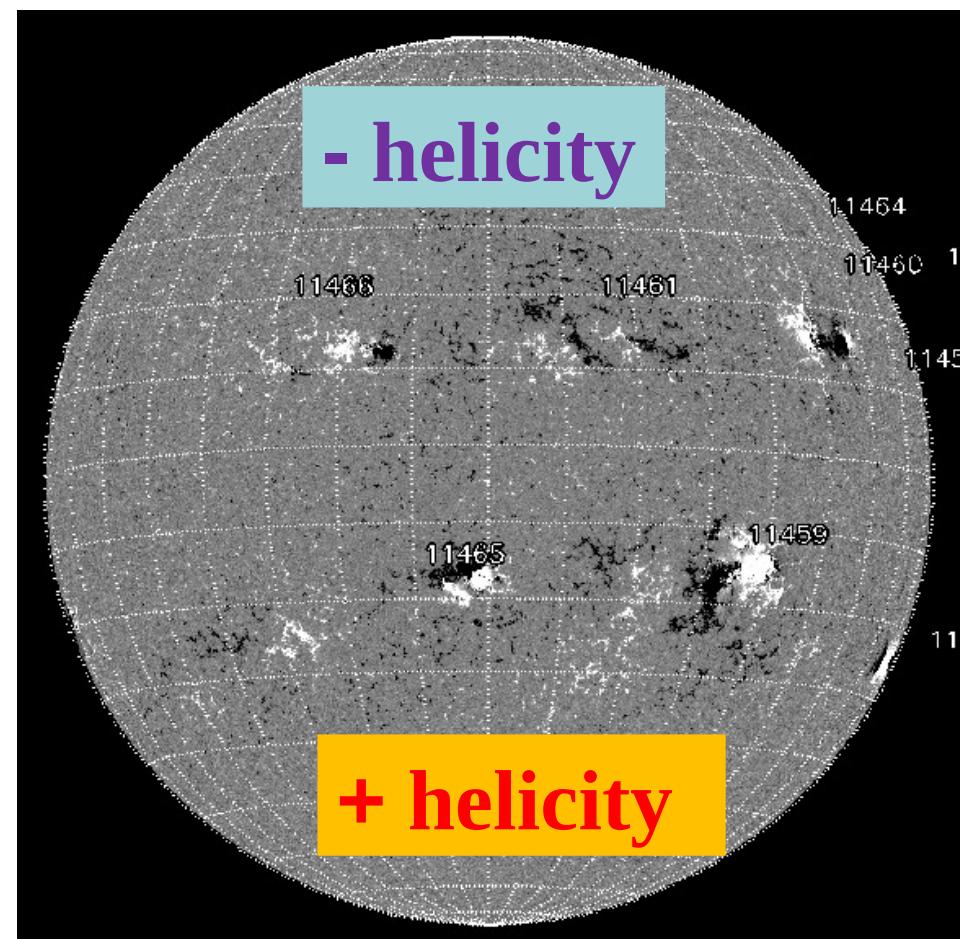
(Image credit: A. Pevtsov)

$$H = J \cdot B$$

current helicity



2001



2013

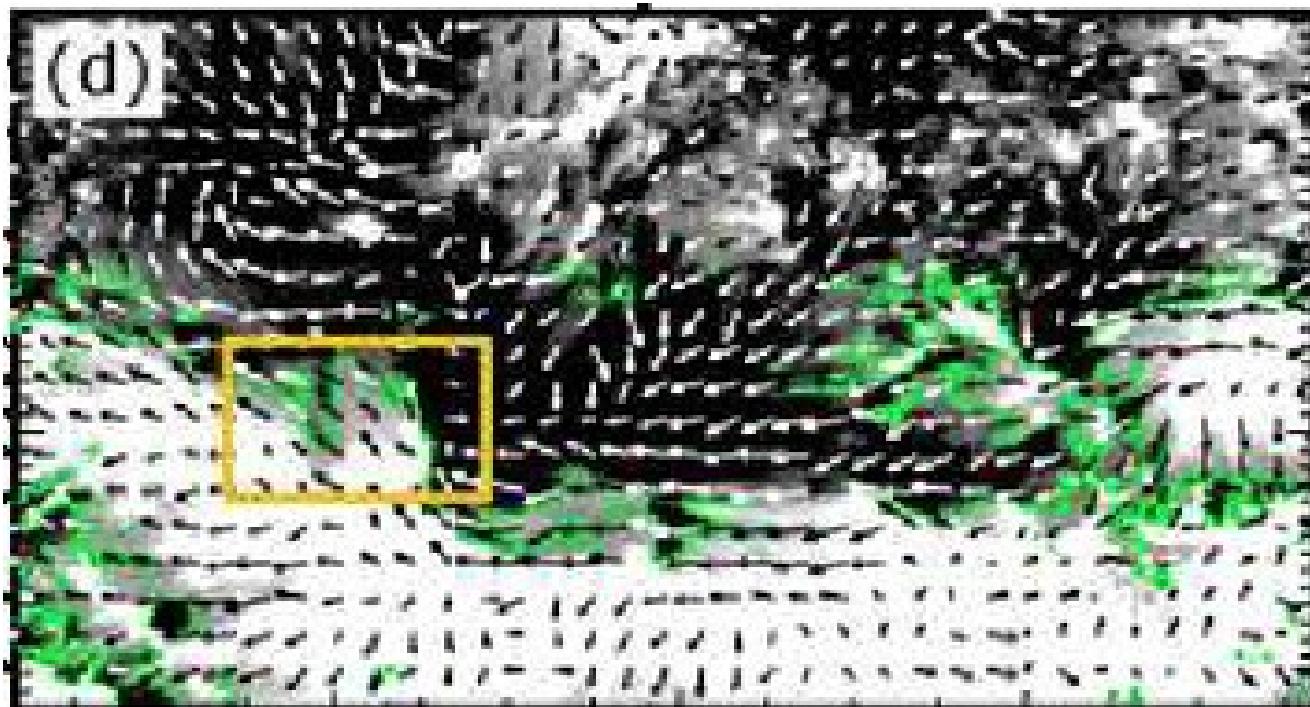


Pevtsov et al. (1995), Abramenko et al. (1997),
Bao & Zhang (1998), Longcope et al. (1998),
Pevtsov et al. (2001), Hagino + (2005), Zhang (2006)

60-82%

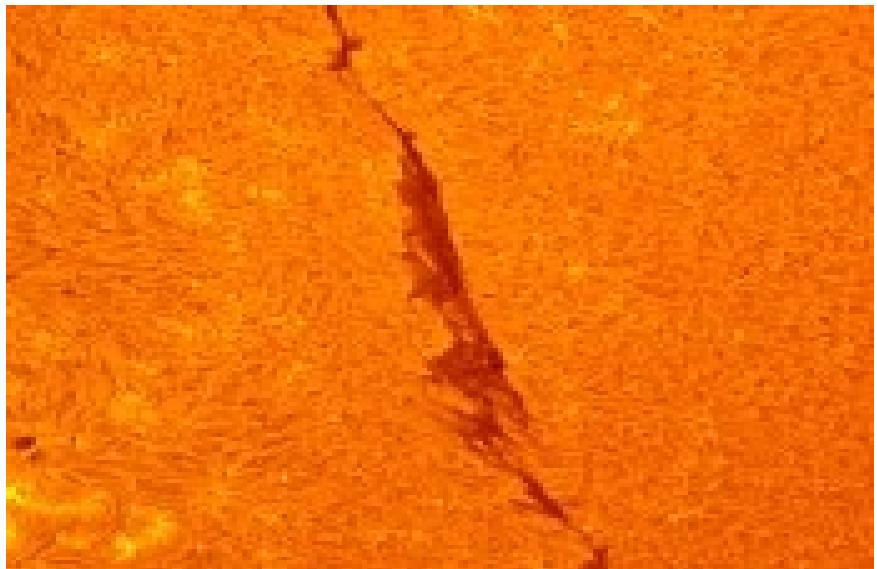
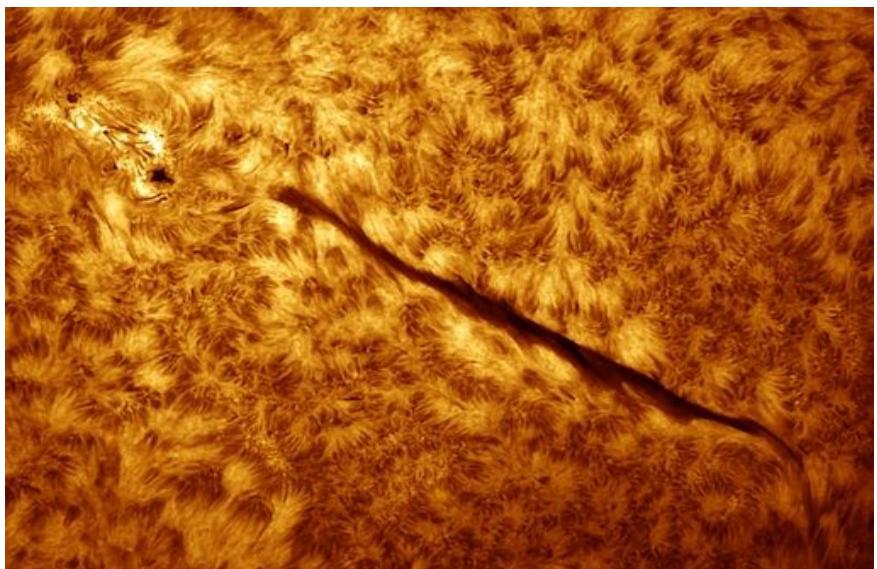
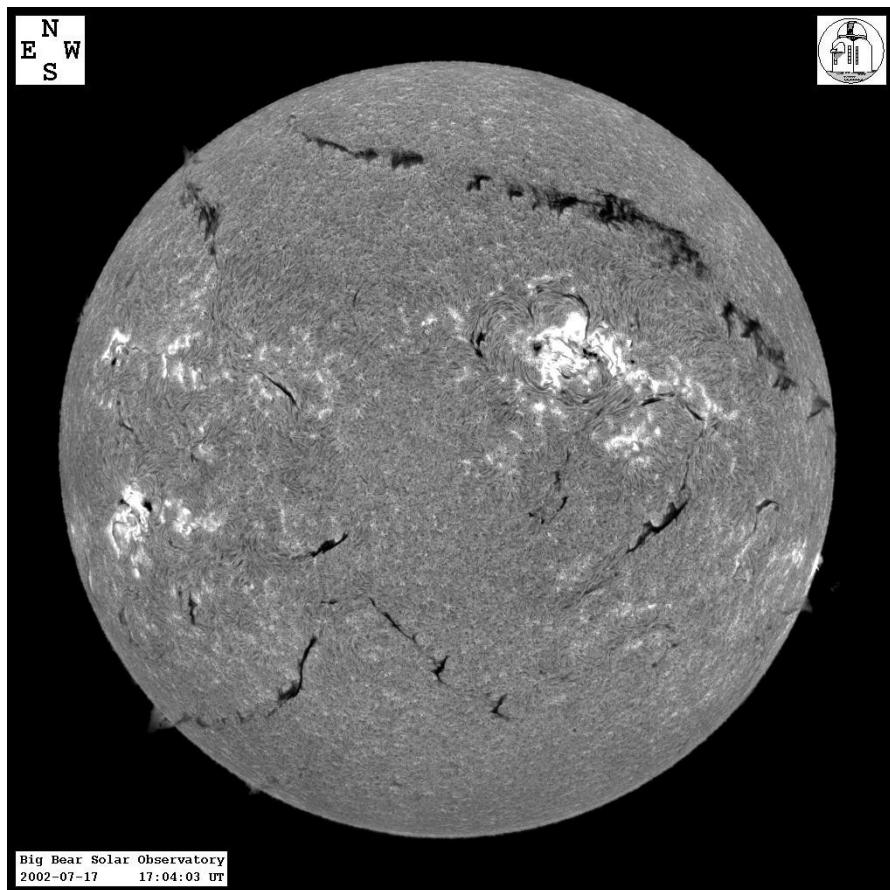
1. Coriolis force

2. Turbulence



1. Size of the sample;
2. Uncertainty of the B measurement

Chirality of Solar Filaments

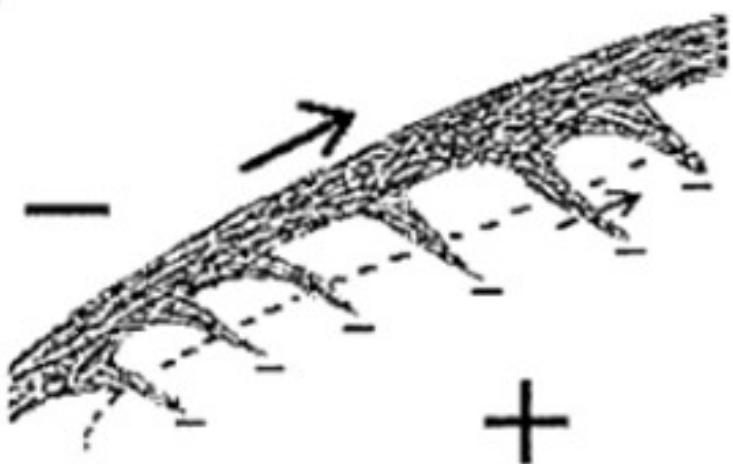


Martin (1994)

Martin's Law

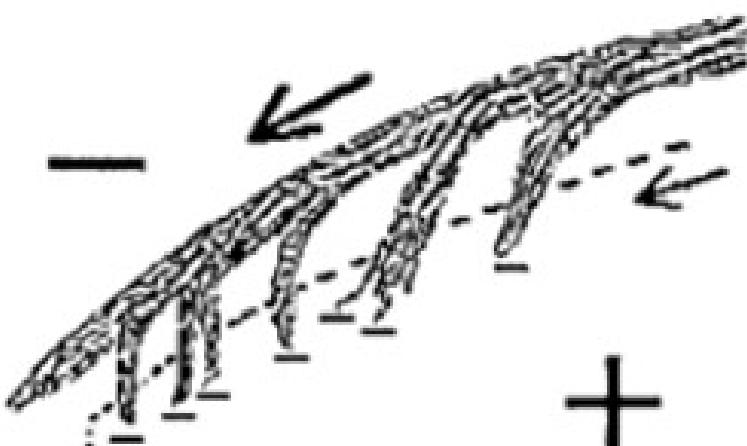
Martin (1999)

— helicity



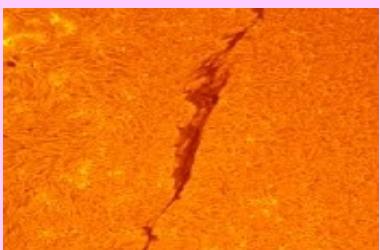
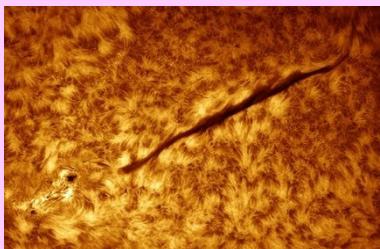
Right-Bearing

+helicity



Left-Bearing

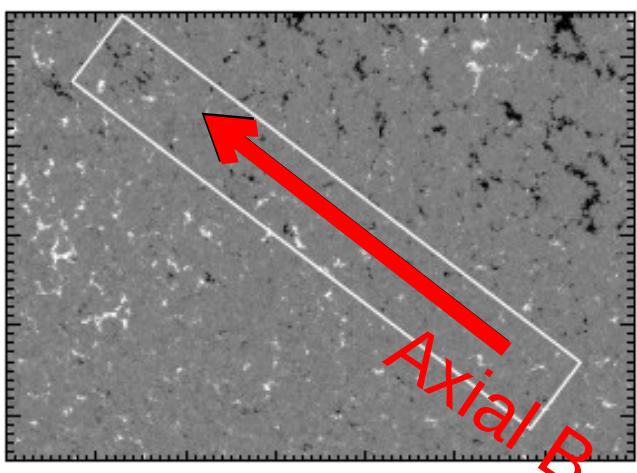
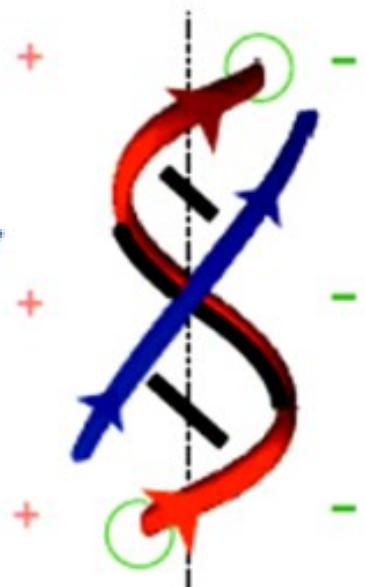
Martin et al. (1994), Pevtsov et al. (2003b),
Lim & Chae (2009), Martin et al. (1994),
Bernaconi et al. (2005), Yeates et al. (2007)



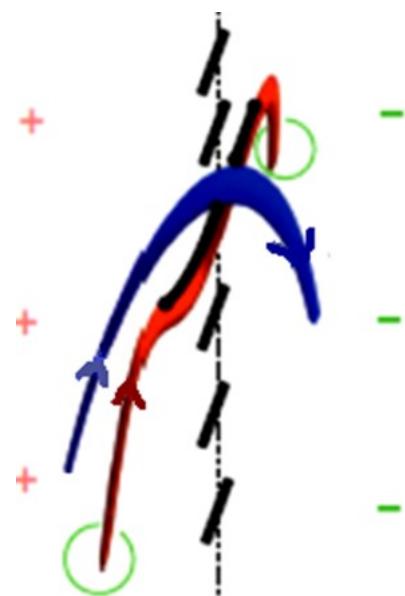
55-87%



Inverse-polarity



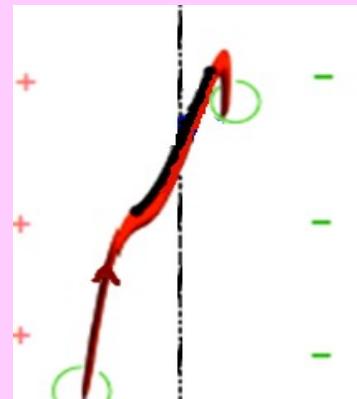
Normal-polarity



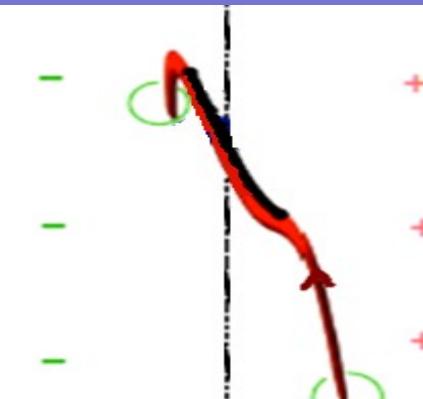
New Method

(Chen, Harra & Fang
2014)

+ helicity



- helicity



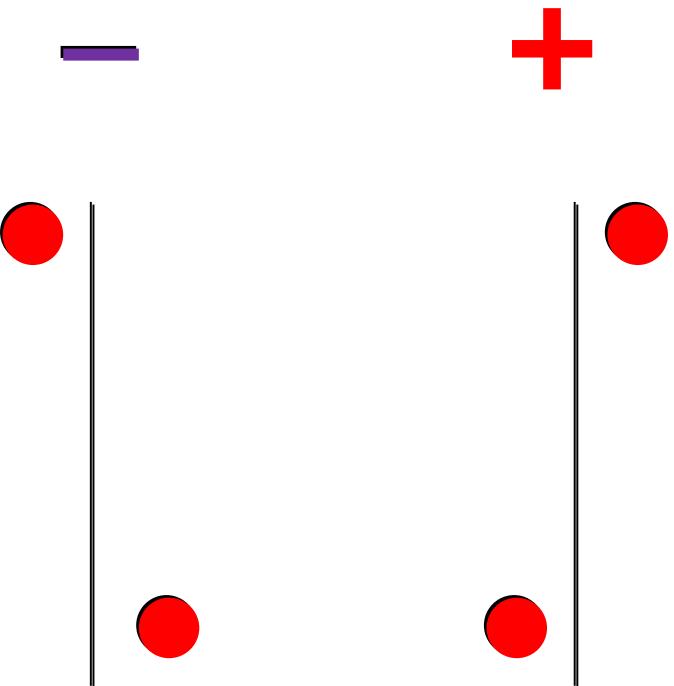
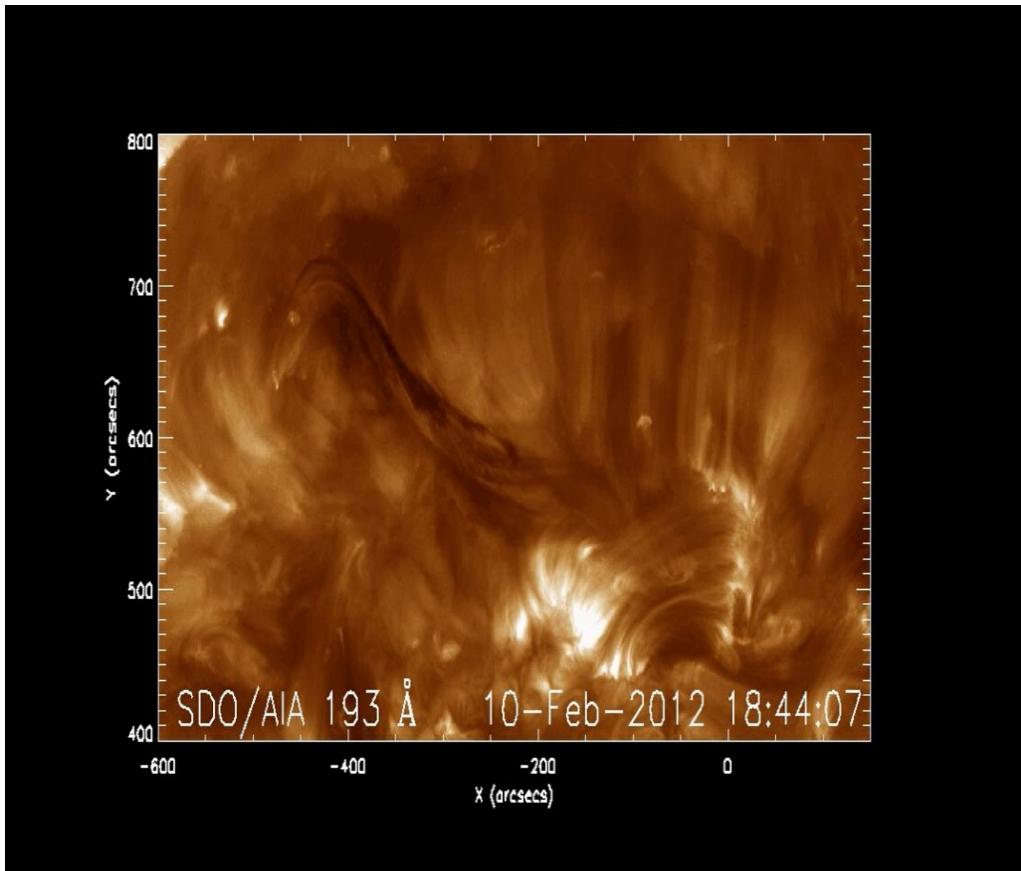
Skew of the drainage sites



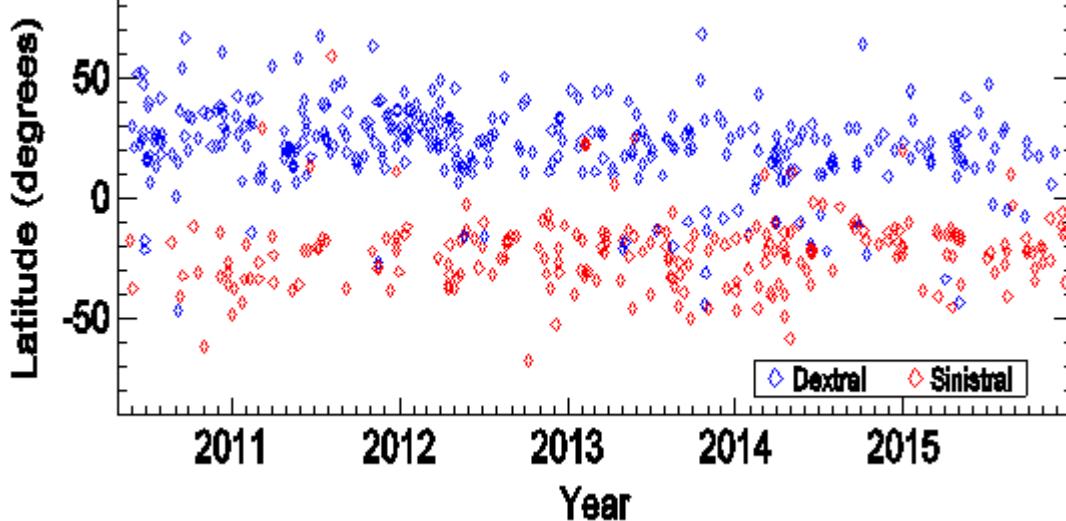
New Method

(Wang, Kliem et al. 2009
Chen, Harra & Fang 2014)

Sign of helicity

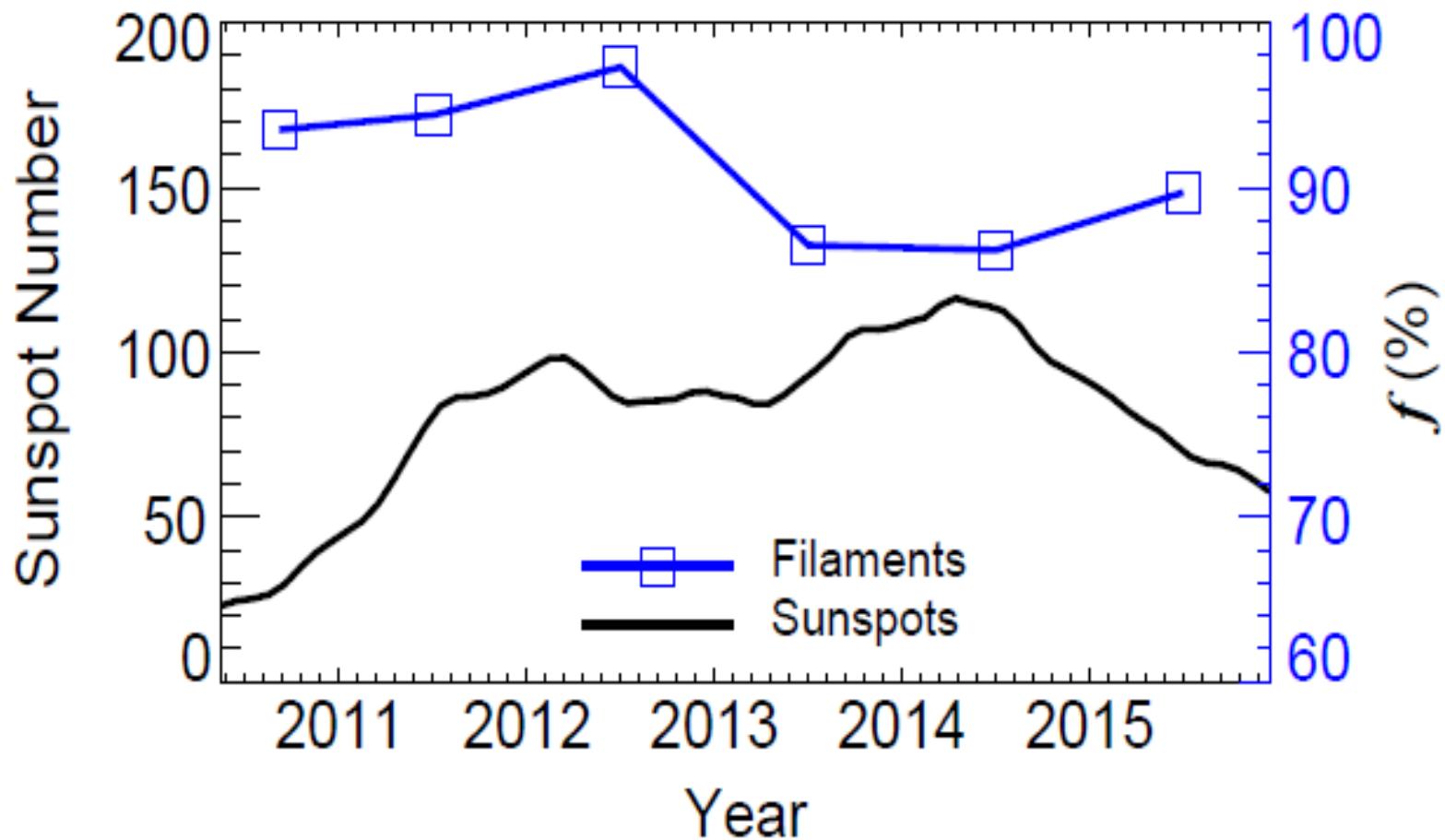


Ouyang et al. (2017, ApJ, 835, 94)

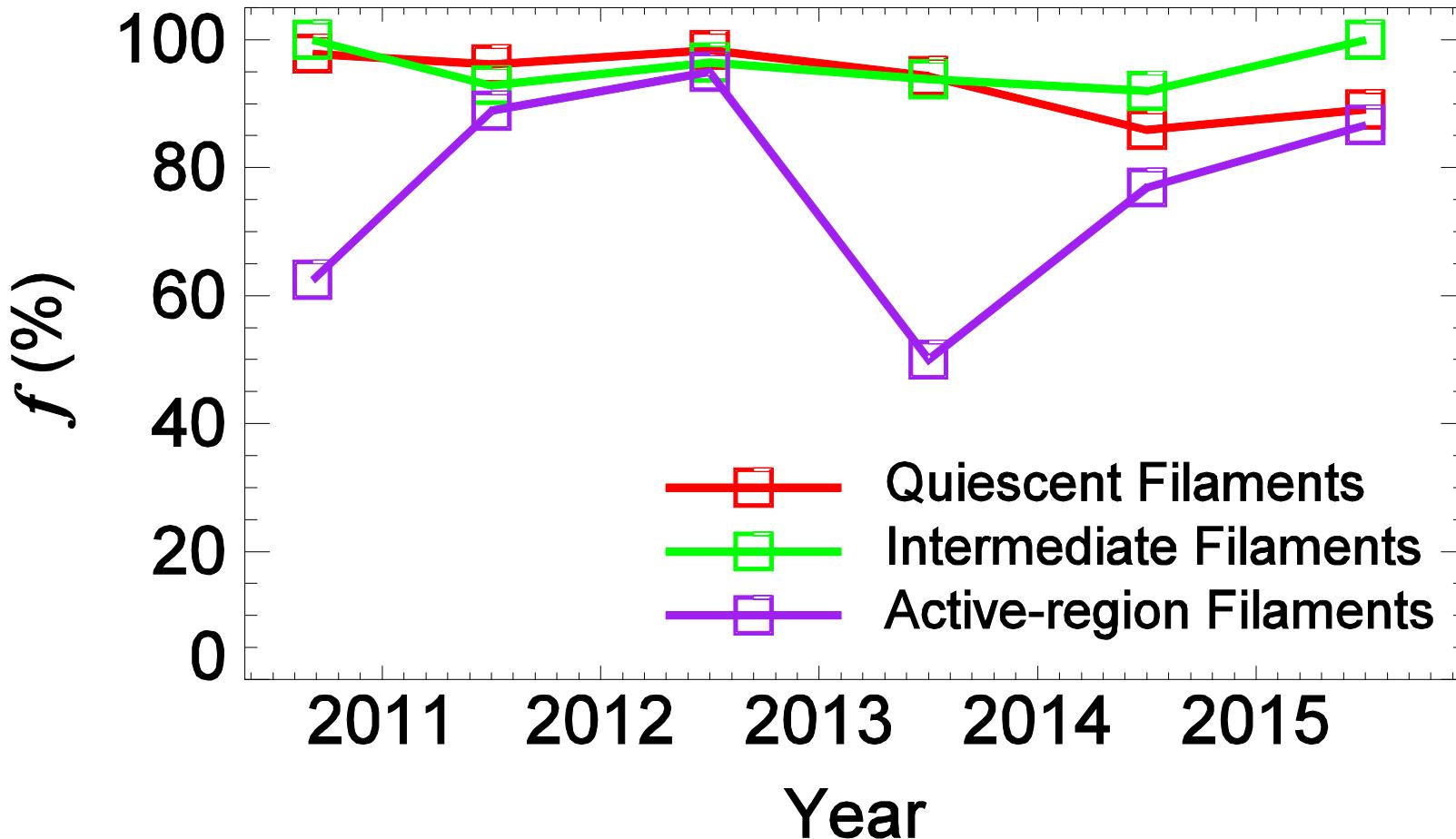


91.6%
follow the
hemispheric
rule

Ouyang et al. (2017)

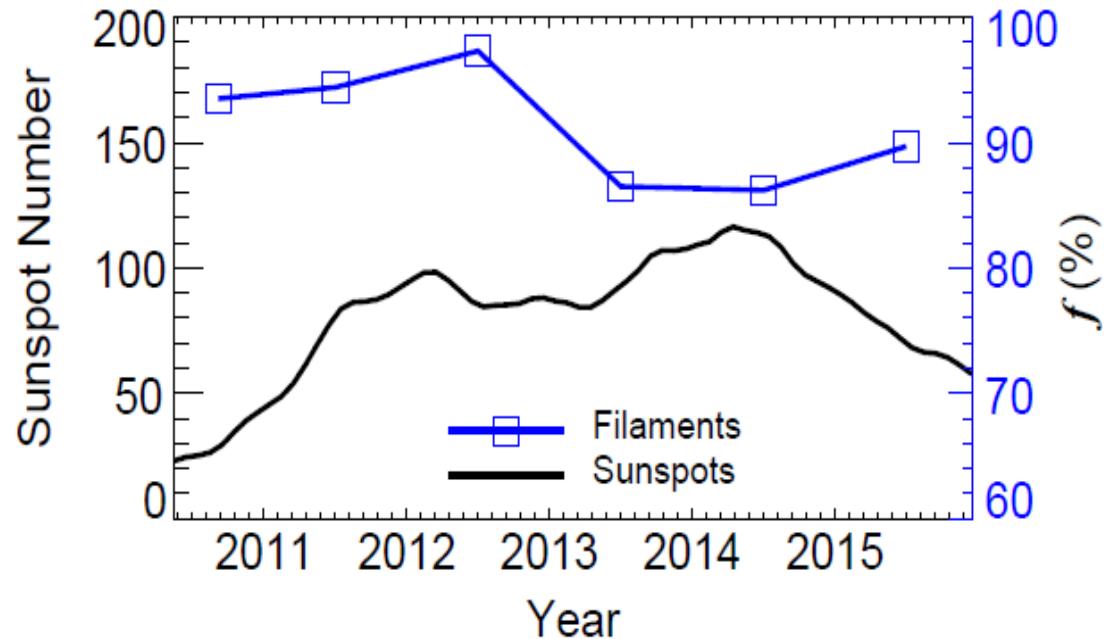


Puzzle



Future Prospects

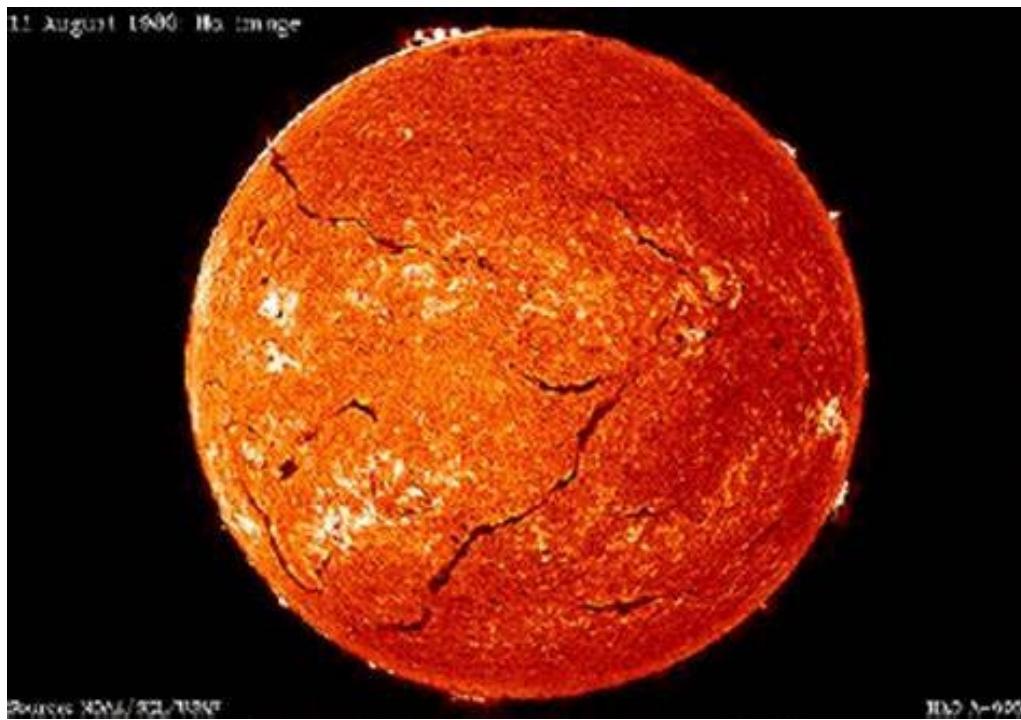
1. Extension to 2020



Ouyang et al. (2017)

Future Prospects

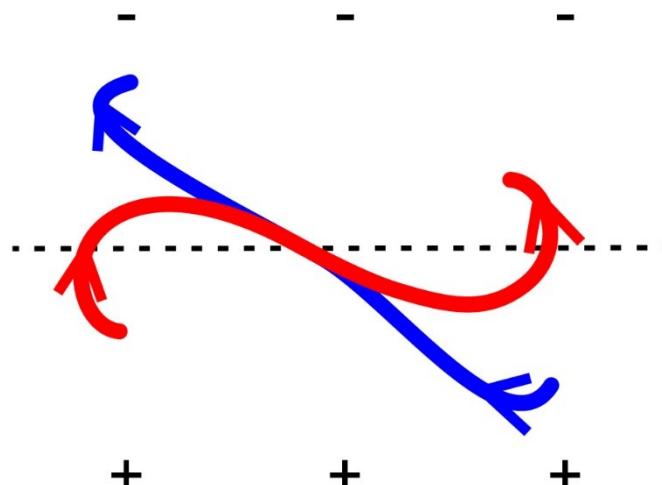
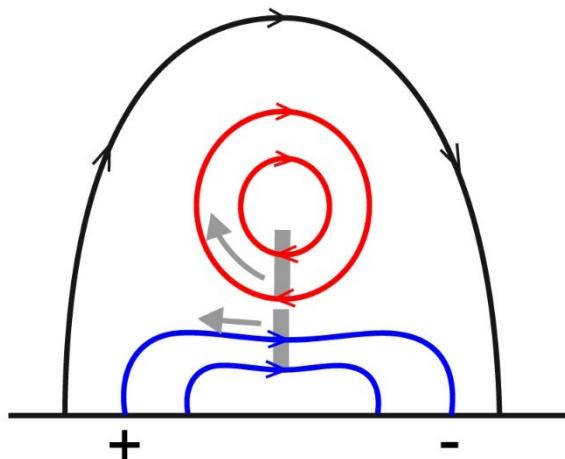
2. Extension to small scales



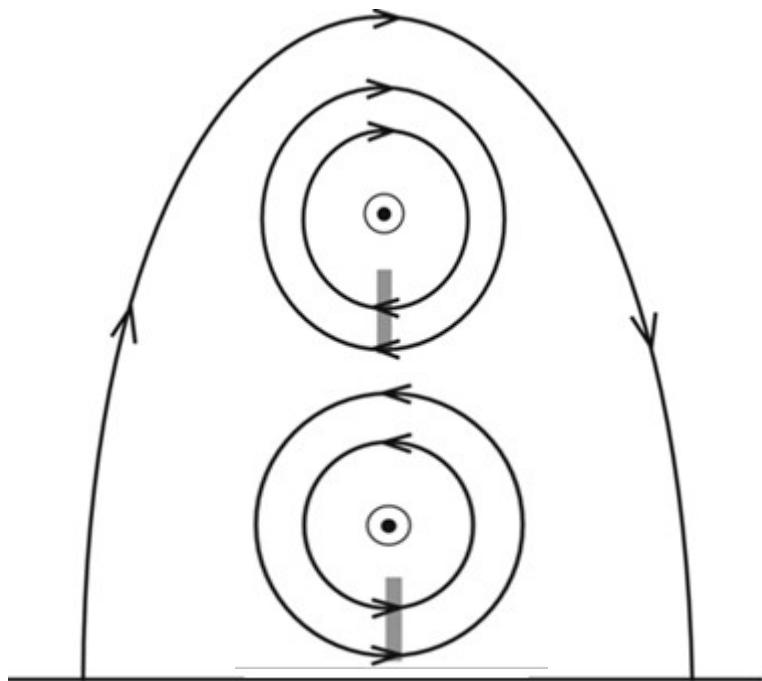
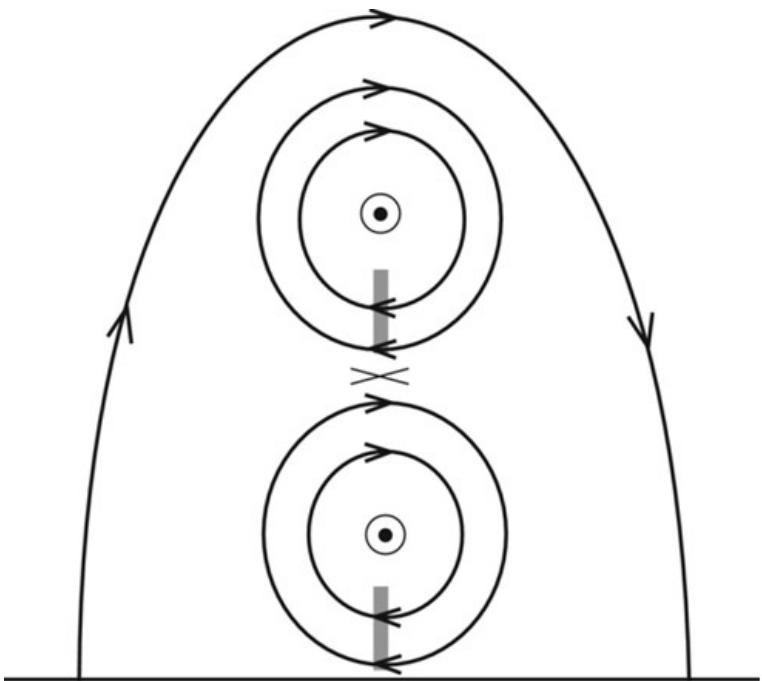
In collaboration with Zhang, Yang, Bi et al.

Future Prospects

3. Double-decker filaments with \pm helicity



Awasthi, Liu
et al. (2019)



Liu, R. (2010)

P. F. Chen et al. (2020, RAA, 20, 166)





Thanks
!

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