



# White-Light Solar Flares as Potential Clues for Stellar Superflares

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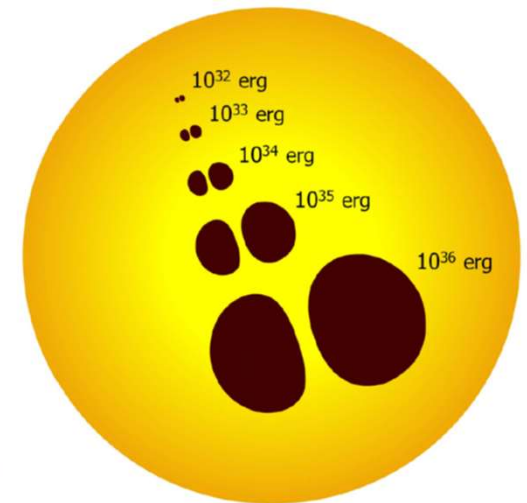
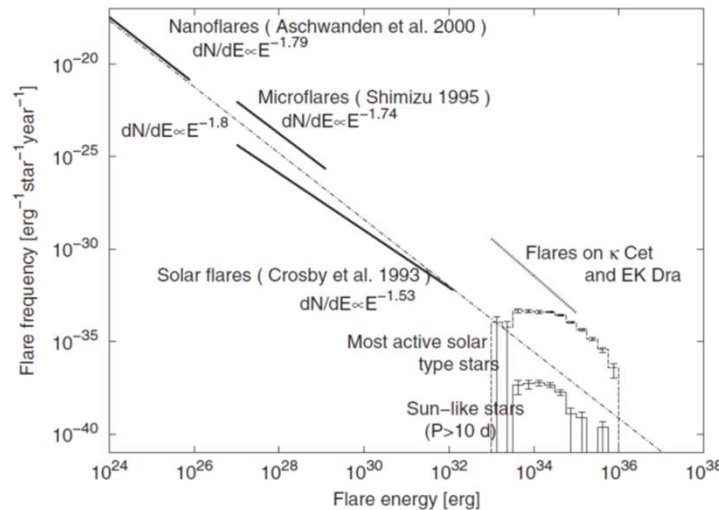
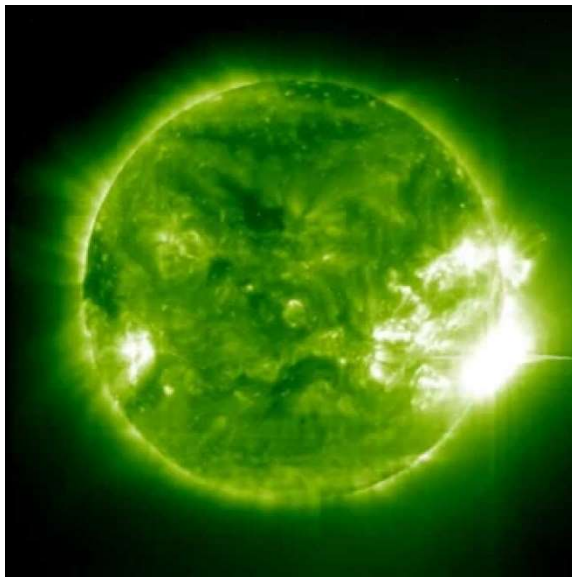
<sup>2</sup>King Saud University

# Can superflares occur on the Sun?

The **Kepler mission** has recently revealed (from 400 to 900 nm) the occurrence of extremely energetic flares, named “superflares” (up to  $10^{38}$  erg), on G-type stars.

From the interpolation of Kepler data, Shibata et al. 2013 suggested a frequency of flares on the Sun to be one flare with energy  $\geq 10^{34}$  erg per 800 years and one flare with energy  $\geq 10^{35}$  erg per 5000 years.

X45-class (4 Nov 2003)

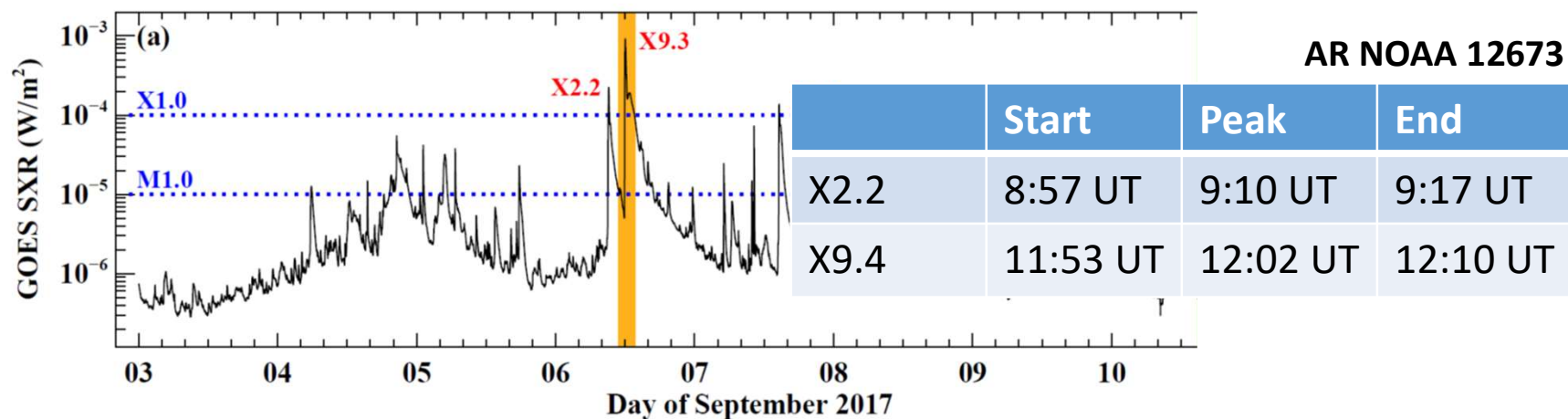


Aulanier et al. (2013)

Cosmogenic isotope studies have identified historical events that were **30–50 times** stronger (in the sense of the fluxes of solar energetic particles) than the most energetic solar flares observed instrumentally!! (Katsova et al. 2018).

# Homologous white light flares

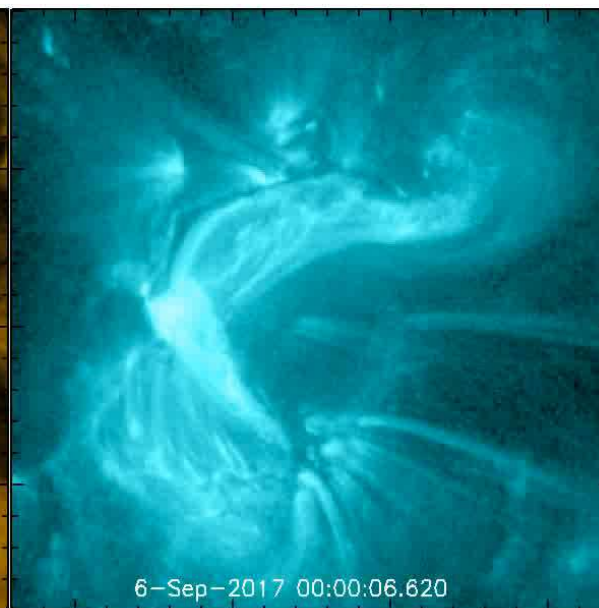
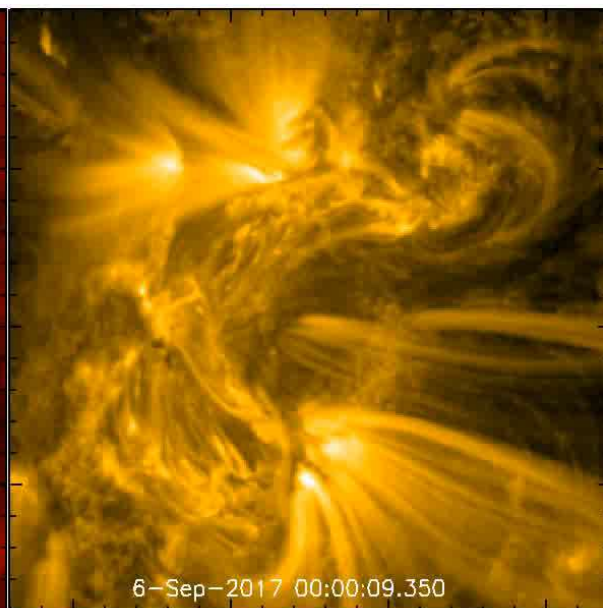
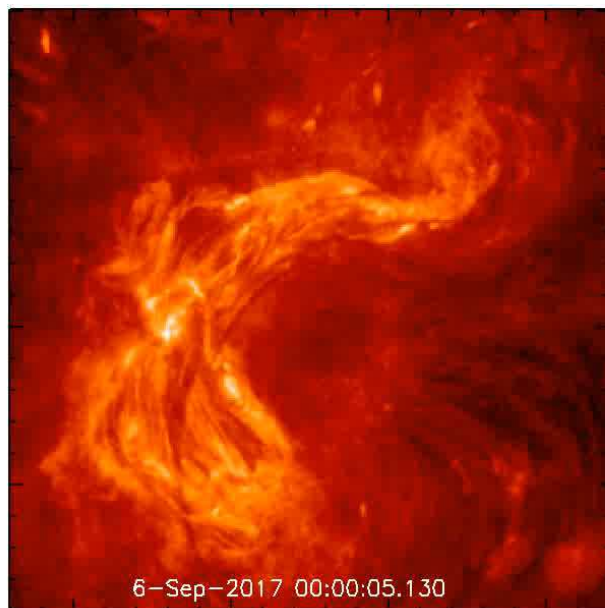
SOL2017-09-06T09:10 (X2.2) & SOL2017-09-06T12:02 (X9.3)



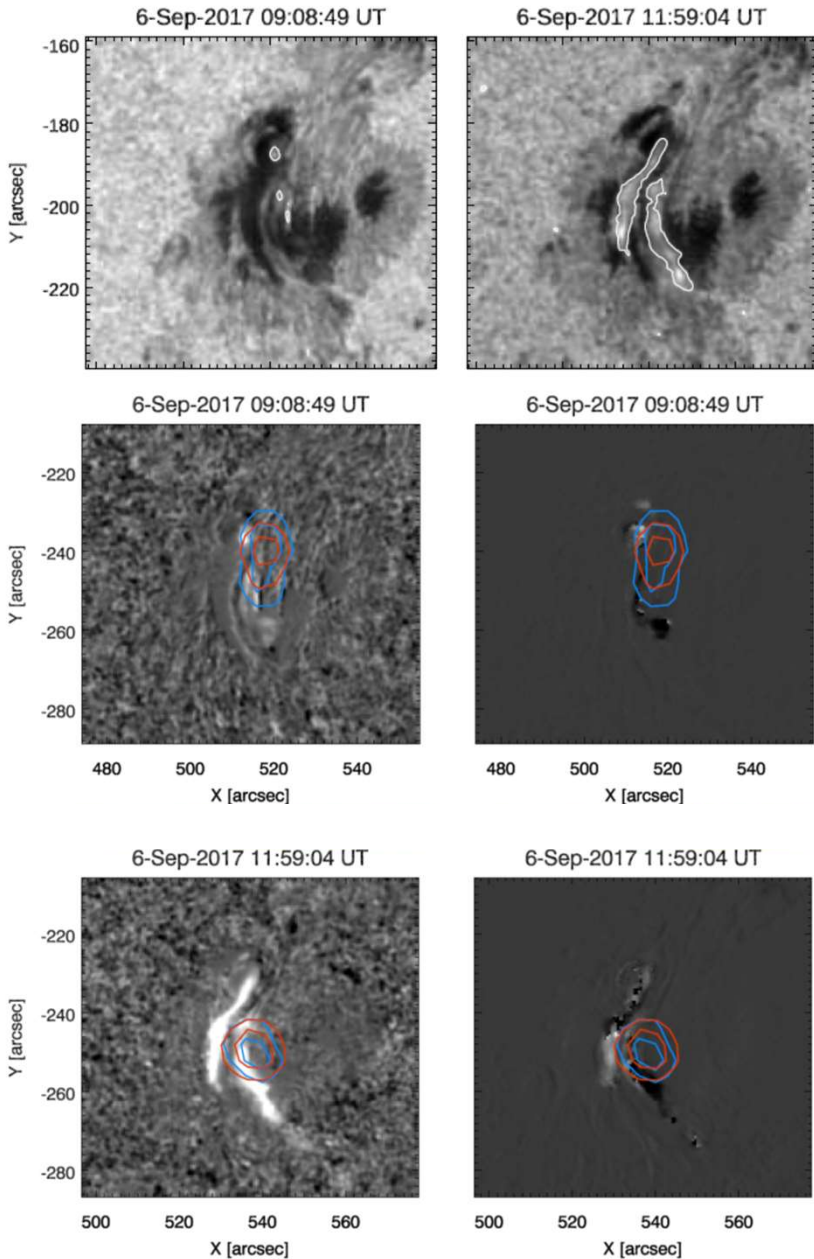
304 Å

171 Å

131 Å



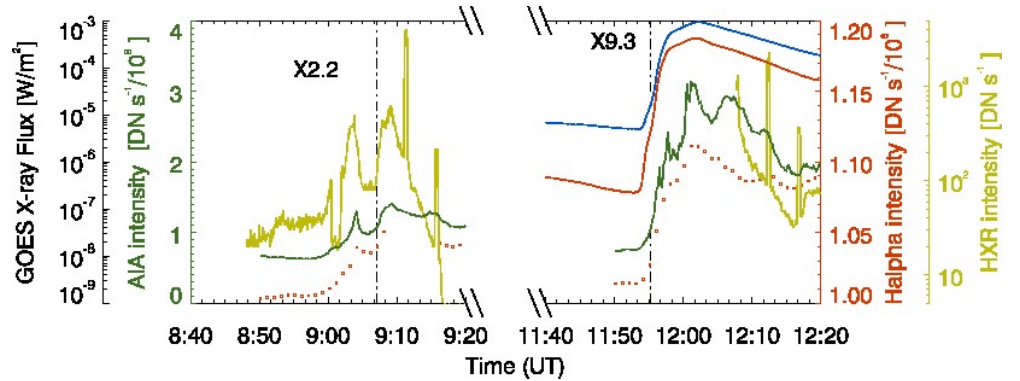
# Homologous white light flares



RHESSI contours:

12-25 keV

25-50 keV

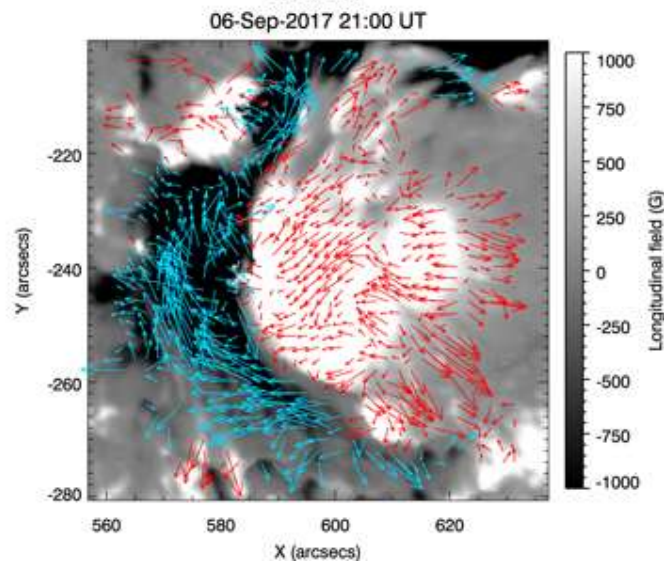
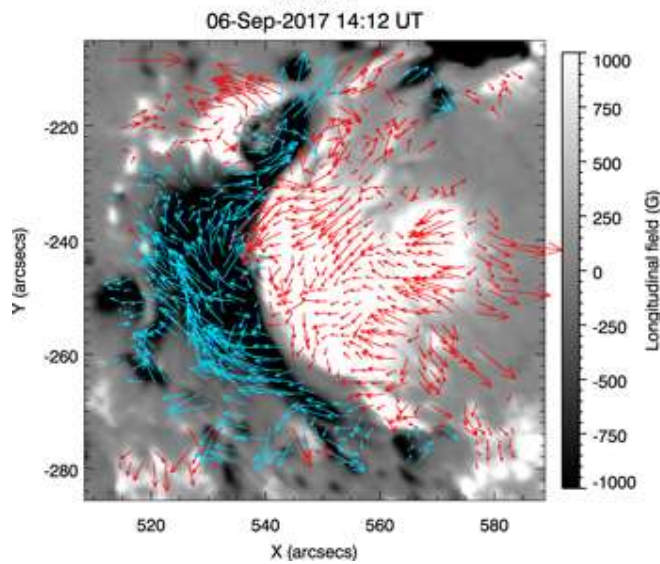
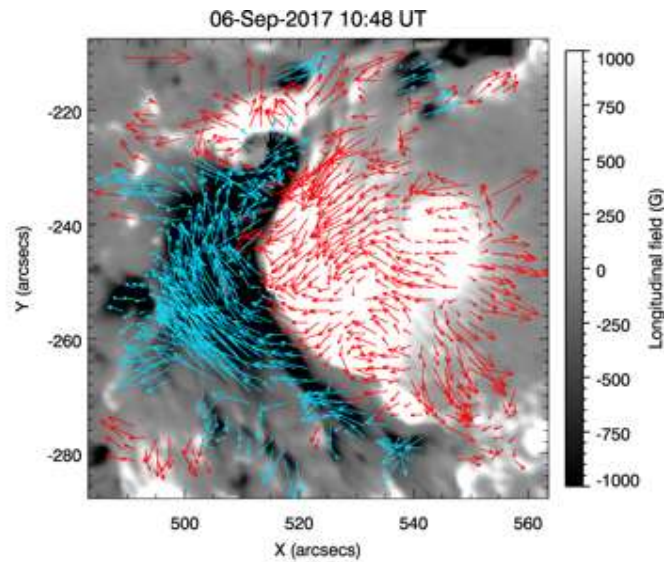
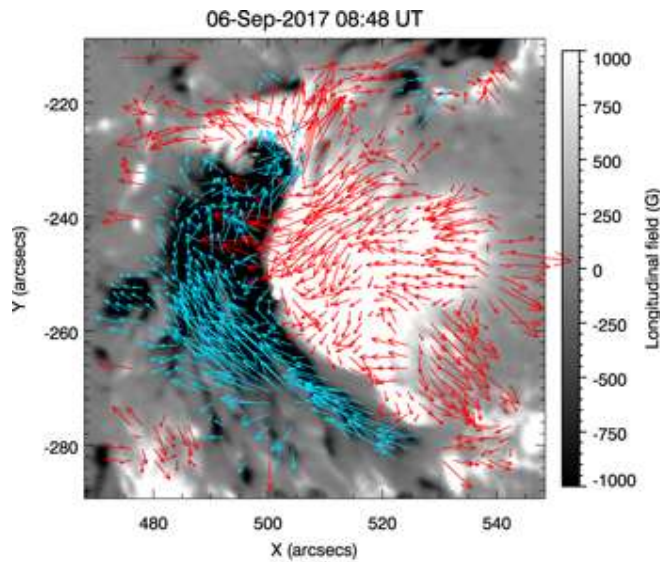


The H $\alpha$  peaks precede the peaks registered in the corona with the other instruments by a few minutes.

The first signatures of the WLFs in the photosphere has been observed several minutes before the emissions in X-rays, EUV, and H $\alpha$  lines (i.e., in the upper layers of the solar atmosphere) reached their maximum.

*Romano et al., ApJ, 852, 10, 2018*

# Photospheric horizontal motions



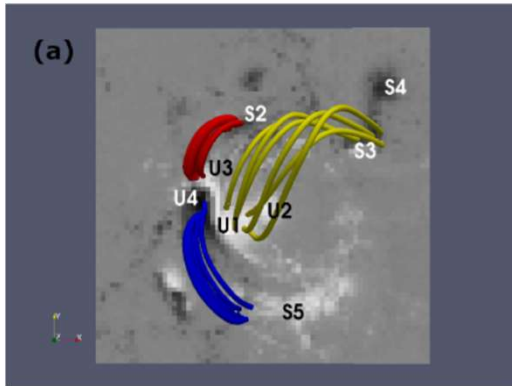
DAVE4VM  
(Schuck, 2008)

FWHM= 11 pixels (5".5)  
 $\Delta t = 24$  minutes

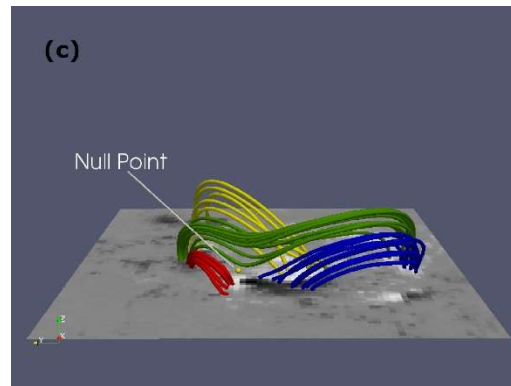
Negative umbra:  
 $\langle v \rangle = 0.4 \text{ km s}^{-1}$   
 $v_{\text{max}} = 0.7 \text{ km s}^{-1}$

## 3D null points

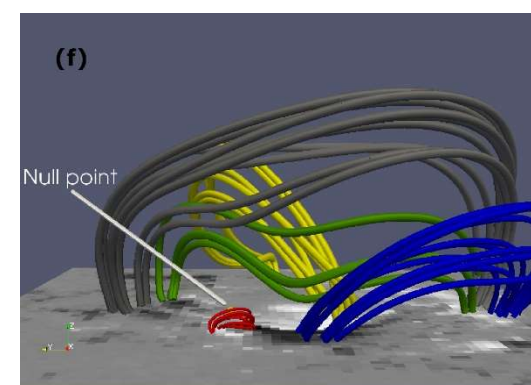
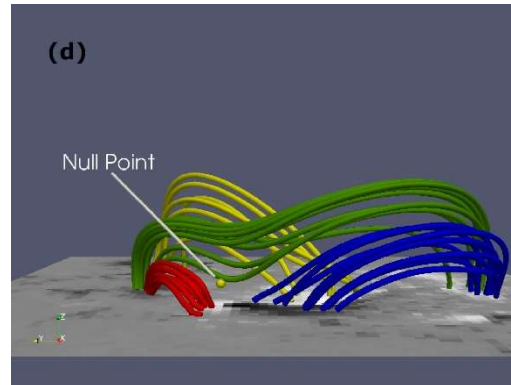
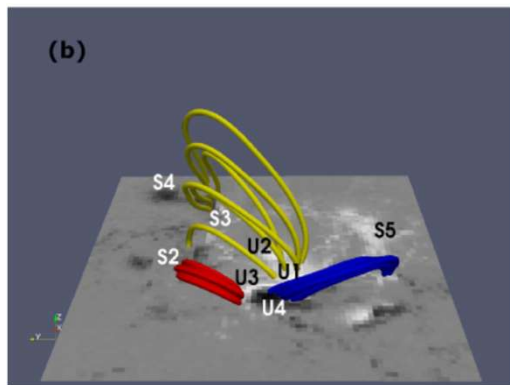
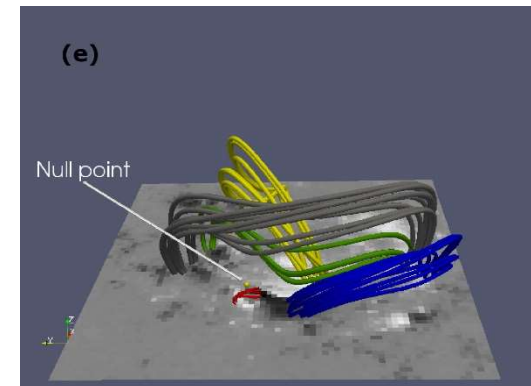
00:00 UT



08:48 UT



11:48 UT



We identified two related 3D null points located at **low heights** above the photosphere: **5000 km** (for X2.2) and **3000 km** (for X9.3).

Their formation at such low altitudes may plausibly be ascribed to the peculiar photospheric horizontal motions

## Conclusions

The extent of the photospheric area affected by the chromospheric radiative heating **depends by the total energy** of the electrons accelerated along the field lines.

The presence of **3D null points** had a crucial role in the flare trigger and in the acceleration of the electrons reaching the lower layers of the solar atmosphere.

The continuum emission at photospheric level could be correlated with a **low height** of the reconnection site in the solar atmosphere.

The **stretching of the magnetic field lines** due to the shear motions seems to be the main source of the lower height of the 3D null points.

The fast rotation drives the emergence of strong magnetic field, but also can be the source of **strong shear** and low height of magnetic reconnection processes

**A possible explanation of the acceleration of huge numbers of particles producing white light emission during superflares in young Sun-like stars, could be the occurrence of magnetic reconnection at low altitudes of atmospheres. their**

*Romano, Elmhamdi and Kordi, Solar Physics, 294, 4, 2019*

Investigation in progress: nature of 3D null-points in ARs holding large energetic flares in SC23 & SC24