

A New Magnetic Parameter of Active Regions Distinguishing Large Eruptive and Confined Solar Flares

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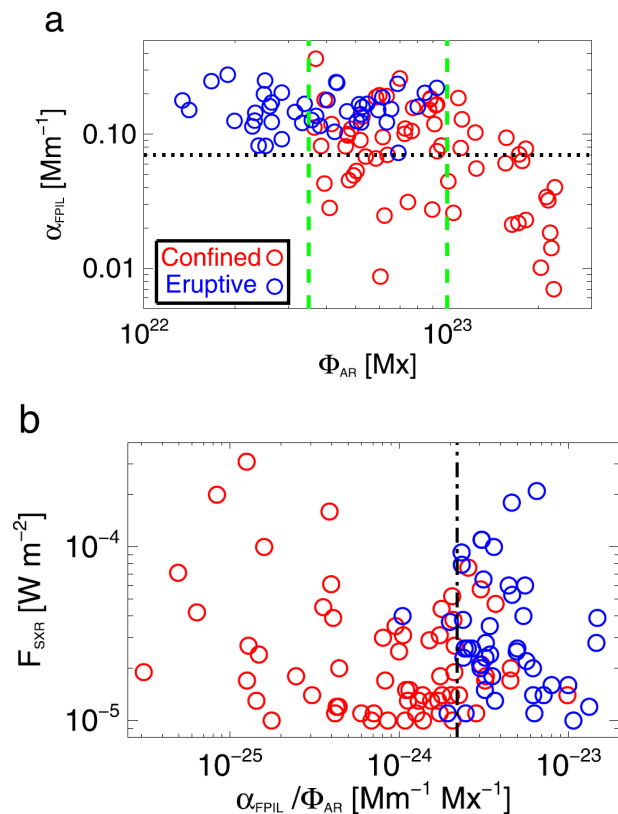
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With the aim of investigating how the magnetic field in solar active regions (ARs) controls flare activity, i.e., whether a confined or eruptive flare occurs, we analyze 106 flares of Geostationary Operational Environmental Satellite (GOES) class $\geq M1.0$ during 2010 – 2019. We calculate mean characteristic twist parameters α_{FPIL} within the "flaring polarity inversion line" region and α_{HFED} within the area of high photospheric magnetic free energy density, which both provide measures of the nonpotentiality of AR core region. Magnetic twist is thought to be related to the driving force of electric current-driven instabilities, such as the helical kink instability. We also calculate total unsigned magnetic flux (Φ_{AR}) of ARs producing the flare, which describes the strength of the background field confinement. By considering both the constraining effect of background magnetic fields and the magnetic non-potentiality of ARs, we propose a new parameter α/Φ_{AR} to measure the probability for a large flare to be associated with a coronal mass ejection (CME). We find that in about 90% of eruptive flares, $\alpha_{\text{FPIL}}/\Phi_{\text{AR}}$ and $\alpha_{\text{HFED}}/\Phi_{\text{AR}}$ are beyond critical values, whereas they are less than critical values in about 80% of confined flares. We find that in about 90% of eruptive flares, $\alpha_{\text{FPIL}}/\Phi_{\text{AR}}$ and $\alpha_{\text{HFED}}/\Phi_{\text{AR}}$ are beyond critical values, whereas they are less than critical values in about 80% of confined flares. This indicates that the new parameter α/Φ_{AR} is well able to distinguish eruptive flares from confined flares. Our investigation suggests that the relative measure of magnetic nonpotentiality within the AR core over the restriction of the background field largely

controls the capability of ARs to produce eruptive flares.

References

- [1] Li, T. et al. 2020, *ApJ*, 900, 128
- [2] Li, T. et al. 2021, *ApJL*, 917, L29
- [3] Li, T. et al. 2022, *ApJL*, 926, L14



Scatter plots of mean characteristic twist parameter α_{FPIL} vs. total unsigned magnetic flux Φ_{AR} and flare peak X-ray flux F_{SXR} vs. $\alpha_{\text{FPIL}}/\Phi_{\text{AR}}$. Blue (red) circles are eruptive (confined) flares.