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Circular-ribbon flares and the related activities

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Solar flares are one of the most spectacular activities, which play a crucial role in driving the space weather. Circular-ribbon flares (CFs) are a special type of flares, featuring a magnetic null point and the associated fan-spine structure. In this talk, I will show our recent progress in CFs research, such as the magnetic reconnection, explosive evaporation and apparent movements in CFs, quasi-periodic pulsation (QPP) in light curves, energy partition, and the related coronal dimmings, transverse oscillations of coronal loops and filaments. Finally, I will show the results of a comprehensive statistical analysis of 134 CFs observed by SDO/AIA.

During the impulsive phase of the C4.2 CF, which was observed by *IRIS* on 2015 October 16, simultaneous plasma upflow at speeds of 35-120 km/s in the Fe XXI line (log T≈7.05) and downflow at speeds of 10-60 km/s in the Si IV line (log T≈4.8) appear at the flare ribbon, indicating explosive chromospheric evaporation, which is driven by nonthermal electrons.

During the impulsive phase of the C3.1 CF observed by *IRIS* on 2015 October 16, the Si IV intensity at the flare ribbon and HXR flux show QPPs with periods of 32-42 s, which is due to intermittent magnetic reconnection near the null point.

We investigate energy partition of two homologous M1.1 CFs in AR 12434. The radiation in 1-8 Å, total radiative losses, peak thermal energy, and nonthermal energy of electrons are calculated in detail. The two flares not only show similar morphology, SXR evolution, but also have similar energy partition.

During the confined M1.1 CF in AR 12434, large-area ($1.2*10^4$ Mm^2) and long-lasting (>3 hr) remote coronal dimmings are found ~180 Mm away from the flare site.

During the C5.5 CF on 2014 August 24, the circular ribbon experiences fast degradation after the impulsive brightening, which is simultaneously observed in AIA UV and EUV wavelengths. The apparent speed of degradation decreases from 58-69 km/s in the first phase to 29-35 km/s in the second phase.

On 2014 March 5, two homologous CFs induced decayless (A: 310-510 km, P: 115-118 s) and decaying (A: 1250-1280 km, P: 70-117 s, τ: 147-315 s) transverse loop oscillations.

We investigate 134 CFs observed by SDO/AIA. The physical properties are derived, including the locations, area, equivalent radius, lifetime, and SXR peak flux. The distributions of areas and lifetimes could be fitted with a lognormal function. The peak SXR flux is in accord with a power-law distribution. About 57% of the CFs are related to remote brightenings, and the total length of brightening is proportional to the average distance. About 47% and 51% of the CFs are related to type III radio burst and coronal jets, respectively. About 38% of them are related to minifilament eruptions, and the association rates increase with flare classes. Only 28% of them are associated with CMEs, indicating that most of them are confined flares rather than eruptive flares, which is probably related to their magnetic topology (fan-spine structure).

References:

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Note: Abstract should be in (full) double-columned one page.

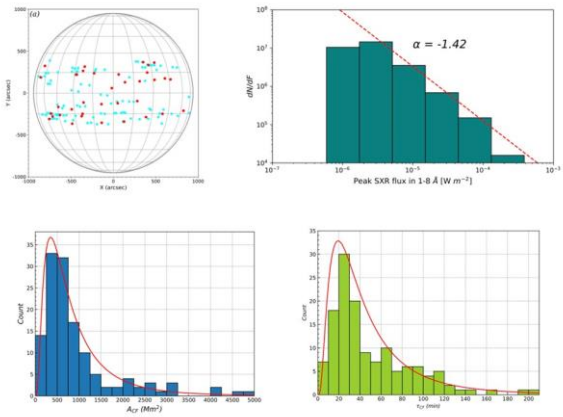

Figure 1. (a) Positions of the 134 CFs. (b) Distribution of the peak SXR flux of the flares. (c) Distribution of the total area of the flares. (d) Distribution of the lifetimes of the flares.