
Sympathetic flares and magnetohydrodynamical avalanches

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Résumé

Solar eruptions stem from a variety of phenomena involving the release of magnetic energy. The phenomenology of solar flares can be mimicked with so-called cellular automata, or avalanche models. These toy models have the advantage of reproducing many statistical features of solar flares, and can even be used to reproduce the features of sympathetic flare. Though, they generally lack a sound physical justification. In this presentation we will cover recent endeavours that aimed to (i) uncover the statistics of sympathetic flares - including the STIX flare list (Guité et al. 2025a, doi 10.1051/0004-6361/202452381) ; (ii) model this sympathy with coupled avalanche models reproducing their statistics (Guité et al. 2025b, doi 10.1007/s11207-025-02501-4) ; and (iii) unveil the avalanche nature of dissipative regions within MHD simulations, bridging the gap between MHD and avalanche models (Lamarre et al. 2025, doi 10.1103/28ws-d57z).

We will report on a recent statistical analysis of sympathetic flares, utilizing data from multiple instruments (SDO/AIA, RHESSI, and Solar Orbiter/STIX) that collectively span from the peak of solar cycle 23 to the present. Our analysis reveals a significant overabundance of hemispheric pairs of flares with short waiting times ($w \leq 1.5$ hours) that are separated by approximately 30 degrees in longitude. The occurrence rate of sympathetic flares is estimated to be around 5% across the three instruments.

Following this study, we will show how simple, coupled avalanche models can be built to reproduce some features of sympathetic flares. In particular, our study suggests that sympathetic solar flares are adequately simulated by weakly coupled avalanche models, showing an excess of pairs of events at short waiting times but with no correlation in the energy of the sympathetic flare pairs. It also suggests a pathway to identify sympathetic flares on other stars, if they happen to have stronger couplings. Those sandpile models, though, generally lack a sound physical justification. We will end our presentation by reporting on the identification of avalanching behavior in magnetohydrodynamical (MHD) numerical simulations of chromospheric dynamics driven by photospheric motions (with both the BIFROT and PLUTO codes). We will briefly discuss the potential of such MHD simulations in providing guidance towards designing better physically motivated evolutionary rules for existing avalanche models used for e.g. flare prediction.

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