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Detection of Flare-induced Plasma Flows in the Corona of a dMe star EV Lac with X-Ray Spectroscopy

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Stellar flares are characterized by sudden enhancement of electromagnetic radiation from the atmospheres of stars. Compared to their solar counterparts, our knowledge on the coronal plasma dynamics of stellar flares and their connection to coronal mass ejections remains very limited. With time-resolved high-resolution spectroscopic observations from the Chandra X-ray Observatory, we detected noticeable coronal plasma flows during several stellar flares on a nearby dMe star EV Lac. In the observed spectra of O VIII (3 MK), Fe XVII (6 MK), Mg XII (10 MK), and Si XIV (16 MK) lines, these flare-induced upflows/downflows appear as significant Doppler shifts of several tens to 130 km s−1 , and the upflow velocity generally increases with temperature. Variable line ratios of the Si XIII triplet reveal that this plasma flows in most flares are accompanied by an increase in the coronal plasma density and temperature. We interpret these results as X-ray evidence of chromospheric evaporation on EV Lac. In two successive flares, the plasma flow pattern and a sharp increase of the measured coronal density are highly suggestive of explosive evaporation. The transition from redshifts to blueshifts in such an explosive evaporation occurs at a temperature of at least 10 MK, much higher than that observed in solar flares (~1 MK). However, in one flare the cool and warm upflows appear to be accompanied by a decreasing plasma density, which might be explained by a stellar filament/prominence eruption coupled to this flare. These results provide important clues to understanding the coronal plasma dynamics during flares on M dwarfs.

References

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Figure xx

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