Investigating unusual three-ribbon solar flares with extreme high resolution

June 2 2014

The 1.6 meter telescope at Big Bear Solar Observatory (BBSO) in California has given researchers unparalleled capability for investigating phenomena such as solar flares. Operated by New Jersey Institute of Technology (NJIT), the BBSO instrument is the most powerful ground-based telescope dedicated to studying the star closest to Earth.

On June 2, Distinguished Professor of Physics Haimin Wang joined NJIT colleagues at the 224th meeting of the American Astronomical Society (AAS), held in Boston, Massachusetts, to present intriguing data about solar flares—specifically, two successive three-ribbon solar flares observed on July 6, 2012. The events were recorded by Wenda Cao, associate professor of Physics at NJIT, BBSO associate director, and a co-author of the paper presented. Flares with two ribbons are typical of these immensely powerful eruptions that can send storms of charged particles and high-energy radiation toward Earth at nearly the speed of light.

The research Wang described at the AAS meeting integrated data acquired with the BBSO telescope at the hydrogen H-alpha spectral line and calcium II H images captured with instrumentation aboard NASA's Hinode satellite. The flaring site observed was characterized by an unusual "fish-bone-like" morphology evidenced by both H-alpha images and a nonlinear force-free field (NLFFF) extrapolation, where two semi-parallel rows of low-lying, sheared loops connected an elongated, parasitic negative field with sandwiching positive fields.

The NLFFF model also showed the two rows of loops to be asymmetric in height with opposite twists, and to be enveloped by large-scale field lines, including open fields. The two flares occurred in succession within half an hour and were located at the two ends of the flaring region. The three ribbons of each flare were parallel to the magnetic polarity inversion line, with the outer two lying in the positive field and the central one in the negative field.

Both flares showed surge-like flows in the H-alpha images presented by Wang, apparently toward the remote region. One of the flares also was accompanied by jets of extreme ultraviolet radiation, possibly along the open field lines. Interestingly, the 12-25 keV hard X-ray sources of the flare first lined up with the central ribbon and then shifted to concentrate on top of the higher branch of loops. The results Wang discussed also suggest that the phenomenon of magnetic reconnection along the coronal null line is involved in producing the three flare ribbons and associated coronal mass ejections.

At NJIT, Wang also is director of the university's Space Weather Research Laboratory, based on campus in Newark, New Jersey. Under Wang's direction, the laboratory uses data from BBSO, the NJIT radio observatory in Owens Valley, California, NASA spacecraft and observatories in other countries to provide information about prevailing solar weather and what's ahead in the near future.

Operating the Global High Resolution H-alpha Network, Wang and his laboratory colleagues monitor solar activity and report space weather 24/7. In addition, they are working to further fundamental understanding of solar activity and geomagnetic effects. Better forecasting of solar events is a chief objective.

Beyond NJIT, Wang is leading a research team under NASA's Living With a Star program focused on gaining new knowledge about solar

flares, the source of space weather. Another project on Wang's agenda "looks back to the future." It involves converting images from Big Bear and other observatories archived only as photographs into more accessible digital formats. This will give all researchers investigating the solar cycle and flare activity access to high-quality data extending over a century.

More information: The research paper is published in the *Astrophysical Journal Letters* at iopscience.iop.org/2041-8205/781/1/L23 . Preprint: arxiv.org/abs/1312.6649

Provided by BBSO/NJIT

Citation: Investigating unusual three-ribbon solar flares with extreme high resolution (2014, June 2) retrieved 8 February 2023 from https://phys.org/news/2014-06-unusual-three-ribbon-solar-flares-extreme.html

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