Sub-Second Two-Color Photometry of a Complex White-Light Flare on EV Lac

○Muhamad Zamzam Nurzaman[1, 2] Daisaku Nogami[1] Hiroyuki Maehara[3] Kosuke Namekata[4, 5, 6, 12] Yuta Notsu[7, 8] Shinnosuke Ichihara[1] Kai Ikuta[9] Kazunari Shibata[10, 11] (1.Department of Astronomy, Kyoto University, Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto 606-8502, Japan 2.Research Center for Space, National Research and Innovation Agency (BRIN), Bandung 40135, Indonesia 3.Okayama Branch Office, Subaru Telescope, National Astronomical Observatory of Japan, NINS, 3037-5 Honjo, Kamogata, Asakuchi, Okayama 719-0232, Japan 4.Heliophysics Science Division, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771, USA 5.The Catholic University of America, 620 Michigan Avenue, NE, Washington, DC 20064, USA 6.Division of Science, National Astronomical Observatory of Japan, NINS, 2-21-1 Osawa, Mitaka, Tokyo 181-8588, Japan 7.Laboratory for Atmospheric and Space Physics, University of Colorado Boulder, 3665 Discovery Drive, Boulder, CO 80303, USA 8.National Solar Observatory, 3665 Discovery Drive, Boulder, CO 80303, USA 9.Department of Social Data Science, Hitotsubashi University, 2-1 Naka, Kunitachi, Tokyo 186-8601, Japan 10.Kwasan Observatory, Kyoto University, 17-1 Kitakazan-ohmine-cho, Yamashina-ku, Kyoto, Kyoto 607-8471, Japan 11.Graduate School of Science and Engineering, Doshisha University, 1-3 Tatara Miyakodani, Kyotanabe, Kyoto 610-0394, Japan 12.The Hakubi Center for Advanced Research, Kyoto University, Yoshida-Honmachi, Sakyo-ku, Kyoto, Kyoto 606-8501, Japan)

M dwarfs are the Galaxy's most numerous stars and its most frequent flare hosts, whose flares strongly affect the habitability of close-in planets. Bolometric energies of M-dwarf flares are routinely derived from a single broadband light curve assuming a fixed ~10,000 K blackbody of time-variable area, an assumption left largely untested through the fast impulsive phase. We address this with simultaneous sub-second, two-band g (≈400–550 nm) and r (≈550–700 nm) photometry of a complex white-light flare on the active M dwarf EV Lac (M3.5 V), obtained with TriCCS on the 3.8 m Seimei telescope together with TESS 120 s photometry (≈600–1000 nm). Using a g/r blackbody color thermometer, we reconstruct the temperature, emitting area, and bolometric luminosity of each component at 0.1 s cadence. The flare resolves into three peaks — a closely spaced double-peaked primary and a temporally separated secondary — with g-band amplitudes reaching 28.5%; the secondary is recorded ≈20 s earlier by TriCCS than by TESS, a timing offset inaccessible at survey cadence. The peaks reach 7244–7953 K, in close agreement with the 8122±273 K measured spectroscopically for an EV Lac flare (Ichihara et al. 2025), and cool rapidly (decay times 24–157 s), with radiative energies of $(4.0–7.7)\times10^{31}$ erg — ordinary flares, not superflares — implying compact loops of 0.07–0.14 $R_\star$. The secondary releases energy comparable to the whole primary complex, yet arises in a smaller, faster-cooling loop and is the brightest peak owing to its large, relatively cool emitting area. Crucially, this emitting area is not constant: it grows significantly through the decay phase as the temperature falls. These results show that accurate bolometric energies for fast M-dwarf flares require simultaneous, high-cadence measurements of both temperature and area, rather than fixed-temperature or fixed-area approximations.