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Multiwavelength Variability of BL Lacertae Measured with High Time Resolution

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Abstract

© 2020. The American Astronomical Society. All rights reserved.. In an effort to locate the sites of emission at different frequencies and physical processes causing variability in blazar jets, we have obtained high time-resolution observations of BL Lacertae over a wide wavelength range: with the Transiting Exoplanet Survey Satellite (TESS) at 6000-10000 Å with 2 minute cadence; with the Neil Gehrels Swift satellite at optical, UV, and X-ray bands; with the Nuclear Spectroscopic Telescope Array at hard X-ray bands; with the Fermi Large Area Telescope at γ-ray energies; and with the Whole Earth Blazar Telescope for measurement of the optical flux density and polarization. All light curves are correlated, with similar structure on timescales from hours to days. The shortest timescale of variability at optical frequencies observed with TESS is ∼0.5 hr. The most common timescale is 13 ± 1 hr, comparable with the minimum timescale of X-ray variability, 14.5 hr. The multiwavelength variability properties cannot be explained by a change solely in the Doppler factor of the emitting plasma. The polarization behavior implies that there are both ordered and turbulent components to the magnetic field in the jet. Correlation analysis indicates that the X-ray variations lag behind the γ-ray and optical light curves by up to ∼0.4 day. The timescales of variability, cross-frequency lags, and polarization properties can be explained by turbulent plasma that is energized by a shock in the jet and subsequently loses energy to synchrotron and inverse Compton radiation in a magnetic field of strength ∼3 G.

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