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Blazar OJ 287 After First VHE Activity: Tracking the Re-emergence of the HBL like Component in 2020

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ABSTRACT

We report the re-emergence of a new broadband emission through a detailed and systematic study of the multi-wavelength spectral and temporal behavior of OJ 287 after its first-ever reported VHE activity in 2017 to date, which includes the second-highest X-ray flux of the source. The source shows high optical to X-ray flux variations, accompanied mainly by strong spectral changes. The optical to X-ray flux variations are correlated and simultaneous except for two durations when they are anti-correlated. The flux variations, however, are anti-correlated with the X-ray spectral state while correlated with optical-UV (ultraviolet). Weekly binned *Fermi*-LAT data around the duration of the highest X-ray activity show a few detections with a log-parabola model but none with a power-law; yet the extracted LAT spectral energy distribution (SED) of the high activity duration for both the models is similar and show a hardening above 1 GeV. Further, near-infrared (NIR) data indicate strong spectral change, resembling a thermal component. Overall, the combined optical to gamma-ray broadband spectrum establishes the observed variations to a new high-energy-peaked (HBL) broadband emission component, similar to the one seen during the highest reported X-ray flux state of the source in 2017. The observed activities indicate some peculiar features that seem to be characteristic of this emission component while its appearance, a few years around the claimed $\sim$ 12-year optical outbursts strongly indicate a connection between the two.

Keywords: BL Lac objects: individual: OJ 287 – galaxies: active – – galaxies: jets – radiation mechanisms: non-thermal – X-rays: galaxies

1. INTRODUCTION

Blazars are the most prominent and persistent non-thermal emitters with a continuum powered by a relativistic jet roughly aligned with our line of sight. The continuum shows variations on all accessible timescales and spread across the entire accessible electromagnetic (EM) spectrum. Detailed multi-wavelength (MW) studies, especially since the launch of the Fermi observatory, have revealed that the variability is pervasive – seen in all: flux, spectra, and polarization with time with changes in one often accompanied by changes in others. These studies have also firmly established or confirmed many phenomenological features e.g. the variations are stochastic (e.g. Sobolewska et al. 2014), the broadband emission show a characteristic bi-modal spectral energy distribution (SED) with one peak in-between infra-red to UV/X-ray energies and the other at MeV/GeV energies (e.g. Abdo et al. 2010). Interestingly, despite being extreme among the accretion-powered sources and a

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