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A Unified Model for Multiepoch Neutrino Events and Broadband Spectral Energy Distribution of TXS 0506+056

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The blazar TXS 0506+056 has been proposed as a high-energy neutrino emitter. However, it has been shown that the standard one-zone model cannot produce sufficiently high neutrino flux due to constraints from the X-ray data, implying more complex properties of the radiation zones in the blazar than that described by the standard one-zone model. In this work, we investigate multiepoch high-energy muon-neutrino events associated with the blazar TXS 0506+056 that occurred in 2014–2015, 2017–2018, 2021–2022, and 2022–2023, respectively. We applied the so-called "stochastic dissipation model" to account for the neutrino-blazar associations detected in the four epochs simultaneously. This model describes a scenario in which the emission of the blazar arises from the superimposition of two components: a persistent component related to the quasi-stable state of the blazar and a transient component responsible for the sudden enhancement of the blazar's flux, either in electromagnetic radiation or in neutrino emission. The latter component could form at a random distance along the jet by a strong energy dissipation event. Under such an assumption, the multiepoch broadband spectral energy distribution can be well explained, and the expected number of high-energy neutrino events is statistically realistic. The expected number of neutrino events in half year is around 8.2, 0.07, 0.73, and 0.41, corresponding to the epoch in 2014–2015, 2017–2018, 2021–2022, and 2022–2023, respectively. Hence, our model self-consistently explains the episodic neutrino emission from TXS 0506+056.

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