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Testing a Lepto-Hadronic Two-Zone Model with Extreme High-Synchrotron Peaked BL Lacs and Track-like High-Energy Neutrinos

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Numerous studies suggest that high-energy (HE) neutrinos and ultra-high-energy (UHE) cosmic rays could originate from extremely high-synchrotron peaked (EHSP) BL Lacs, which have been identified as effective particle accelerators. Due to the discovery of HE-neutrinos by the IceCube telescope, these hypotheses may shortly have the opportunity to be tested. In this work, we use a two-zone leptohadronic model to explain the spatial coincidence of three EHSP BL Lac: 1RXS J09462.5+010459, 1ES 1101-232, and 3HSP J095507.9+355101 with the arrival of track-like neutrinos. Our results for 1RXS J09462.5+010459 and 1ES 1101-232 indicate that the model accurately describes the electromagnetic emission and neutrino events without increasing the fluxes in the measured bands. In addition, the X-ray flaring state of 3HSP J095507.9+355101 can be explained by our model, but the measured ultraviolet flux during the neutrino arrival time window cannot be explained. For all cases, the broadband emission and neutrino arrival are better described by hard proton distributions ≈1.5. Finally, the proton luminosity required to explain the neutrino fluxes is slightly higher than the Eddington limit with a photopion efficiency of ≈0.1 for non-flaring state cases. On the other hand, for the flaring state of 3HSP J095507.9+355101, the proton luminosity must be higher than the Eddington limit at least by one order of magnitude, even if the photopion efficiency reaches unity.

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