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VHE Gamma-Ray Emission in the Inner 10 Parsecs of the Galactic Center with CTAO-N LSTs

Observations of the Galactic Center with Imaging Atmospheric Cherenkov Telescopes (IACTs) have identified HESS J1745-290, a very-high-energy (VHE; > 100 GeV) gamma-ray source that is spatially coincident with the dynamical center of the Milky Way Galaxy. The emission detected by IACTs appears point-like (< 0.1 deg) and exhibits a pronounced suppression in its energy-differential spectrum at around 10 TeV. This spectral curvature is generally modeled by a power law with an exponential cutoff.

In this study, model parameters that accurately describe the available datasets are determined, considering both statistical and systematic uncertainties, by analyzing data obtained from current-generation IACTs: H.E.S.S., MAGIC, and VERITAS. Our investigation is in line with the framework of plausible emission mechanisms, including a spike of annihilations of dark matter densely located in the region, a population of millisecond pulsars in the central stellar cluster, and the interaction of accelerated protons near Sagittarius A* with the interstellar medium.

Using the determined models for corresponding physical mechanisms, we examine the sensitivity of forthcoming observations using an array of Large-Sized Telescopes (LSTs) at the Northern site of the Cherenkov Telescope Array Observatory (CTAO-N). Inspired by the models and scenarios proposed to explain the emission from HESS J1745-290 as mentioned above, an objective is defined to distinguish between super-exponential and exponential energy cutoff models through projected measurements of the HESS J1745-290 energy spectrum. We demonstrate that large-zenith-angle observations of the Galactic Center, expected to be performed with the four LSTs at CTAO-N, will enable an investigation into the sharpness of the spectral cutoff, which serves as a key feature distinguishing the possible emission scenarios.

Applying a log-likelihood ratio test statistic, we demonstrate that these physical models can be effectively investigated using accumulated data of the CTAO-N LST array over a five-year period. With 500 hours of observation time, a dark matter annihilation spike model can be clearly differentiated from both the millisecond pulsar and hadronic scenarios, with early indications of distinction observable within the first year of observations, although the latter two scenarios remain indistinguishable from one another.

Collaboration(s)

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