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Hunting for the Extreme Accelerators in Our Universe with Multi-Messenger Observations

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The Earth has been bombarded by high-energy particles for millions of years. Known as cosmic rays, these particles can have higher energies than particles accelerated by the best human-made accelerators. We have studied these energetic particles for over a hundred years. However, the sources of these particles remain a mystery because of the deflection of their trajectories by magnetic fields and their interactions with particles and radiation in interstellar and intergalactic space. Observations of the neutral particles, such as gamma rays and neutrinos, produced during the interactions experienced by cosmic rays have been studied in order to search for their elusive source sites. Observations of neutrinos provide an essential element in these studies as the neutrinos are only generated by hadronic interactions, and they can travel much longer distances than gamma rays. The best way to study the extreme accelerators in our Universe is to combine all of the information from different messengers - cosmic rays, gamma rays, and neutrinos. Recent multi-messenger observations triggered by the IceCube neutrino observatory in the direction of the blazar TXS 0506+056 showed the potential of this approach. I will highlight the role that these high-energy neutrino observations play in the emerging discipline of multi-messenger astrophysics and this will allow us to explore fundamental physics, including searches for decaying dark matter throughout the Universe.

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Please select: Experiment or Theory

Theory

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