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Using Neural Networks to Detect Dark Star Candidates in the Early Universe

Dark Stars, hypothesized to have formed during the cosmic dawn era, are unique stellar objects powered by dark matter annihilation, which provides the energy necessary to counteract gravitational collapse. These stars can achieve immense sizes and luminosities, rivaling entire galaxies. Consequently, they may serve as precursors to the many observed supermassive black holes at high redshift, addressing a significant open question in astronomy. The advent of the James Webb Space Telescope (JWST) has unveiled a plethora of galaxy candidates that are too massive and too numerous for their early appearance in the universe. Inspired by recent work by Ilie et al. (2023, PNAS), who identified the first three Supermassive Dark Star (SMDS) candidates, we developed a Neural Network (NN) to automate the identification of SMDS candidates from JWST photometric data. Trained on simulated SMDS spectra, the NN independently re-identified the three candidates reported by Ilie et al. and uncovered additional potential SMDS candidates.
Expanding on this work, we also trained a neural network to predict the physical parameters of Dark Stars directly from their simulated spectra. This approach achieves near-perfect accuracy when applied to simulated data, demonstrating the powerful synergy between spectral data and neural network models. Spectral confirmation offers significant advantages over photometric analysis alone, as it reduces uncertainties inherent in photometric estimations and provides information about potential spectral lines. While photometry is crucial for initial candidate identification, spectroscopy enables a more robust verification of Dark Star signatures and a deeper understanding of their nature. Our study highlights the potential of neural networks to revolutionize the search for SMDS candidates. The ability to derive precise physical parameters from spectra enhances the prospects of confirming Dark Stars and contributes to our understanding of the early universe and the elusive nature of dark matter. Future applications of this methodology to real JWST spectral data promise to refine our insights into these enigmatic objects, paving the way for breakthroughs in astrophysics and particle physics.

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