Unveiling Distant Worlds: Discovering 13 Ultracool Y-Dwarf Candidates With a Novel Model-Based Machine Learning Detection Technique

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Ultra-cool (<600 K) brown dwarfs are elusive objects between the planetary and stellar regimes. Due to their faint magnitudes in common photometric bands, they are notoriously difficult to detect. As of 2023, only 32 Y-type brown dwarfs have been detected. Modern automated detection methods for these objects often use incomplete empirical training data, which limits searches to already-cataloged spectral types. To address these challenges, I present a breakthrough technique, involving machine learning and state-of-the-art atmospheric models, which I used to search for ultra-cool brown dwarfs in the UKIDSS Ultra Deep Survey (UDS) field. The isochrones presented in these models were filtered to T/Y parameters, interpolated by metallicity, and assigned spectral-type labels based on their MKO and WISE photometry. The model sets were further narrowed down by an alternate (as opposed to the deuterium limit) brown dwarf minimum mass calculation based on the lower mass limit of shock-induced star formation. These synthetic models, along with non-substellar templates, were finally used to train an ensemble classification system built on several machine learning networks, including k-NNs, random forests, and ANNs. This classifier was subsequently applied to the UDS field, which resulted in the discovery of 13 new Y-type brown dwarf candidates, 7 of which had SIMBAD 'Near-IR' counterparts, and 6 uncatalogued detections, all of which were preliminarily verified through proper motion measurements. These dwarfs are the first to be identified directly from UDS photometry and are some of the coolest dwarfs discovered yet (~400 K).

Awards Won:
Third Award of $1,000
Shanghai Science Association for Young Talents: Science Seed Award
NC State College of Engineering: Alternates (not read aloud)