Atmospheric and Dust Properties of Brown Dwarfs Based on JWST Observations

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Brown dwarfs are substellar objects with masses between the heaviest gas giant planets and the lightest stars, exhibiting complex and dynamic atmospheric processes. Investigating their atmospheric structure, chemical composition, and dust characteristics is essential for understanding the physics and chemistry of low-temperature atmospheres, as well as improving models of stellar evolution and planet formation.

With effective temperatures generally ranging from approximately 250 to 2500 K, brown dwarfs are cool enough to allow the formation of atmospheric dust clouds composed of high-temperature condensates such as metal oxides and silicates. Additionally, young brown dwarfs may retain circumstellar dust disks from their formation stages. However, due to their low temperatures and infrared-dominated radiation, systematic observations of brown dwarfs have historically been limited by instrumental capabilities, resulting in a relatively small number of confirmed objects and limited related studies.

The James Webb Space Telescope (JWST), with its exceptional infrared sensitivity, provides an unprecedented opportunity to investigate the atmospheric and dust properties of brown dwarfs in detail. Based on JWST/NIRSpec and MIRI observations, we analyzed the spectra of 20 extremely cold brown dwarfs, identifying prominent absorption features from H_2O, CH_4, and NH_3. In even colder objects, absorption lines of CO and CO_2 were also detected. Furthermore, we conducted a systematic search of over 40,000 JWST/NIRSpec PRISM-mode spectra, identifying 65 brown dwarf candidates with effective temperatures below 2000 K, including 13 newly discovered objects. Based on these brown dwarfs, we will further investigate their molecular compositions, dust characteristics, and circumstellar environments.