The Mysterious Auroras of Brown Dwarf W1935

Recently discovered emission spectra from the ancient Brown Dwarf W1935 indicate that it likely has auroras. The object is cold, dark, and has no known companions. So what are the possible power sources for its light emissions?

Link to YouTube Video | Link to Blog Post | Link to Research Paper

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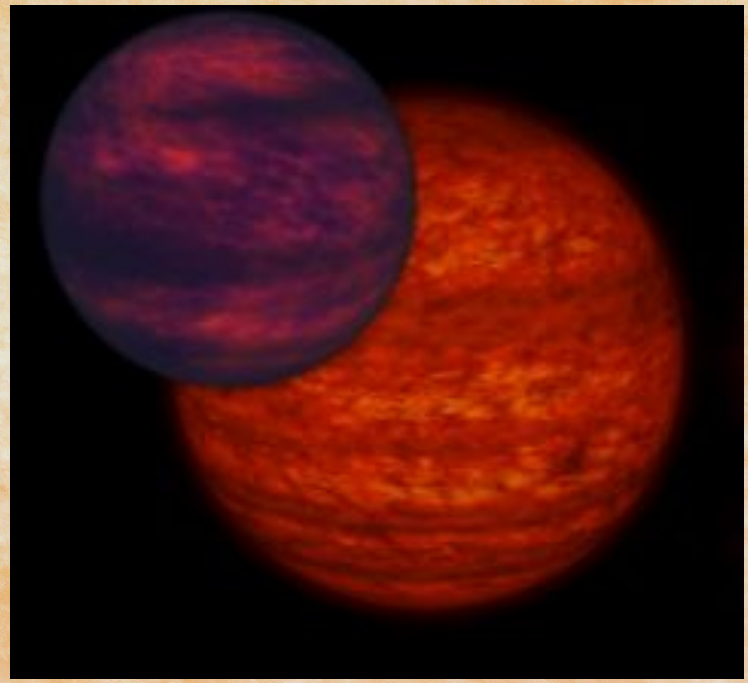
Brown Dwarf Basics

- Brown Dwarf stars were originally theorized by Shiv S Kumar in 1962. He proposed their maximum temperature to be 2 million degrees and maximum mass 0.07 Solar Masses (about 80 Jupiters)
- Take ~1 Billion years to form, then are heated by deuterium fusion for ~10 million years
- The theoretical mass range is 13.7 to 80 Jupiters
- Emit radio waves and infrared light, and glow dimly in the visible range. Some emit X-rays.

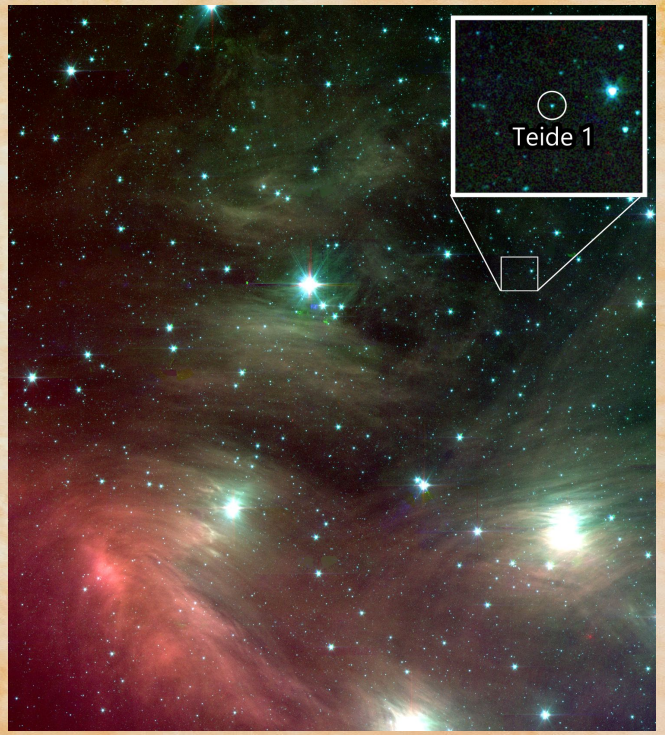
Brown Dwarf De-Evolution

- During their hot phase, the core temperature rises to about 2 million degrees
- Strong convection currents mix deuterium into the core
- After about 10 million years, the deuterium is exhausted
- In the cooling phase, the Brown Dwarf shrinks. Metallic clouds of Si, Fe, Mn, Mg, Na, and K form, and eventually drift to the core
- As cooling continues, molecules like ammonia, carbon- monoxide and dioxide, water, and methane accumulate in the atmosphere



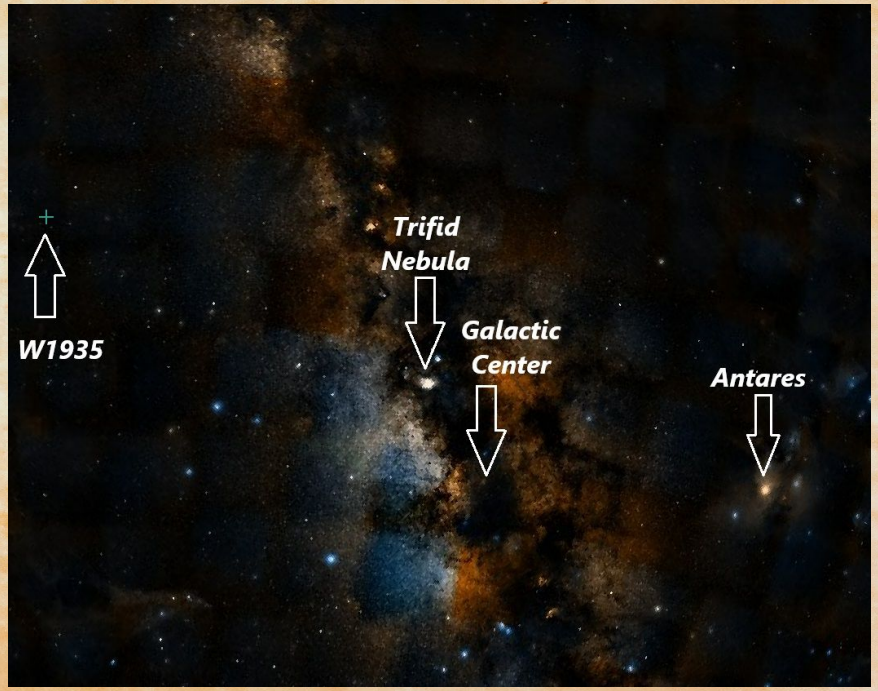
Tiede 1 – The First Brown Dwarf Discovered

- Tiede 1 was discovered by Lopez, Zaptero-Osorio, and Martin in 1994 and verified in 1995
- Lithium is destroyed by proton bombardment in stars, but Brown Dwarfs don't produce enough heat for this
- Identified in the Pleiades cluster by its Lithium signature
- It's estimated to be 55 Jupiter masses, 4200 deg F, and 70 to 140 million years old (same as the rest of the cluster)



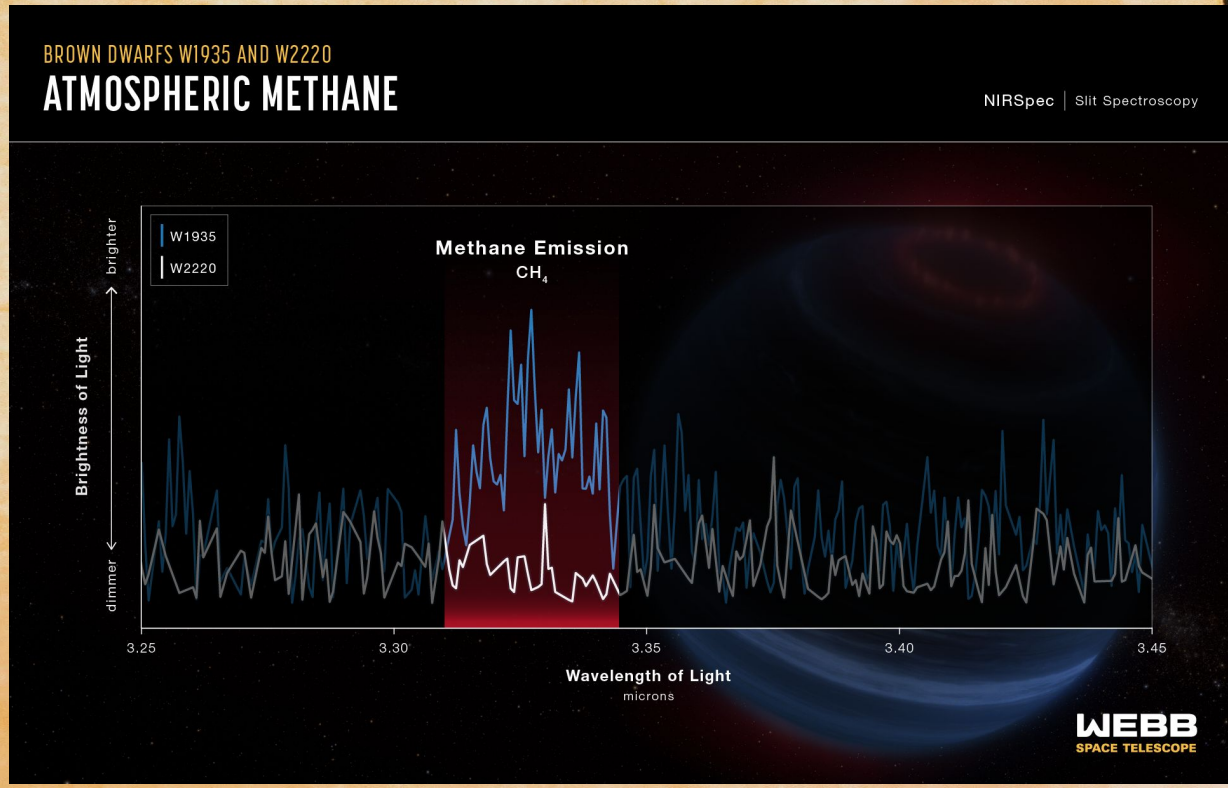
W1935 - Ancient, Cold, and Dark

- W1935 is 47 light years away in Sagittarius, near the galactic center
- Discovered by NASA Citizen Scientist Dan Caselden through machine learning analysis of CatWISE data
- Verified using GAIA data, and visually analyzed by the Spitzer Space Telescope
- Estimated to be 5 to 35 Jupiter masses, less than 415 degrees F, and 1.5 to 6.5 billion years old
- No known companions



Recent Discovery of CH_4 Emission Spectrum

- A group of astronomers used JWST to observe the infrared spectra of 12 potential Brown Dwarfs, including W1935 and W2220
- Where all others showed only absorption across the methane spectrum, W1935 showed a jump in energy in one band, indicating IR emission
- This indicates small blips or curtains of light are visible at the surface



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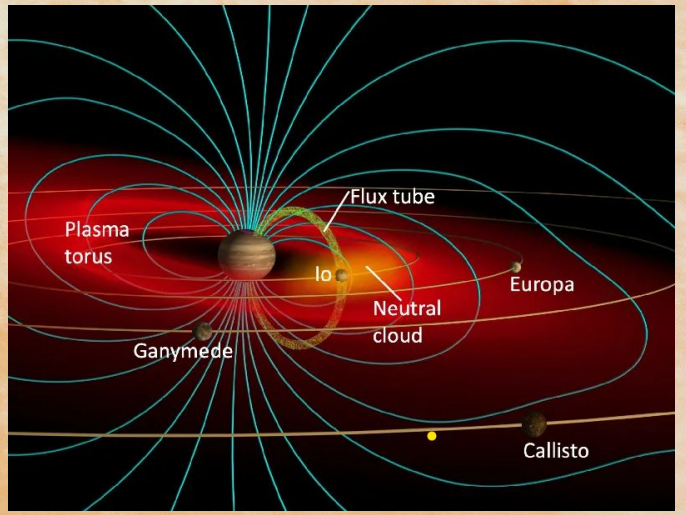
Auroras on Earth

Auroras in our solar system require an atmosphere, a magnetic field, and electromagnetic emissions from the Sun. On Earth, the Sun's emissions, aka the Solar Wind, penetrate the magnetic field at the winter pole and ionize molecules in the atmosphere. This creates curtains of light known as the Aurora Borealis and Aurora Australis.

Auroras on Jupiter

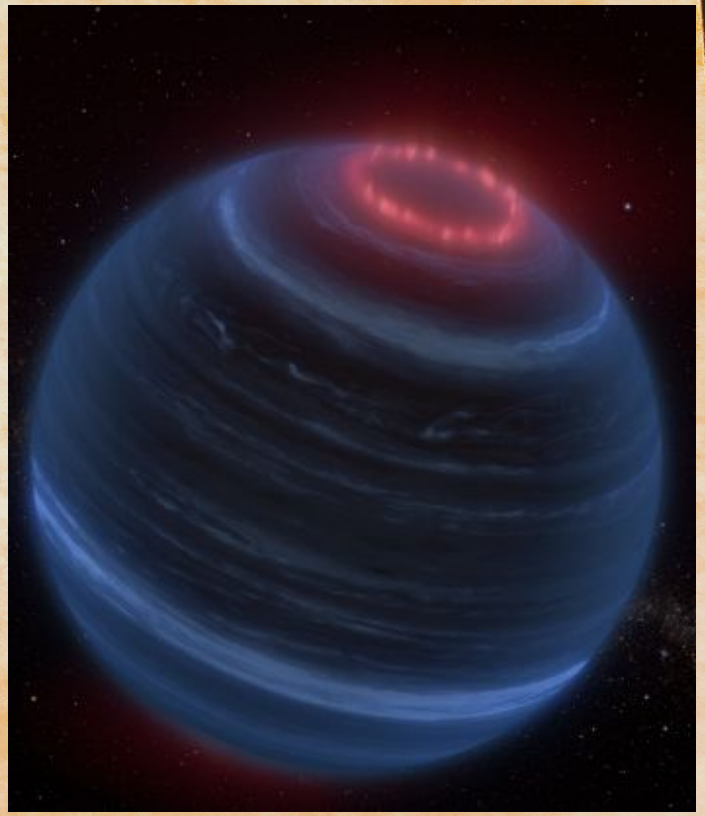
- Jupiter's occur at both poles simultaneously, often spread beyond 80 degrees, and have a more variable pattern than Earth's
- Juno's JEDI ion detector found accelerated protons travelling at speeds up to 31 million MPH between Jupiter's poles and Io
- It's now believed that material from Io, Ganymede, and Europa is ionized by solar wind, and accelerated to the poles along Jupiter's magnetic field lines. These contribute to the outer oval.
- Likely to be similar on Saturn.



The Mystery

Because W1935 has no stellar companion the emissions can't be lit by solar winds, so there must be another energy supply.

- Extensive and expansive lightning storms
- An X-Ray source directed toward it, such as an emission jet from a distant black hole or neutron star
- Plasma injections from a galactic filament
- Ionic mass transfer from a moon or local molecular cloud
- Volcanic emissions from settling within the core



Future Implications

- The auroras of Jupiter, Saturn, and Neptune are strong in the radio spectrum. Using radio telescopes to analyze W1935's auroras could lead to a faster way to find similar phenomena.
- The discovery shows that Brown Dwarfs aren't only highly dynamic objects, variability may be relatively common and observable
- Auroras are more complex than previously understood and there are more avenues for studying them
- Brown Dwarfs are high in Carbon Monoxide. If ionization and electrical impulses are common on them, they're likely to be rich in complex organic compounds as well.

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