New Kinds of Stars

L & T Dwarfs

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For many years astronomers were faced with two questions that offered no ready answers: What are objects that are intermediate in mass between stars and planets like? Are they prevalent in the Universe and could they be a source of dark matter? Thanks partly to observations made from the Keck Observatory, astronomers can now provide those answers.

Stars form as gas collapses and heats up within interstellar clouds. "Brown dwarfs" are thought to form in the same way, but with masses too low to generate sufficient heat to ignite hydrogen fusion. Without a central energy source, brown dwarfs continue to cool forever, much like embers plucked from a roaring fire.

The term "brown dwarf" can be a bit misleading. Brown dwarfs actually appear to be reddish. Just like embers, brown dwarfs become redder as they cool (very hot embers are actually blue), so the best prospect for discovering them is with surveys conducted at infrared wavelengths, beyond the red extreme of the visible spectrum. One survey in particular, the Two Micron All Sky Survey (2MASS), scanned the entire night sky at these wavelengths between 1997 and 2001.

Brown dwarf suspects were selected by looking for objects that were detected by the 2MASS survey, but that appeared virtually invisible (or at least very dim) on optical images of the same patch of sky. In 1997 observations on these candidates began at the Keck Observatory to obtain their spectra, a kind of fingerprint that splits the light into its component "colors" to reveal the object's temperature and chemical makeup. With these spectra we were able to verify over two hundred previously unidentified brown dwarfs in the vicinity of the Sun.

Because of the distinctive new range of temperatures and chemical makeup of these objects, the century-old spectral type sequence that had become familiar to all astronomers had to be revised.

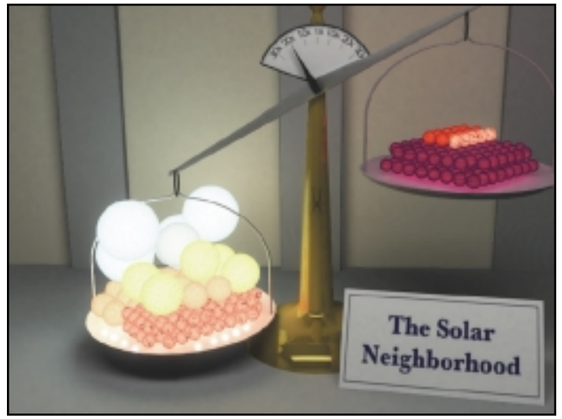
Fig. 1 shows an artist's rendition comparing these new brown dwarf objects with the Sun. On the far left is the limb of the Sun. To its right is a "late-M dwarf" star, a type of very low-mass brown dwarf. The next is a hotter "L dwarf" star and a cooler "T dwarf" star. The planet Jupiter is on the far right.

The colors of the brown dwarfs are chosen to match an age of 1 billion years. Despite the range in mass, all four of these objects are approximately the same size, about 10 times smaller than the diameter of the Sun. Fig. 1 shows how these objects might appear to the human eye; the M and L dwarfs are red, while the T dwarf is dimly magenta.

Not only have observations at the Keck telescopes enabled us to learn more about what these objects are made of, they have also allowed us to answer the second question: Can these objects be the source of dark matter in the Universe?

1) Artist rendition of new brown dwarf objects compared to the Sun. Ranked left to right: Late-M dwarf, hotter L dwarf, cooler T dwarf, and Jupiter on far right.

Fig. 2 shows a typical slice of the Milky Way Galaxy (our Solar Neighborhood) and the numbers of objects we could expect to find in that slice. Despite escaping detection for so many years, it seems these new types of brown dwarf objects are at least as common as the stars in our own Milky Way galaxy, even though most are so cool that even the Keck telescopes cannot detect them. However, even with these large numbers, the mass of these brown dwarfs is so low they can be ruled out as the source of the missing dark matter. Thus, the nature and source of this dark matter remains mysterious.



2) A typical slice of the Milky Way galaxy, our Solar Neighborhood. The mass of newly-discovered brown dwarfs (right) does not match the mass of stars (left).