Binary system discovered with two stars so close together they could fit inside the sun

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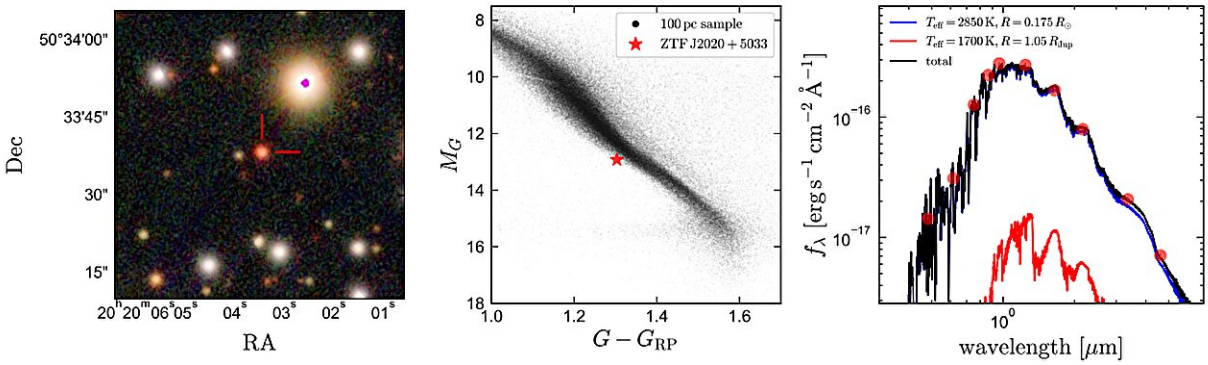

Left: 1-arcminute wide Pan-STARRS i/r/g postage stamp centered on ZTF J2020+5033. Middle: the source's position on the Gaia color-magnitude diagram, compared to the 100 pc sample. The source is slightly blueward of the main sequence, suggesting low metallicity and little contribution from a second star in the optical. Right: optical and infrared spectral energy distribution (SED), with best-fit models (Section 3) overplotted. The SED is dominated by an M dwarf with Teff ≈ 2850 K and R ≈ 0.175 R⊙. In the infrared, the cooler brown dwarf contributes ≈ 10% of the light. Credit: *arXiv* (2023). DOI: 10.48550/arxiv.2307.15729

A small team of astrophysicists from the California Institute of Technology, the MIT Kavli Institute for Astrophysics and Space Research and the University of Amsterdam has discovered a binary system with two stars so small and close together they could fit inside the

sun. The team has submitted a paper describing their findings for publication in *The Open Journal of Astrophysics*; currently, it is posted on the *arXiv* preprint server.

The two stars, a brown dwarf and a red dwarf, are approximately 457 light-years from Earth, which is considered to be very close. The team has named the system ZTF J2020+5033. Data from the Zwicky Transient Facility revealed that the two stars spin around each other in a 1.9-hour orbit—by far the closest orbit every recorded for a brown dwarf.

Brown dwarfs are unique in the universe because they barely qualify as stars—they are more like glowing planets. They are large enough to ignite fusion at their cores, but not hydrogen. Thus, they are quite dim, which makes them difficult to spot and study. The research team suggests finding one in a binary system with a red dwarf should help to learn more about brown dwarfs.

The researchers found that the red dwarf is small for stars in its category, with a radius of just 17.6% that of the sun and a mass just 13.4%. The brown dwarf, however, is large for its category. It has a radius that is about the same as Jupiter's, though its mass is 80.1 times that of the planet.

The research team also found evidence suggesting that the binary system is quite old and that the two stars were likely once larger and circling each other at a greater distance. The data also showed that the two stars will likely continue moving closer together. As they do, because the brown dwarf has higher surface gravity, it will eventually begin to steal material from the red dwarf.

The research team plans to continue to study the binary system, hoping to learn more about both brown and red dwarfs and about how such a

system could have come to exist.

More information: Kareem El-Badry et al, A transiting brown dwarf in a 2 hour orbit, *arXiv* (2023). DOI: 10.48550/arxiv.2307.15729