IOPscience

OPEN ACCESS

Identification of a Low-mass Companion to the White Dwarf SDSS J131730.84+483332.7

Peter A. Jalowiczor[1], Sarah Casewell[2], Adam C. Schneider[3,4], Jonathan Gagné[5,6], Jacqueline K. Faherty[7], Marc J. Kuchner[8], Aaron M. Meisner[9], and Adam J. Burgasser[10]

Published April 2021 •

Research Notes of the AAS, Volume 5, Number 4

Focus on AAS 237

Citation Peter A. Jalowiczor *et al* 2021 *Res. Notes AAS* **5** 76

[1] Backyard Worlds: Planet 9

[2] Department of Physics and Astronomy, University of Leicester, Leicester, LE1 7RH, UK

[3] United States Naval Observatory, Flagstaff Station, 10391 West Naval Observatory Rd., Flagstaff, AZ 86005, USA

[4] Department of Physics and Astronomy, George Mason University, MS3F3, 4400 University Drive, Fairfax, VA 22030, USA

[5] Planétarium Rio Tinto Alcan, Espace pour la Vie, 4801 ave. Pierre-de Coubertin, Montréal, QC H1V 3V4, Canada

[6] Institute for Research on Exoplanets, Université de Montréal, 2900 Boulevard Édouard-Montpetit Montréal, QC H3T 1J4, Canada

[7] Department of Astrophysics, American Museum of Natural History, Central Park West at 79th Street, NY 10024, USA

[8] Exoplanets and Stellar Astrophysics Laboratory, NASA Goddard Space Flight Center, 8800 Greenbelt Road, Greenbelt, MD 20771, USA

[9] NSF's National Optical-Infrared Astronomy Research Laboratory, 950 N. Cherry Ave., Tucson, AZ 85719, USA

[10] Center for Astrophysics and Space Science, University of California San Diego, La Jolla, CA 92093-0424, USA

Peter A. Jalowiczor https://orcid.org/0000-0002-4175-295X

Sarah Casewell https://orcid.org/0000-0003-2478-0120

Adam C. Schneider https://orcid.org/0000-0002-6294-5937

Jonathan Gagné https://orcid.org/0000-0002-2592-9612

Jacqueline K. Faherty https://orcid.org/0000-0001-6251-0573

Marc J. Kuchner https://orcid.org/0000-0002-2387-5489

Aaron M. Meisner https://orcid.org/0000-0002-1125-7384

Adam J. Burgasser https://orcid.org/0000-0002-6523-9536

Received March 2021
Revised March 2021
Accepted March 2021
Published April 2021

https://doi.org/10.3847/2515-5172/abf49a

Substellar companion stars; Binary stars

Abstract

We present the discovery of 2MASSJ13173072+4833343, a low-mass stellar companion to the ~5.5Gyr old white dwarf SDSSJ131730.85+483332.8. This companion was discovered through the Backyard Worlds: Planet 9 citizen science collaboration. We obtained a near-infrared spectrum of the companion and determined a spectral type of M8.5. Using the cooling age of the white dwarf, we determined that the stellar companion has a mass of $0.077^{+0.005}_{-0.017}$ $M_\odot$, or $80.2^{+0.5}_{-1.8}$ $M_{\rm Jup}$, near the substellar boundary.

1. Introduction

The Backyard Worlds: Planet 9 (BYW; Kuchner et al. 2017) project investigates whether the hypothetical Planet 9 (Batygin & Brown 2016), presumed to exist at the fringes of our solar system, may be detectable in archival infrared data from a visual inspection of Wide-field Infrared Survey Explorer (WISE; Wright et al. 2010) data by citizen scientists. The same technique is also used to identify many previously unknown low-mass stars and brown dwarfs in the Solar neighborhood. The project has been extremely successful in discovering new brown dwarfs, and has generated the discovery of exotic objects such as extreme T-type subdwarfs (Schneider et al. 2020) and common proper motion companions to other stars (Rothermich et al. 2021).

2. Discovery of 2MASSJ13173072+4833343

We identified a candidate substellar companion co-moving with the previously known white dwarf SDSS J131730.85+48332.8 (Kepler et al. 2015) through the BYW project. WISEA J131730.63+483333.0 (2MASSJ13173072+4833343) was identified as having a similar proper motion and Gaia parallax (Gaia Collaboration et al. 2016) to the white dwarf at a separation of 2'' on the sky, indicating that they are likely associated.

We obtained a near-infrared spectrum for the low-mass star using the SpeX spectrograph (Rayner et al. 2003) which was in PRISM mode with the 08 slit; the resolving power is about *R*~100. at NASA's Infrared Telescope Facility (IRTF) on UT 2020 December 24. This target was observed with 4 exposures of 90 s each, at an airmass ~1.22. The night was clear with a 05 seeing. The data were reduced with Spextoolv4.1 (Cushing et al. 2004) and telluric corrected using the A0 star HD116405 with the method of Vacca et al. (2003).

Kilic et al. (2020) determined that the DA white dwarf SDSSJ131730.85+483332.8 has an effective temperature of 5903±22K and a surface gravity $\log g = 8.040 \pm 0.008$. Using the Bergeron et al. (2019) atmosphere models and the Kilic et al. (2020) parameters, we estimate a mass of 0.611±0.005 $M_{\odot}$, and a total age of $5.5^{+4.3}_{-1.9}$ Gyr by combining the Bédard et al. (2020) cooling tracks with the Cummings et al. (2018) initial-to-final mass relations coupled with the main-sequence lifetimes of the MIST evolutionary models (Choi et al. 2016). We estimate that the progenitor of this white dwarf was an ≈F1-type star with a mass of 1.5±0.4 $M_{\odot}$.

3. Discussion

A visual comparison of our IRTF/SpeX spectrum to spectroscopic templates (Figure 1) allowed us to estimate a spectral type of M8.5, whereas the H_2O index-based classification of Allers & Liu (2013) yields a consistent spectral type of M8.8±0.5. We estimate a mass of $0.077^{+0.005}_{-0.017}$ $M_{\odot}$ for the low-mass star using the BT-Settl model tracks (Baraffe et al. 2002) at the age of the white dwarf, using its 2MASS and AllWISE photometry and the likelihood method of Gagné et al. (2015). Our model-dependent mass estimation is only consistent with the stellar regime, although it is located close to recent estimates of the substellar boundary (e.g., 75.0±0.8M_{Jup}; Dieterich et al. (2018), versus $80.2^{+0.5}_{-1.8}$ M_{Jup} for our companion).

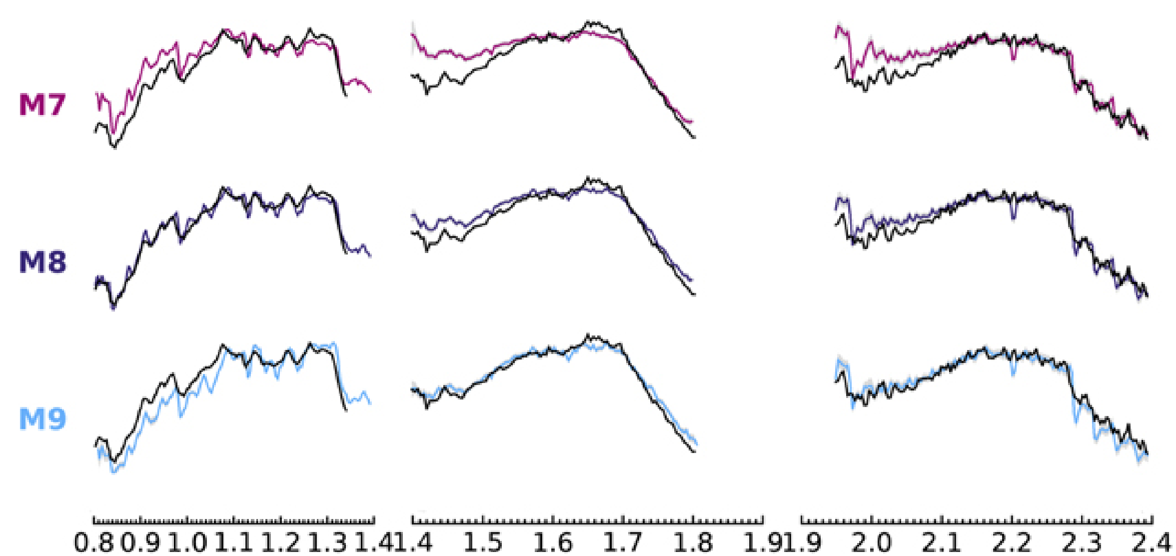

Figure 1. IRTF/SpeX 0.8–2.4μm spectrum of 2MASSJ13173072+4833343, compared with M7, M8, and M9 spectral templates (Gagné et al. 2015). We determine a near-infrared spectral type of M8.5. Built with the method described as per (Cruz et al. 2018). The IRTF/SpeX FITS spectrum shown this figure is available as the Data behind the Figure.(The data used to create this figure are available.)

The GaiaEDR3 (Gaia Collaboration et al. 2020) proper motions of the white dwarf and companion are, respectively, ($\mu_\alpha \cos\delta$, μ_δ)=(−68.78±0.05, −113.21±0.06) $\mathrm{mas\,yr^{-1}}$ and (−65.2±0.2, −111.9±0.2) $\mathrm{mas\,yr^{-1}}$, and their respective parallaxes are 25.63±0.06mas and 25.8±0.2 mas. These kinematics indicate that the two objects are likely gravitationally bound, but the proper motion difference is significant at 3.8±0.2$\mathrm{mas\,yr^{-1}}$ and may be due to the orbital motion of the secondary. We estimate the orbital period of the pair at ~900 yr assuming a circular orbit.

4. Conclusion

We present the discovery of a low-mass stellar co-moving companion to the DA white dwarf SDSSJ131730.85+48332.8. We obtained a near-infrared spectrum for the M8.5-type low-mass star and we estimate its mass at $0.077^{+0.005}_{-0.017}$ $M_\odot$ from the cooling age of the white dwarf. This system has a wide projected orbital separation of ~79au. This system joins a growing list of recent discoveries from the Backyard Worlds: Planet 9 Citizen Science community.

We thank Antoine Bédard for useful comments and for providing updated white dwarf cooling tracks. This work has made use of data from the European Space Agency (ESA) mission Gaia (https://www.cosmos.esa.int/gaia), processed by the Gaia Data Processing and Analysis Consortium (DPAC,https://www.cosmos.esa.int/web/gaia/dpac/consortium). Funding for the DPAC has been provided by national institutions, in particular the institutions participating in the Gaia Multilateral Agreement, This publication makes use of data products from the Wide-field Infrared Survey Explorer, (WISE) which is a joint project of the University of California, Los Angeles, and the Jet Propulsion Laboratory/ California Institute of Technology, funded by the National Aeronautics and Space Administration. Data were obtained by the visiting Astronomer program at the Infrared Telescope Facility, which is operated by the University of Hawaii under contract 80HQTR19D0030 with the National Aeronautics and Space Administration.

The authors wish to recognize and acknowledge the very significant cultural role and reverence that the summit of Maunakea has always had within the indigenous Hawaiian community. We are most fortunate to have the opportunity to conduct observations from this mountain.