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EMBARGO CONDITIONS: This press release is EMBARGOED until 14 November 2018 at 19.00h Central European Time (CET)

Our stellar neighbourhood is getting crowded — Planet discovered orbiting the second closest stellar system to the Earth

Measurements from high-precision instruments reveal a cold super-Earth around Barnard's star

- **An international team of astronomers led by Ignasi Ribas of the Institute of Space Studies of Catalonia (IEEC) and Institute of Space Sciences (ICE, CSIC) has found a candidate planet in orbit around Barnard's star.**
- **Barnard's star is the closest single star to the Sun and second only to the Alpha Centauri triple stellar system.**
- **The team used about 18 years of observations and combined them with new observations with the CARMENES planet-hunter spectrograph at Calar Alto/Spain and other facilities.**
- **Astronomers obtained significant evidence of a planet with mass just over 3 times the Earth's mass orbiting the red dwarf star every 233 days. This would place the super-Earth near the so-called snow-line of the star, where it is likely to be a frozen world.**
- **This is the first time astronomers discover this kind of exoplanet using the radial velocity method [1].**
- **The finding will be published in the journal Nature on 15 November 2018.**

At only six light-years from us, Barnard's star appears to move across Earth's night sky faster than any other star. This red-dwarf star, smaller and older than our Sun is among the least active red dwarfs known and represents an ideal target to search for exoplanets with various methods.

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Since 1997, several instruments have been gathering a large amount of measurements on the star's subtle back-and-forth wobble. An analysis of the data collected up to 2015, including observations from HIRES/Keck, and ESO's HARPS and UVES spectrometers, suggested the wobble could be caused by a planet with an orbital period of about 230 days. To confirm this, however, more measurements were deemed necessary.

Trying to see if the result could be confirmed, astronomers regularly monitored Barnard's star with high precision spectrograph such as the CARMENES (Calar Alto Observatory in Spain), and also HARPS and HARPS-N in an international effort called the Red Dots collaboration [2]. This technique consists on using the Doppler effect on the starlight [1] to measure how the velocity of an object along our line of sight changes with time.

"For the analysis we used observations from seven different instruments, spanning 20 years, making this one of the largest and most extensive datasets ever used for precise radial velocity studies. The combination of all data led to a total of 771 measurements," explains Ignasi Ribas.

A clear signal at a period of 233 days arose again in the re-analysis of all the measurements combined. This signal implies that Barnard's star is approaching and moving away from us at about 1.2 m/s — approximately the walking speed of a person — and it is best explained by a planet orbiting it.

"After a very careful analysis, we are over 99% confident that the planet is there, since this is the model that best fits our observations," assures Ignasi Ribas. "However, we must remain cautious and collect more data to nail the case in the future, because natural variations of the stellar brightness resulting from starspots can produce similar effects to the ones detected." Follow-up observations are already happening at different observatories.

The planet candidate, named Barnard's star b (or GJ 699 b), is a super-Earth with a minimum of 3.2 Earth masses. It orbits its cool red parent star every 233 days near the snow-line, a distance where water would be frozen. In the absence of an atmosphere, its temperature is likely to be about -150 ºC, which makes it unlikely that the planet can sustain liquid water on its surface. However, its characteristics make it an excellent target for direct imaging using the next generation of instruments such as NASA's Wide Field InfraRed Survey Telescope (WFIRST, [3]), and maybe with observations from the ESA mission Gaia [4].

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Exoplanets so small and so far away from their parent star have not been discovered before using the Doppler technique [1]. This means that astronomers are getting better at finding and exploring a relatively new kind of planets outside our Solar System. With the next generation of instruments, these capabilities can only expand.

“We all have worked very hard on this result,” said Guillem Anglada-Escude from Queen Mary University of London and co-leader of this work. “This is the result of a large collaboration organised in the context of the Red Dots project, which is why it has contributions from teams all over the world including semi-professional astronomers coordinated by the AAVSO.”

Cristina Rodríguez-López, researcher at the Instituto de Astrofísica de Andalucía (IAA, CSIC) and co-author of the paper, comments on the significance of this finding. "This discovery means a boost to continue on searching for exoplanets around our closest stellar neighbours, in the hope that eventually we will come upon one that has the right conditions to host life".

Notes

[1] In the radial velocity method, precision spectrometers are used to measure the Doppler effect. When an object moves away from us, the light we observe becomes slightly less energetic and redder. The opposite -light becomes slightly more energetic and bluer- happens when the star comes to us.

[2] RedDots is a collaborative observational effort dedicated to searching for terrestrial planets in warm orbits around the nearest red-dwarf stars to the Sun.

[3] WFIRST is a planned NASA mission that will be dedicated to answer cosmological questions, and also enable the detection of very nearby exoplanets with direct imaging.

[4] Gaia is an astrometric space mission from the European Space Agency (ESA) that is currently measuring precise positions and motions of stellar objects.

Observatories and Instruments

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The **CARMENES** (*Calar Alto high-Resolution search for M dwarfs with Exoearths with Near-infrared and optical Échelle Spectrographs*) instrument is a high-resolution optical and near infrared spectrograph built in collaboration by various Spanish and German research institutions, and it is operated by the Calar Alto observatory (Spain).

The **European Southern Observatory** (ESO) operates two facilities used in this research, namely the HARPS and UVES instruments. HARPS (*High Accuracy Radial velocity Planet Searcher*) is dedicated to the discovery of exoplanets at the ESO 3.6-metre telescope (La Silla, Chile). UVES (*Ultraviolet and Visual Echelle Spectrograph*) is a high-resolution optical spectrograph at ESO's Very Large Telescope (Paranal, Chile).

HIRES (*High Resolution Echelle* Spectrograph) is a high-resolution spectrograph at the W. M. Keck Observatory (Mauna Kea, Hawaii).

PFS (Planet Finder Spectrograph) is a high-resolution precision spectrograph at the Magellan 6.5m telescopes (Las Campanas Observatory, Chile).

APF (Automated Planet Finder) is a 2.4m telescope with a custom-made high-resolution precision spectrograph for precision radial velocities at the Lick observatory (California, USA).

HARPS-North (or HARPS-N) is a replica of ESO's HARPS installed at the Telescopio Nazionale Galileo/Italy (La Palma, Spain).

Several observatories contributed to follow-up activities through the RedDots project, including observers from the AAVSO (*American Association of Variable Star Observers*). The AAVSO is an association formed by amateur astronomers that collect, evaluate, analyse, publish and archive variable star observations. These observations will be presented in more detail in a forthcoming publication.

Links

- IEEC
- RedDots

More information

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This research is presented in a paper entitled "A super-Earth planet candidate orbiting at the snow-line of Barnard's star", by I. Ribas et al., to appear in the journal Nature on 15 November 2018.

IEEC (Institut d'Estudis Espacials de Catalunya) is a research institute dedicated to the study of all areas of space and space sciences including astrophysics, cosmology, planetary sciences, Earth observation, and space engineering; and it is integrated in the CERCA network (Centres de Recerca de Catalunya). Its mission is the promotion and coordination of space research and technology development in Catalonia for the benefit of the broader society. IEEC is integrated by four units : Institute of Cosmos Sciences (ICCUB - Universitat de Barcelona), Center of Space Studies and Research (CERES - Universitat Autònoma de Barcelona), Research Group in Space Sciences and Technologies (CTE - Universitat Politècnica de Catalunya), Institute of Space Sciences (ICE - Consejo Superior de Investigaciones Científicas). IEEC is a highly ranked international research centre producing a large number of high-impact publications; and it leads key world-class projects. IEEC's engineering division also develops instrumentation for multiple ground-based and space-based projects, and has extensive experience in working with aerospace and technology in both the private and public sectors.

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