FACULTY OF SCIENCE
THE UNIVERSITY OF HONG KONG
香港大學理學院

DEAN
Professor Qiang ZHOU

Press release For Immediate release

# HKU Astrophysicists Lead Research Team to Uncover the Role of Binary Star Evolution in the Origin of a Retrograde Planet

25 May, 2025

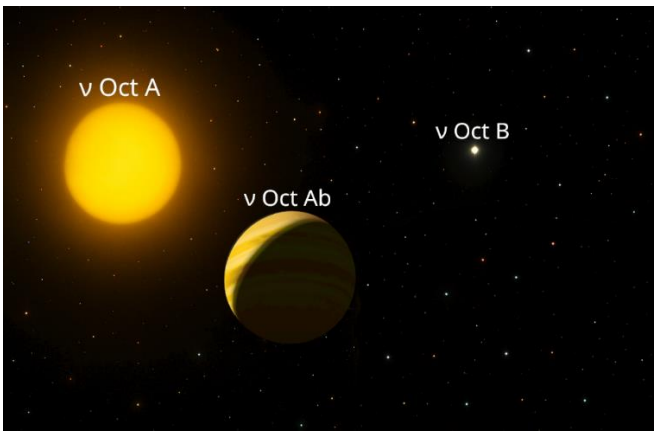


***Image 1:*** *Artist's impression of the ν Octantis system, with the planet ν Oct Ab and the white dwarf ν Oct B around the primary subgiant star ν Oct A. Image generated by ChatGPT-4.0 and further modified by Trifon TRIFONOV using the GNU Image Manipulation Program.*

Most stars in the Universe exist in binary or multiple star systems, where the presence of close-in companion stars in such systems can adversely influence the formation and orbital stability of planets around one of the stars. An international team of astrophysicists led by Professor Man Hoi LEE from the Department of Earth Sciences and the Department of Physics at The University of Hong Kong (HKU) and Mr Ho Wan CHENG, an MPhil student in his team, has confirmed the existence of a planet in an unprecedented retrograde orbit (moving in the opposite direction to the binary's orbit) in the ν Octantis (nu Octantis) binary star system and revealed the role of binary star evolution in the origin of this planet. The findings have been published in the journal *Nature*.

ν Octantis is a tight binary star system comprising a primary subgiant star, ν Oct A, with about 1.6 times the mass of the Sun, and a secondary star, ν Oct B, with about half the mass of the Sun. The two stars orbit each other with a period of 1,050 days.

An additional periodic signal in the radial velocity observations (measurements of how a star moves towards or away from us) of this system was first reported by Dr David RAMM, a co-author of this new paper, during his PhD studies at the University of Canterbury, New Zealand, in 2004. This signal was consistent with the presence of a Jovian planet of about twice the mass of Jupiter orbiting around the primary star, ν Oct A, with a period of about 400 days. However, the existence of this planet has been controversial because its orbit would be so wide that it could only remain stable if it were retrograde and moved in the opposite direction to the orbit of the binary. There were no observational precedents for such a planet and strong theoretical grounds against its formation.

To settle the debate, the research team obtained new high-precision radial velocity observations using the European Southern Observatory (ESO)'s HARPS spectrograph, which confirmed the existence of the planet signal. 'We performed an analysis of the new and archival radial velocity data spanning 18 years and found stable fits that require the planetary orbit to be retrograde and nearly in the same plane as the binary orbit," said Mr Ho Wan CHENG, the first author of the paper.

Another key focus of the new study was the determination of the nature of the secondary star ν Oct B. The mass of ν Oct B suggests that it could be either a low-mass main-sequence star or a white dwarf. All stars

spend most of their lives on the main sequence, generating energy through nuclear fusion of hydrogen to helium in their core. After a star has exhausted its nuclear fuel, its core collapses into a stellar remnant, which would be a white dwarf if the star's initial mass is less than several times that of the Sun. A white dwarf has a mass comparable to that of the Sun packed in an Earth-sized volume.

To identify which type of star ν Oct B is, the research team used the adaptive optics imaging instrument SPHERE at ESO's Very Large Telescope to observe the system. The fact that ν Oct B was not detected in these observations indicated that it must be a very faint white dwarf. This suggests that the binary system has evolved significantly since its formation, as ν Oct B has already ejected most of its mass and entered the final stage of its stellar evolution.

The research team looked into the possible primordial configurations of the binary — that is, the initial masses of the two stars and the initial orbit of the binary. 'We found that the system is about 2.9 billion years old and that ν Oct B was initially about 2.4 times the mass of the Sun and evolved to a white dwarf about 2 billion years ago,' said Cheng. 'Our analysis showed that the planet could not have formed around ν Oct A at the same time as the stars.'

The discovery that ν Oct B is a white dwarf opens new possibilities for how the retrograde planet may have originated. 'When ν Oct B evolved into a white dwarf about 2 billion years ago, the planet could have formed in a retrograde disc of material around ν Oct A accreted from the mass ejected by ν Oct B, or it could be captured from a prograde orbit around the binary into a retrograde orbit around ν Oct A,' explained Professor Man Hoi LEE.

'We might be witnessing the first compelling case of a second-generation planet; either captured, or formed from material expelled by ν Oct B, which lost more than 75% of its primordial mass to become a white dwarf, ' added Dr Trifon TRIFONOV of Zentrum für Astronomie der Universität Heidelberg in Germany and Sofia University St. Kliment Ohridski in Bulgaria and a co-author of the paper.

'The key to this exciting discovery was the use of several complementary methods to characterise the system in its entirety,' said PD Dr Sabine REFFERT of Zentrum für Astronomie der Universität Heidelberg and another co-author of the paper.

As astronomers continue to search for planets in different environments, this study highlights that planets in tight binary systems with evolved stellar components could offer unique insights into the formation and evolution of planets.

This research uses two facilities operated by the European Southern Observatory (ESO), namely the High Accuracy Radial Velocity Planet Searcher (HARPS) spectrograph at the ESO La Silla 3.6-metre telescope and the Spectro-Polarimetric High-contrast Exoplanet Research (SPHERE) instrument at the Very Large Telescope.

**Watch the video about the research:** https://tinyurl.com/4uf5k5bp

For more details, please refer to the journal paper '*A retrograde planet in a tight binary star system with a white dwarf'*, published in *Nature*: https://www.nature.com/articles/s41586-025-09006-x

For media enquiries, please contact HKU Faculty of Science (tel: 852-3917 4948/ 3917 5286; email: caseyto@hku.hk / email: cindycst@hku.hk).

**Images download and captions:** https://www.scifac.hku.hk/press