Groundbreaking survey reveals secrets of planet birth around dozens of stars

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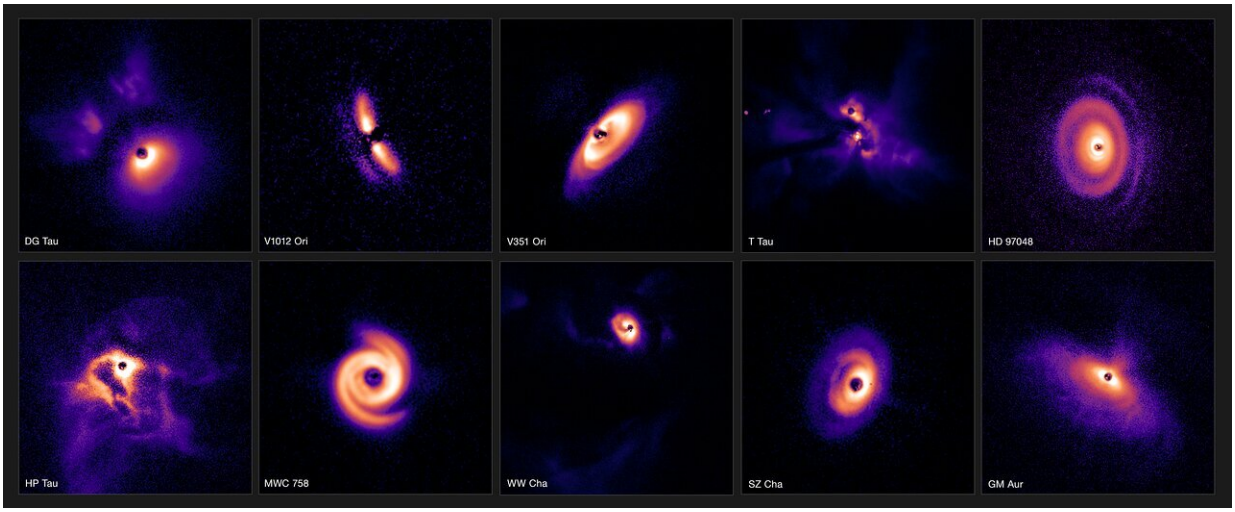


This research brings together observations of more than 80 young stars that might have planets forming around them in spectacular discs. This small selection from the survey shows 10 discs from the three regions of our galaxy observed in the papers. V351 Ori and V1012 Ori are located in the most distant of the three regions, the gas-rich cloud of Orion, some 1600 light-years from Earth. DG Tau, T Tau, HP Tau, MWC758 and GM Aur are located in the Taurus region, while HD 97048, WW Cha and SZ Cha can be found in Chamaeleon I, all of which are about 600 light-years from Earth. Credit: ESO/C. Ginski, A. Garufi, P.-G. Valegård et al.

In a series of studies, a team of astronomers has shed new light on the fascinating and complex process of planet formation. The stunning

images, captured using the European Southern Observatory's Very Large Telescope (ESO's VLT) in Chile, represent one of the largest ever surveys of planet-forming disks. The research brings together observations of more than 80 young stars that might have planets forming around them, providing astronomers with a wealth of data and unique insights into how planets arise in different regions of our galaxy.

"This is really a shift in our field of study," says Christian Ginski, a lecturer at the University of Galway, Ireland, and lead author of one of three new papers published in *Astronomy & Astrophysics*. "We've gone from the intense study of individual star systems to this huge overview of entire star-forming regions."

To date, more than 5,000 planets have been discovered orbiting stars other than the sun, often within systems markedly different from our own solar system. To understand where and how this diversity arises, astronomers must observe the dust- and gas-rich disks that envelop young stars—the very cradles of planet formation. These are best found in huge gas clouds where the stars themselves are forming.

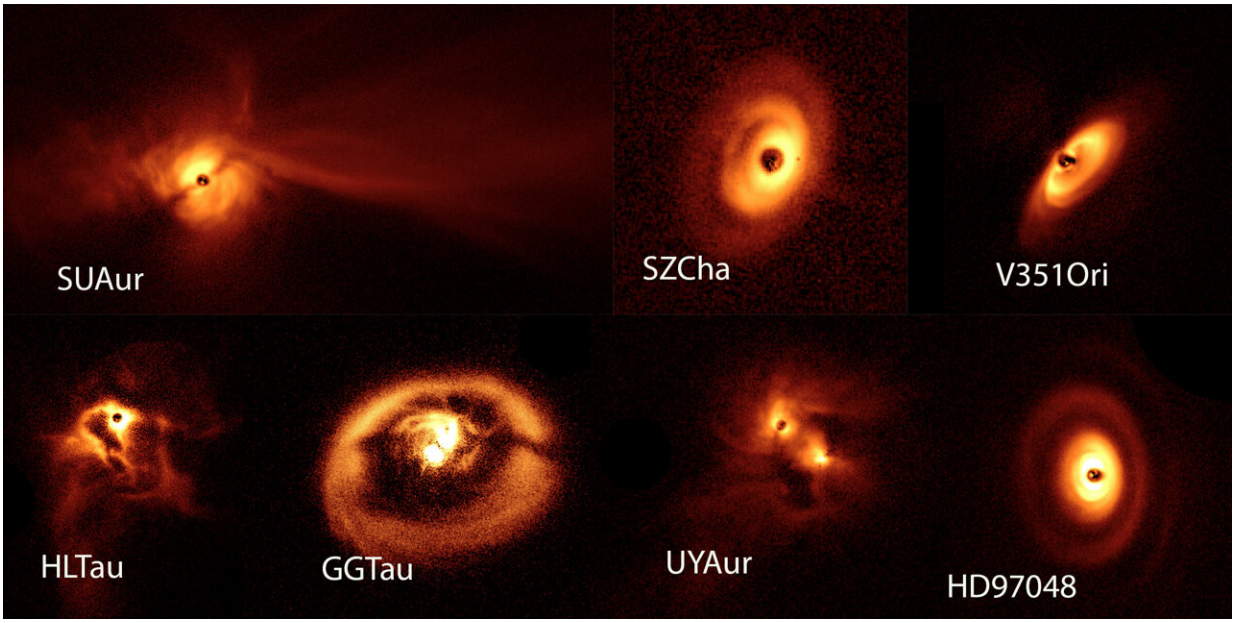
Much like mature planetary systems, the new images showcase the extraordinary diversity of planet-forming disks. "Some of these disks show huge spiral arms, presumably driven by the intricate ballet of orbiting planets," says Ginski.

"Others show rings and large cavities carved out by forming planets, while yet others seem smooth and almost dormant among all this bustle of activity," adds Antonio Garufi, an astronomer at the Arcetri Astrophysical Observatory, Italian National Institute for Astrophysics (INAF), and lead author of one of the papers.

The team studied a total of 86 stars across three different star-forming regions of our galaxy: Taurus and Chamaeleon I, both around 600 light-

years from Earth, and Orion, a gas-rich cloud about 1,600 light-years from us that is known to be the birthplace of several stars more massive than the sun. The observations were gathered by a large international team, including scientists from more than 10 countries.

The team was able to glean several key insights from the dataset. For example, in Orion they found that stars in groups of two or more were less likely to have large planet-forming disks. This is a significant result, given that unlike our sun, most stars in our galaxy have companions. As well as this, the uneven appearance of the disks in this region suggests the possibility of massive planets embedded within them, which could be causing the disks to warp and become misaligned.



ESO planetary formation disks—Colourised infra-red images of planetary formation captured by the European Southern Observatory's Very Large Telescope. Credit: ESO/Christian Ginski/University of Galway.

While planet-forming disks can extend for distances hundreds of times greater than the distance between Earth and the sun, their location several hundreds of light-years from us makes them appear as tiny pinpricks in the night sky. To observe the disks, the team employed the sophisticated Spectro-Polarimetric High-contrast Exoplanet REsearch instrument (SPHERE) mounted on ESO's VLT. SPHERE's state-of-the-art extreme adaptive optics system corrects for the turbulent effects of Earth's atmosphere, yielding crisp images of the disks. This meant that the team was able to image disks around stars with masses as low as half the mass of the sun, which are typically too faint for most other instruments available today.

Additional data for the survey were obtained using the VLT's X-shooter instrument, which allowed astronomers to determine how young and how massive the stars are. The Atacama Large Millimeter/submillimeter Array (ALMA), in which ESO is a partner, on the other hand, helped the team understand more about the amount of dust surrounding some of the stars.

As technology advances, the team hopes to delve even deeper into the heart of planet-forming systems. The large 39-meter mirror of ESO's forthcoming Extremely Large Telescope (ELT), for example, will enable the team to study the innermost regions around young stars, where rocky planets like our own might be forming.

For now, these spectacular images provide researchers with a treasure trove of data to help unpick the mysteries of planet formation.

"It is almost poetic that the processes that mark the start of the journey towards forming planets and ultimately life in our own solar system should be so beautiful," concludes Per-Gunnar Valegård, a doctoral student at the University of Amsterdam, the Netherlands, who led the Orion study. Valegård, who is also a part-time teacher at the

International School Hilversum in the Netherlands, hopes the images will inspire his pupils to become scientists in the future.

This research was presented in three papers to appear in *Astronomy & Astrophysics*. The data presented were gathered as part of the SPHERE consortium guaranteed time program, as well as the DESTINYS (Disk Evolution Study Through Imaging of Nearby Young Stars) ESO Large Program.

More information: C. Ginski et al, The SPHERE view of the Chamaeleon I star-forming region. The full census of planet-forming disks with GTO and DESTINYS programs, *Astronomy & Astrophysics* (2024). DOI: 10.1051/0004-6361/202244005

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P.-G. Valegard et al, Disk Evolution Study Through Imaging of Nearby Young Stars (DESTINYS): The SPHERE view of the Orion star-forming region, *Astronomy & Astrophysics* (2024). DOI: 10.1051/0004-6361/202347452

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