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FREE-FLOATING BINARY 'PLANETS' BAFFLE THEORISTS

BY RICHARD TALCOTT

JWST found 40 Jupiter-mass objects with binary companions in the Orion Nebula. Now scientists have to figure out how they got there.

EVER SINCE THE James Webb Space Telescope (JWST) opened its eye to the universe in 2022, astronomers have been inundated with astounding new views that threaten to overturn what seemed to be solid ideas dating back decades. Early on, for instance, researchers discovered massive galaxies that existed just a few hundred million years after the Big Bang — far earlier than anyone expected.

Now, astronomers Samuel Pearson and Mark McCaughrean of the European Space Agency's European Space Research and Technology Centre in Noordwijk, the Netherlands, have brought the revolution closer to home. Their observations of the Orion Nebula (M42) reveal dozens of Jupiter-mass objects orbiting in pairs. The findings cast doubt on models that predict how planet-sized bodies form.

The researchers turned JWST's Near-Infrared Camera on M42 for 34.9 hours. They zeroed in on the nebula's core, a region about 3.9 by 2.6 light-years across that includes the Trapezium Cluster. The hottest and brightest stars in this cluster radiate the ultraviolet light that ionizes the entire nebula and causes it to glow.

The scientists chose the Orion Nebula because it contains stars from the most massive O-types to the smallest M dwarfs, a plethora of sub-stellar brown dwarfs, and lots of even smaller objects with planetary masses. When you combine this with its young age (less than 2 million years), its proximity to Earth (1,350 light-years away), and its advantageous location nearly 20° from our galaxy's plane (which reduces foreground contamination) and just in front of the massive Orion Molecular Cloud 1 (which lessens background interference), you have an ideal

JWST captured the inner region of the Orion Nebula, including the bright stars of the Trapezium Cluster just left of center, at near-infrared wavelengths.
NASA/ESA/CSA/S. PEARSON AND M. MCCAUGHREAN (ESTEC)

INSETS: These close-up images reveal five JuMBOs. All 10 of these planetary-mass objects have masses less than 7 Jupiters.

laboratory for studying how stars and planets form.

Young brown dwarfs and planetary-mass objects glow as they contract, converting gravitational energy into light. Nearly all of their radiation is in the infrared part of the spectrum, making JWST essential for detecting them. Pearson and McCaughrean found 540 objects with masses no more than 13 times that of Jupiter, putting them in the realm of planetary masses and below that of brown dwarfs. Of these, 168 have masses ranging from 5 Jupiters down to 0.6 Jupiter.

But what really threw the scientists for a loop was the number of binary objects in their sample. Forty of the objects have a companion and two appear to be part of triple systems. The separations range from 25 AU to 390 AU. (One AU, or astronomical unit, is the average Earth-Sun distance — 93 million miles [150 million kilometers].) And even JWST can't separate objects closer than 25 AU at M42's distance, so the count could be higher.

The number of Jupiter-Mass Binary Objects (JuMBOs for short) far exceeds expectations. Nearly all high-mass stars have at least one companion. This drops to around 50 percent for Sun-like stars, 15 percent for high-mass brown dwarfs, and 8 percent for low-mass brown dwarfs. If this trend continued to planetary-mass objects, as theory predicts, the number of binary objects should be around zero. But the percentage actually climbs back up to brown-dwarf levels.

The researchers stress that theorists must be missing something in their explanations for how planetary-mass objects form. If they arise by collapsing gravitationally, as stars do, then an unknown factor must assist the process because no current theory can produce these low-mass objects in this way.

If such objects come about by coalescing in a circumstellar disk, as planets do, then they must be ejected violently from their host stars. But the JuMBOs would have to miraculously weather this storm to stay together. Pearson and McCaughrean suggest that some combination of these two ideas might solve the problem, though a brand new third way seems equally likely.

Contributing Editor **Richard Talcott** *wrote about JWST's discovery of a building block of life in the Orion Nebula in December 2023.*