Water Vapor Detected in Protoplanetary Disks

Water is an essential ingredient for forming planets, yet has remained hidden from scientists searching for it in protoplanetary systems, the spinning disks of particles surrounding newly formed stars where planets are born. Now the detection of water vapor in the inner part of two extrasolar protoplanetary disks brings scientists one step closer to understanding water's role during terrestrial planet formation.

By maximizing the spectroscopic capabilities of NASA's Spitzer Space Telescope and high-resolution measurements from the Keck II Telescope in Hawaii, researchers from the California Institute of Technology and other institutes found water molecules in disks of dust and gas around two young stars. DR Tau and AS 205A, respectively around 457 and 391 light-years away from Earth, are each at the center of a spinning disk of particles that may eventually coalesce to form planets.

"This is one of the very few times that water vapor has been detected in the inner part of a protoplanetary disk--the most likely place for terrestrial planets to form," says Colette Salyk, a graduate student in geological and planetary sciences at Caltech. She is the lead author of a group of scientists reporting their findings in the March 20 issue of the *Astrophysical Journal Letters*.

Salyk and her colleagues first harnessed light-emission data captured by Spitzer to inspect dozens of young stars with protoplanetary disks. They honed in on DR Tau and AS 205A because these presented a large number of water emission lines--spikes of brightness at certain wavelengths that are a unique fingerprint for water vapor. "Only Spitzer is capable of observing these particular lines in a large number of disks because it operates above Earth's obscuring water-vapor-rich atmosphere," says Salyk.

To determine in what part of the disk the vapor resides, the team made high-resolution measurements at shorter wavelengths with NIRSPEC, the Near-InfraRed cross-dispersed echelle grating Spectrometer for the Keck II Telescope. Unlike Spitzer, which observed water lines blended together into clumps, NIRSPEC can resolve individual water lines in selected regions where the atmospheric transmission is good. The shape of each line relays information on the velocity of the molecules emitting the light. "They were moving at fast speeds," says Salyk, "indicating that they came from close to the stars, which is where Earthlike planets might be forming."

"While we don't detect nearly as much water as exists in the oceans on Earth, we see only a very small part of the disk--essentially only its surface--so the implication is that the water is quite abundant," remarks coauthor Geoffrey Blake, professor of cosmochemistry and planetary sciences and professor of chemistry at Caltech.

The presence of water in the inner disk may indicate its stage on the road to planet formation. A planet like Jupiter in our solar system grew as its gravitational field trapped icy solids spinning in the outer part of the sun's planetary disk. However, before Jupiter gained much mass, these same icy solids could have traveled towards the star and evaporated to produce water vapor such as that seen around DR Tau and AS 205A.

Although they have not detected icy solids in the extrasolar disks, says Salyk, "our observations are possible evidence for the migration of solids in the disk. This is an important prediction of planet-forming models."

These initial observations portend more to come, says coauthor Klaus Pontoppidan, a Caltech Hubble Postdoctoral Scholar in Planetary Science. "We were surprised at how easy it is to find water in planet-forming disks once we had learned where to look. It will take years of work to understand the details of what we see."

Indeed, adds Blake, "This is a much larger story than just one or two disks. With upcoming observations of tens of young stars and disks with both Spitzer and NIRSPEC, along with our data in hand, we can construct a story for how water concentrations evolve in disks, and hopefully answer questions like how Earth acquired its oceans."

Other authors on the paper are Fred Lahuis of Leiden Observatory in the Netherlands and SRON, the Netherlands Institute for Space Research; Ewine van Dishoeck, also of Leiden Observatory; and Neal Evans of the University of Texas at Austin.

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