

In Pursuit of Cosmic Origins

What question could be more profound or interest a wider audience than the one that asks how we got here? Ongoing research in science disciplines ranging from cosmology to biology approaches this question from a variety of vantage points. It has puzzled philosophers for millennia, and it captures the public's imagination.

We – life – originated because our habitable planet, Earth, formed, and our planet's habitability owes a lot to the presence of water here. A fundamentally important piece to the puzzle of life's origin is embodied in the scientific question "How do water-bearing planets form?" This is a *scientific* question because hypotheses can be proposed, analyses conducted, and experimentation used to eliminate false hypotheses.

A good deal has already been accomplished. We now know that extrasolar planets are common, and that some are Earth-like in size and mass. We know that water exists in space, in both gaseous and frozen forms. We have good working hypotheses for star and planet formation, and for the delivery of water to the surface of a planet situated where the water will be in liquid form. To take the next big step, the working hypotheses will have to be tested experimentally.

We know what it will take to do this, and we know that space-based observations will play a key role. The far-infrared spectral region hosts a plethora of H₂O spectral lines, and is home to prominent water ice spectral features. Water is not observable from the ground because ground-based observations from even the driest terrestrial sites are made through a damp atmosphere. At stratospheric altitudes, much of this water is gone, but suborbital platforms are too warm to have the sensitivity to detect water in protostars and the gaseous disks that represent young, developing planetary systems. Only a cryogenic telescope in space can find the water reservoirs in these systems and learn how water reaches the surface of a potentially habitable planet.

The *Herschel Space Observatory*, the largest telescope ever flown in space, at 3.5 m, has many of the right measurement capabilities, but it lacks the sub-arcsecond angular resolution needed to map out the distribution of water in proto-planetary systems. Such objects are the size of our solar system, and the closest examples lie at distances from tens to hundreds of parsecs. When angular resolution in the tens to hundreds of milli-arcseconds is available with a cryogenically cooled far-infrared space observatory, then potential answers to the question posed above - How do water-bearing planets form? – will be subjected to experimental scrutiny and we will have significantly better understanding of our origins. A mission with these measurement capabilities deserves a place in the NASA Astrophysics Roadmap.