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WATER JETS ON CERES

Ken Tapping, 10th June, 2014

In the 1960's we believed that the outer Solar System was a mostly a cold, frozen place. We knew of weather activity and storms on Jupiter and Saturn, and assumed there would be something of the same kind on Uranus and Neptune. However the assorted moons and asteroids out there would be extremely cold balls of rock. The temperatures would be low enough to ensure water would just be another solid mineral making up the rocks. The only big puzzle was Titan, Saturn's biggest moon, because it was known to have an atmosphere.

However, the Voyager flybys of the outer planets in the 1970's showed our lack of imagination. Io, Jupiter's closest large moon has volcanoes jetting out molten sulphur and other materials. Europa, the second closest moon has a deep ocean underlying a thick layer of ice. Triton, the largest moon of Neptune has cryovolcanoes, emitting water vapour and a "lava" consisting of liquid water. Now we view volcanism and cryovolcanism in the outer Solar System as fairly widespread.

Moons and asteroids are very unlikely to have the volcanic processes we have here on Earth; they are too small. On them, our sort of volcanism would have ended a long time ago, because small bodies cool much faster than large ones. Their volcanism is driven by tidal forces produced by the giant planets they orbit. The gravitational fields of the giant planets are strong enough to pull any nearby moon out of shape, making it slightly egg-shaped. Moreover, if that moon is rotating, it is continuously changing shape. This kneading generates heat. In the case of Io, enough heat to melt the moon's interior. In the case of others, enough to melt or even boil water. We are gradually better understanding the process of tidal heating, and are seeing more subtle signs of it on other moons orbiting close to the giant planets. However, now Mother Nature has pitched us another surprise to work on. Our idea of tidal heating of small bodies requires the body in question to be orbiting close to a giant planet. Now

jets and clouds of water vapour have been observed on an asteroid, orbiting between Mars and Jupiter, well away from any large bodies.

In 1801, Italian astronomer Guiseppe Piazzi discovered Ceres, the first of the asteroids, small bodies that orbit the Sun in huge numbers, mainly between the orbits of Mars and Jupiter. Ceres has a diameter of about 490 km and orbits the Sun between 2.55 and 2.98 times the Earth's distance from the Sun. At such distances from the Sun, with no tidal heating, we would expect Ceres to be another totally frozen object. However, once again this assumption was wrong. Recent observations made using the Herschel Space Observatory showed Ceres jetting out water vapour and surrounded by clouds of it. That was a surprise.

More detailed calculations and laboratory experiments have shown that an icy object closer than five times the Earth's distance to the Sun will be warm enough for ice to evaporate, turning directly to water vapour without ever becoming a liquid. This is another example of something we could have expected if we had just thought harder.

Since water is an essential requirement of life as we know it, the presence of water as other than a rock mineral raises questions about the possibility of life on some of the moons and asteroids in the Solar System. We need to have a closer look.

Our Moon has a very dry surface. Being much closer to the Sun than the asteroids, the large daily temperatures have baked the surface dry. However, there may be ice below the surface, and some amateur and professional astronomers have reported seeing something squirting out. So we need to go back there for a closer look too.

Jupiter is low in the west at sunset, Saturn and Mars lie high in the south and Venus rises about 4 am. The Moon will be Full on the 12th.

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