Will Avatar's Pandora be a reality?

ASTRONOMY Hundreds of exoplanets have been discovered so far, but only a few of them have been classified as being within the habitable zone of their host star. Much like our own Jupiter and Saturn, they are not suitable for life. But, could the moons of these planets be fit for life? Detecting them could be the first step, writes **C Sivaram**

Recent discoveries of water rich exoplanets, especially GJ1214b, which has a total water mass several thousand times that of earth, has caused excitement among astrobiologists as water is a crucial substance for sustenance of life.

In our solar system, only the earth is in such a zone, Mars being too cold, and Venus being too hot. The earth is at the right distance from the sun for vast quantities of water to be found on the surface. It is not surprising that astronomers always look for traces of water on any planet or other celestial body, while looking for exohabitats.

However, out of the over 400-odd exoplanets discovered so far, only about 35 of them are classified as being within the habitable zone of their host star, that is, their equilibrium temperatures lie between the freezing and boiling points of water. Although these exoplanets lie within the habitable zone of their stars, they are not habitable as they are huge gas giants like Jupiter and Saturn, not regarded as suitable habitats for complex advanced life. GJ1212b is too close to its host star so its surface temperature would be torrid!

Europa has more water than earth?

But in our solar system, we know that moons of giant planets could have more suitable habitats for life. Jupiter's moon, Europa and more recently, Saturn's moon, Enceladus are believed to have vast reservoirs of water beneath their surface. Europa could have a subterranean ocean containing more water than the earth. Indeed, a future space probe has been planned exclusively to explore Europa.

Jupiter and Saturn have over 60 moons each. Uranus has around 30 and Neptune over a dozen. There are more than 170 moons in our solar system. As most of the exoplanets found so far are gas giants, they are also likely to be accompanied by retinues of moons orbiting them. So even if the hot exo-Jupiters are inhabitable, their moons could lie within a habitable zone around them. Just as in the cases of Europa, Encedalus, Titan etc., considered possible abodes for primitive life forms, it is quite conceivable that there could be moons of these exo-Jupiters, which could have habitable conditions.

So, if the exoplanets (within the habitable zone of their host stars) had large moons around them, then these worlds would be good candidates for supporting life. Again, the presence of a relatively large moon orbiting the earth is supposedly crucial for the planet's habitability as it acts to stabilise the axial tilt and precession of the earth, unlike Mars where dramatic changes in the tilt cause extreme climatic variations over long-time scales.

Could such exomoons be detected?

James Cameron's movie *Avatar* featured a beautiful exomoon called Pandora. Will we get to see a moon such as Pandora at some point? The first step would be to detect a Pandora, in the first place.

The angular size of the earth as seen from ten light years is hardly half a micro arc second. Current interferometric precision with the best technology is more like twenty micro arc seconds. Looking for exomoons is beyond present technology. The bulk of the exoplanets have been detected by the so called radial velocity method, that is, a giant planet like Jupiter causes a wobble in the sun's motion dragging it around with a velocity of about 13 meter/sec over a period of eleven years (Jupiter's orbital period).

EXCITING HABITATS The basic chemistry for life has been detected in a hot gas planet, HD 209458b, depicted in this artist's concept. PHOTO: NASA IMAGES

A planet like the earth would cause a wobble of only four centimeters per second with a yearly period! This is beyond current detection. Even for a giant planet like Jupiter, the wobble in the sun's motion due to Jupiter plus all its satellites is hardly any different from that of Jupiter alone. This method thus pictures planets as only point masses giving no information about the moons. In the transit method (used for instance by the orbiting Kepler spacecraft to detect exoplanets) when a planet passes in front of a star, it causes a dip in the luminosity and can be used to find the planetary radius. We have for example the transits of Venus and Mercury, which on earth are notable astronomical events. If moons orbit the transiting planet, the small moon-dip would be visible only after the planet has left the stellar limb and the time duration of this dip would also typically be less than one per cent of the transit duration of the planet (that is, distance between the planet and its moon divided by the velocity of the planet around the star).

Unlikely even for Kepler telescope

Thus, even the Kepler Space Telescope, which requires at least six hours of integration to spot terrestrial planets is very unlikely to photometrically detect exomoons. However, moons can make transits occur slightly later or earlier than expected if the planetary transits occur once over every orbital period (as planets and the moons orbit a common centre of gravity which orbits the star). This so called transit time variation (TTV) can be up to a minute and in principle can be seen even in ground-based observatories. Unfortunately, it would be difficult to separate the effect from so many competing effects due to their perturbing planets, relativistic effects, parallax effects etc. This method also cannot find the mass of the exomoon.

However, another effect has been suggested, the transit duration variation. This arises because the velocity of the planet also varies depending on the phase of the orbiting moon around it, at times increasing and later decreasing. This causes changes in transit duration. In the next few years, precise monitoring of exoplanets could lead to detection of several exomoons.

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