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Self inspection in cosmology

Seeing oneself through others' eyes can be revealing, says S.Ananthanarayanan.

This precept of personality development has found relevance in the pursuit of earth-like planets. While we have spotted a large number of objects that may have earth-like features, a good way of telling which ones are most earth-like may be to know what the earth herself looks like from far away.

The quest for other 'earths'

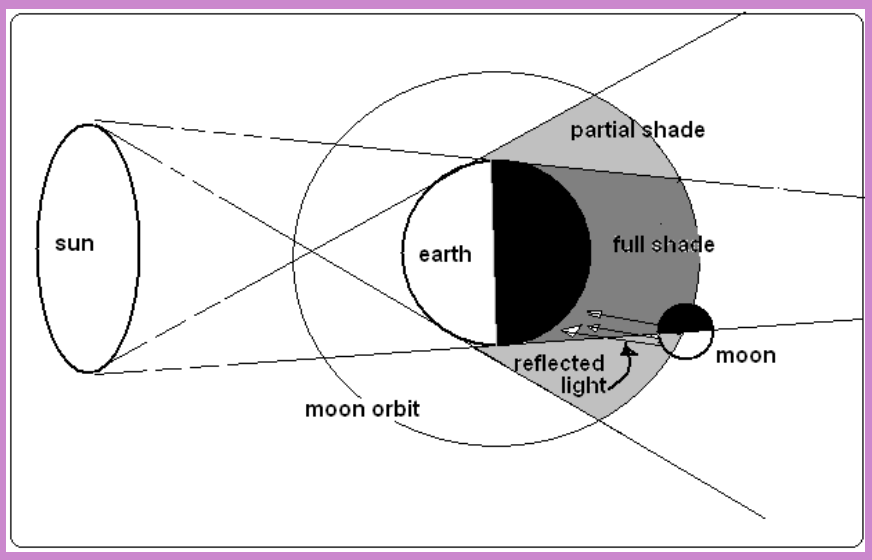
The quest has revealed 342 planets of far away stars, so far. Of this number, 58 'transit the stellar disk', which is to say that they pass between the earth and the star around which they orbit. In such cases, it is the slight drop in luminosity of the star, when its planet passes before it, which is the way of detecting the existence of the planet!

In some of the cases of detection transit, we are able to analyse the starlight that has passed through the planet's atmosphere. When starlight passes through the planet's atmosphere, certain wavelengths of light in the starlight get absorbed by gases in the planet's atmosphere. Analysis of the light then gives us a picture of the elements in the planets' atmosphere and we have this data, albeit provisional, for a good number of planets that transit their parent stars.

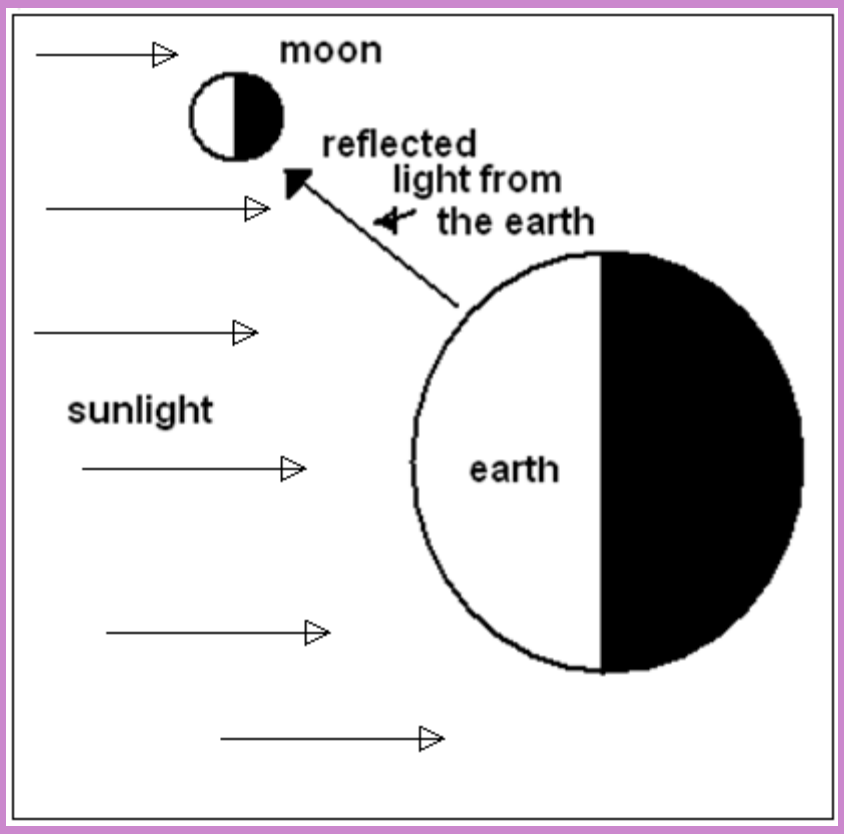
To make out whether these distant planets are 'earth-like', it would be useful to know what 'transmission spectrum' the earth presents, if it were observed from a distant world, while it transited the sun. A recent issue of the journal, ***Nature*** describes the work done to find this out, by a team of scientists in the Institute of Astrophysics in La Laguna, Tenerife, in Spain.

The lunar eclipse

The lunar eclipse occurs when the earth is between the sun and the moon. There is a part where there is full shadow and a part where the shadow in partial. In the full shadow part, the only light that gets through is the light that passes through the earth's atmosphere, or the 'transmitted light'. Getting data about this light is via the same light that comes back to us after reflection from the moon. (First picture)



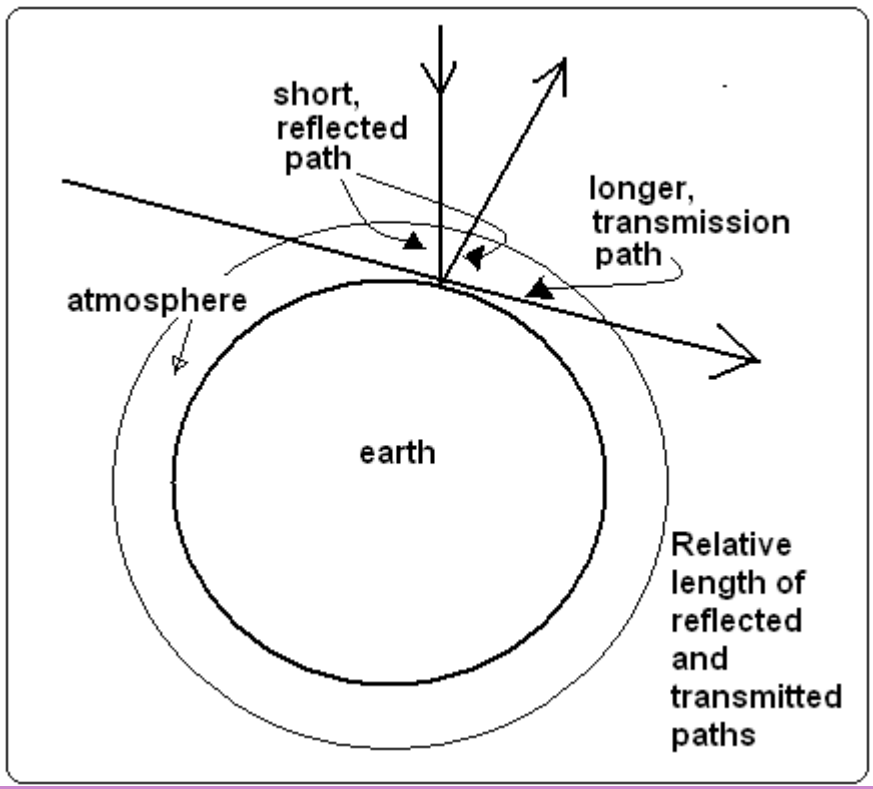
This is in contrast to the light that shines from the earth and on the moon when the moon is not eclipsed (second picture). This light, which could be called ‘earthshine’, is the reflected light from the earth, just like moonlight on a full moon day is the reflected light from the moon.



The group of scientists collected extensive data on such dim, secondary reflected light from the moon, during a lunar eclipse, in a study made perhaps for the first time so far.

Transmitted light

The first obvious result of the study is that transmitted light is like sunlight during a sunset, rather than at midday. As we can see in the third picture, light passes through a much longer atmospheric region during transmission than during reflection. A simple effect of passing through the atmosphere is that short wavelengths get scattered. This is why the sun's disk appears red during sunset and sunrise – slanting beams of light pass through more atmosphere and the blue gets scattered more than the red part, leaving more red light than blue. Later in the day, this happens to a lesser extent and the sun appears yellow, while the scattered light which fills the atmosphere makes the sky look blue!



The light getting through to the moon during a lunar eclipse is thus richer on the red side. In contrast, the 'earthlight' that shines on the dark side of the moon, as analysed from the same light reflected back from the moon, is rich on the blue side. The earth thus looks blue, when viewed in sunlight, from outer space!

Absorption lines

But more important than just the mix of colours are the details of specific wavelengths absorbed by the elements in the atmosphere. It is seen that the earth's atmosphere strongly absorbs light at the wavelengths characteristic of oxygen and also of oxygen in combination with nitrogen. Nitrogen, although the most abundant gas in the atmosphere, does not have its own clear absorption fingerprint. This kind of combination of elements in absorption spectra are called

dimers, and may be important in the analysis of different components to be found in distant planets. They are also more marked in transmission spectra than in reflection spectra.

The other characteristics of the earth's transmission spectrum in the evidence of ozone, water, carbon dioxide and methane. There may also be traces of gases that are generated by human activity, but more sensitive methods are needed to find them. The evidence has also been found of calcium, the sixth most abundant element on the earth. The present study is confined to the visible and near infra-red light. Later studies at shorter wavelengths may reveal more elements.

Future experimental missions may be able to study transits of exoplanets (planets of other suns) more closely and collect better data. But the study of the earth's transmission spectrum with the help of reflection from the moon suggests that getting a good transmission spectrum of an exoplanet would not be daunting. It is estimated that observing about 20 to 30 one hour transits should yield enough data to identify the major features of an earth-like exoplanet's atmosphere.