EXTRASOLAR PLANETS

Fluorescent methane spotted

Seth Redfield

The atmospheric properties of distant worlds are becoming increasingly clear. The latest observations reveal fluorescent emission from methane in the upper atmosphere of a Jupiter-like extrasolar planet.

The first extrasolar planet found to be orbiting a Sun-like star was detected less than 15 years ago. As astronomers detect more and more planets orbiting stars other than the Sun in our Galactic neighbourhood, increasing attention is being paid to probing their atmospheres, and for good reason. Planetary atmospheres can be easily altered by geophysical[1], photochemical[2] and biological[3] processes. Owing to the relatively small amount of mass in an atmosphere, its properties can bear the signatures of processes driven from the planetary interior or surface that would not otherwise be observable. A notable example is the presence of the powerful greenhouse gas methane (CH_4) in planetary atmospheres.

In Earth's atmosphere, the dominant sources of non-anthropogenic methane are anaerobic bacteria and methanogens, which inhabit wetland and oceanic sediments, and the digestive tracts of some organisms (for example, ruminants and termites). Methanogens, like most archaeal microorganisms, can thrive in a wide range of conditions, including many that would be harmful to the bulk of complex life forms on Earth. Jupiter's methane, meanwhile, is photochemical in origin, and so is dependent on the radiation field incident on the atmosphere and the specific abundances of carbon, oxygen and hydrogen[4].

To disentangle the various processes that affect an atmosphere, it is crucial to obtain as much information as possible on a diverse sample of planetary atmospheres. On page 637 of this issue, Swain *et al.*[5] report the discovery of fluorescent emission from methane in the upper atmosphere of a nearby, Jupiter-mass extrasolar planet[6], HD 189733b (Fig. 1).

Fluorescence occurs when an atom or molecule absorbs a photon, is excited into a higher energy state and subsequently de-excites, emitting light at lower energies. It requires the relatively low particle densities that occur high in planetary atmospheres, where the time between collisions is longer than the time required for radiative relaxation. Methane, like all molecules, can only make such transitions among specific permitted electronic, rotational and vibrational energy pathways that are unique to its molecular structure. The

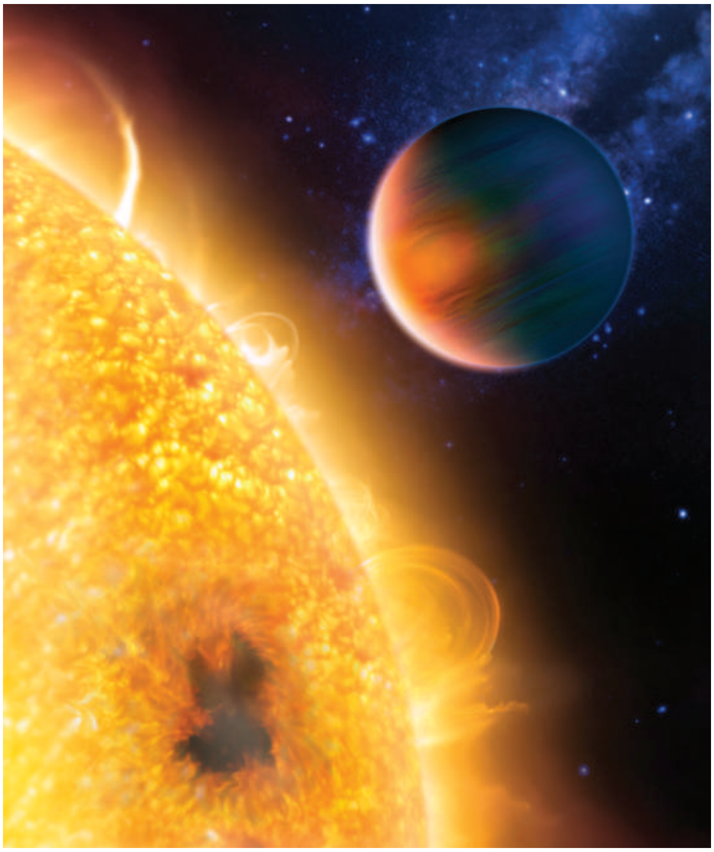

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Figure 1 | Artist's impression of HD 189733b. Swain and colleagues' ground-based observations[5] of the Jupiter-mass extrasolar planet HD 189733b reveal fluorescent emission from methane in the planet's upper atmosphere. The work highlights the value of complementary ground- and space-based studies of such planets.

50 & 100 YEARS AGO

50 YEARS AGO

Although the problem of alcohol and road safety has been much in the public eye, there has hitherto been little precise evidence as to the effects of small quantities of alcohol on driving skill. For this reason, the careful study by Prof. George Drew and his colleagues recently published by the Medical Research Council ... will attract widespread interest. This report describes the effects of small doses of alcohol (the highest being roughly equivalent to only five fluid ounces of whiskey for a man of average weight) upon performance on the 'Miles motor driving trainer' ... It was found that the mean error of forty subjects on the test increased significantly with increasing blood alcohol ... These results strongly suggest that amounts of alcohol far too small to give rise to recognizable signs of intoxication may none the less significantly impair driving ability.

From *Nature* 6 February 1960.

100 YEARS AGO

Readers of these columns should be fairly well acquainted with Prof. Lowell's views concerning the Martian features and their significance, but they will find interesting the comprehensive summary given by Prof. Lowell in No. 13 of *Scientia* ... Therein the author reviews the observations of the melting snow-caps, of the "canals" and oases, which, by virtue of their dependent vegetation, undergo striking changes in conformity with the Martian seasons, and the theoretical considerations which have led him to conclude that Mars is habitable by organisms not essentially different from those with which we are acquainted. That Mars has no water except that contained in its atmosphere and that which forms the snow-caps, Prof. Lowell avers, but he contends that that water is artificially "engineered" in such a way that organic existence is rendered possible.

From *Nature* 3 February 1910.

BIOMATERIALS

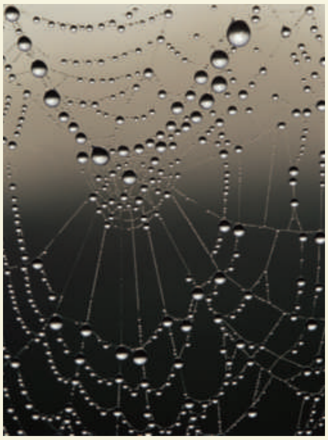
Dew catchers

Why did Incy Wincy Spider climb up the water spout? If he was after a drink, a report by Yongmei Zheng *et al.* in this issue suggests that he might have missed a trick — spiders don't need to look for water because the silk fibres that they spin are highly efficient at collecting it from moist air (Y. Zheng *et al. Nature* **463,** 640–643; 2010).

To uncover the water-collection mechanism, Zheng *et al.* exposed silk fibres of the cribellate spider *Uloborus walckenaerius* to humid air, and monitored them with a scanning electron microscope. They observed that initial contact with water causes the hydrophilic fibres to re-structure, so that spindle-knots form periodically along the thread axis, separated by elongated joints roughly fourfold thinner.

Small water droplets then condense randomly onto the spindle-knots and joints, and begin to grow as they accumulate moisture from the air. When they reach a critical size, droplets that are attached to joints move towards the nearest spindle-knots, where they coalesce to form larger water drops. This leaves the joints free to start a new cycle of water condensation and collection.

Zheng *et al.* found that the structure of the silk fibres is crucial for water collection. They observed that the spindle-knots are made up of randomly arranged nanofibrils and have rough surfaces, whereas the joints consist of aligned nanofibrils and have smooth surfaces. The difference in roughness causes a surface-energy gradient that drives water towards the spindle-knots. This effect is boosted by the different shapes of the knots and the joints, which cause the drops to deform differently, thereby generating surface-tension forces that also drive water drops towards the spindle-knots. A final helping hand is provided by the different orientations of the nanofibrils in the fibres: water drops move easily along joint regions where the nanofibrils are aligned, but stick to the spindle-knots where the nanofibrils are randomly orientated.



C. VARNDELL/NATUREPL.COM

The authors went on to make artificial fibres that mimicked the structure of spider silk, and found that these successfully reproduced the water-collection properties of the natural material. They speculate that their work will help in the design of fibres that could be used in devices that collect water from the atmosphere, or that remove liquid aerosols in manufacturing processes.

Magdalena Helmer

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result is a characteristic spectrum of emission lines, and it is one of these emission lines, distinctive to methane, that has been detected by Swain and colleagues[5].

Fluorescent emission is relatively common in astrophysical environments. It has been detected, for example, in the accretion disks surrounding supermassive black holes[7], in the interstellar medium[8] and in comets[9]. Specifically, the fluorescent methane emission detected by Swain *et al.*[5] on HD 189733b has also been observed in the atmospheres of Jupiter, Saturn and Titan[10]. Fluorescence of other organic compounds has been detected on Venus and Mars[11]. These detections provide a probe of the physical structure of the upper atmosphere of these planets from the perspective of a minor atmospheric constituent. Methane is particularly important because it may help us to find and evaluate possible biological influences on extrasolar planetary atmospheres.

The upper atmosphere is a fascinating and important region where minor molecular constituents, such as methane, can play an indispensable part in establishing the overall heat budget of a planet, thereby altering the thermal profile of a considerable portion of the atmosphere. Powerful winds and vertical mixing of high-altitude atmospheric layers present the possibility for temporal and spatial variability of the fluorescent emission from such molecules. In addition, ionized particles in the upper atmosphere are affected by any global magnetic field — as is dramatically exemplified on Earth by another form of emission-line radiation, the aurorae. Because HD 189733b is extremely close to its host star (less than one-tenth the distance between Mercury and the Sun), energetic particles from its star will interact with any magnetic field the planet may have, possibly resulting in stronger emission-line displays than we see on Earth or Jupiter. Many other observed extrasolar planets are similarly close to their host stars, so variability in emission components because of magnetic effects may be common in these systems.

Swain and colleagues' detection[5] of a fluorescent emission line of methane on HD 189733b paves the way for future observations of alternative fluorescent emission lines of methane and other molecules in extrasolar planetary atmospheres. These observations will require sensitive, high-spectral-resolution instruments that can resolve the emission-line profile of fluorescent signals. In addition, this discovery highlights a crucial theme in modern astronomy: the necessity of making complementary observations from the ground and from space. Depending on the wavelengths of the relevant spectral features, Earth's own atmosphere may or may not interfere with detection. The authors' observations[5] were made with the 3.0-metre NASA Infrared Telescope Facility located at the summit of Mauna Kea in Hawaii. Our increasing understanding of this one extrasolar planet — from its discovery[6] to the growing list of known constituents of its atmosphere, which includes sodium[12], carbon monoxide[13], carbon dioxide[13], water vapour[13] and methane[14] — has been possible only with observations from both the ground and space.

During the past few years, we have made a transition that deserves some rumination. Rather than speculating about the possibility of other worlds in the cosmos, we can now identify them specifically and enumerate their various characteristics. Many stars that are readily visible to the naked eye, at least from relatively dark sites that are not heavily polluted by artificial light, have planets orbiting them, the masses and orbital characteristics of which we know. A number of other worlds, soon to be discovered, will be small and rocky like Earth, and will have atmospheres that we can detect, inventory and monitor. It is quite possible that, within our lifetimes, atmospheric studies of these extrasolar planets will provide the first evidence of biological life beyond Earth. Swain and colleagues' detection of the fluorescence of a hydrocarbon in the upper atmosphere of an extrasolar planet not only provides insight into the structure of the atmospheres of other worlds, but is also an important step in the far-reaching journey to uncover what may be below them. ■

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