Unexpected astro laboratory

The internal combustion engines of automobiles are helping scientists understand the cosmos better

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'To see a World in a Grain of Sand...' was a flight of William Blake's poetic fancy. Closer to the ground is the work of a group of scientists who leverage existing knowledge of the internal combustion engine, which powers motor cars, to make sense of the atmosphere of giant planets in close proximity of distant suns.

O Venot, E Hébrard, M Agúndez, M Dobrijevic, F Selsis, F Hersant, N Iro and R Bounaceur, astronomers and applied combustion experts from the universities of Bordeaux and Lorraine in France, Keele University in the UK, the CNRS lab in Floirac, France and the Observatory of Paris, describe in *Astronomy and Astrophysics*, the journal of the European Southern Observatory, the value of "importing well-tried methods from any other field whenever they exist," to solve problems thrown up in research.

A large number of planets in solar systems that exist deep in space have been discovered in the last few decades. While the quest has been to find "Earth-like" planets, or planets with temperature that could support liquid water and hence life, many planets with different characteristics have been discovered too. One class of such planets is that of Hot Jupiters or planets the size of Jupiter, or over ten times the size of the Earth and orbiting very close to the mother star. We have good methods to study the fiercely hot atmosphere of the sun and stars, and we have some understanding of their interiors. But it is recently that we have started grappling with atmospheres that are not nearly as hot, in these planets that are nearly 50 times closer to their suns than the Earth.

The temperature of the Sun goes from some 5000°C at the surface to millions of degrees in the core. A feature of gases at such temperatures is that the atoms in their molecules separate and lose their outer electrons, to behave as fast-moving, charged objects. Models of such objects in behaving as gases have been developed and features of such atmospheres, like the Sun's, where the outermost layer seems to be hotter than layers that lie below, have been explained.

The atmosphere of Hot Jupiters, in contrast, are comparatively cooler, at 1000°C to 3000°C, and the behaviour is not quite like a gas of charged particles. Nor do the usual laws of motion that work when applied to gases lead to satisfactory results. When pressures and speeds of movement get exceedingly high, as in Hot Jupiters, the approximations, like treating an atom as an object with zero dimensions, break down and chemical reactions that cannot take place in ordinary conditions become possible.

As Hot Jupiters are very close to their suns, which are at great distances from the Earth, any reflected light from the planets is swamped by the glare of the sun. There are hence no methods of directly seeing what goes on in such atmospheres. These planets themselves have been detected only thanks to a wobble that such massive satellites impart to the mother star, or by the dip in the intensity of light from the star when the planet passes it during its orbit. Any information about the atmosphere comes to us by analysing the starlight that passes through the atmosphere of the planet when the planet goes past the star. Variations in the dim reflected light during phases of a large planet in orbit also indicate what gases the atmosphere contains.

The high pressures and temperature, the intense radiation from the mother star and the winds and currents, however, bring about rapid chemical changes in the composition of the atmosphere, the paper in the journal says. Understanding the course of changes, calls for models that mimic the complex and rapid processes taking place.

Creating such a model, or a sequence of causes and effects that could account for the information that is available, or could suggest features that should be looked for, would need two things, the paper says. One is a list of the different players and their interactions in the process. And the other is to have data of how the ensemble of reactants would behave in time. The available literature, however, is not good enough to plan, or experimental facilities sufficient to test possible models, the paper says.

Despite the lack of dedicated facilities to study conditions in Hot Jupiters, members of the team had noted that very similar conditions exist within the cylinders of motor car engines. The temperatures in internal combustion engines rise to some 2500°C and pressure rises to 1,500 psi, or over a hundred times the atmospheric pressure. In recent times, the drive to build more environment-friendly and less polluting petrol engines has led to wide research into the behaviour of gases and the chemical reactions that are encouraged or inhibited at this range of temperatures and pressures.

As the fuels that burn in automobile engines contain hundreds of forms of hydrocarbon molecules, the focus has been on finding models that simulate the main combustion parameters, like when the fuel starts to burn, how the flame spreads, distribution of heat generation. These are the features that help the design of engines or burners, to estimate the fuel consumption, and to visualise how some of the main pollutants (carbon monoxide, nitrogen oxides, unburned hydrocarbons and particulate matter) are formed. "Most of these models were developed for industrial applications and have been validated in a range of temperatures and pressures," the paper says.

The paper notes that the fuels that burn in internal combustion engines consist of carbon, hydrogen, oxygen and nitrogen, which are also the main constituents of the molecules and molecular groups found in Hot Jupiter atmospheres. The existing models created for IC engines hence find ready extension to picture the dynamics of Hot Jupiter atmospheres.

Current observations of very hot planets are still tentative and can be interpreted in different ways. But with facilities that are under development, data is expected to become more elaborate and chemical modelling will become an important part of the analysis, the paper says. Even this bare access is now possible only with the very hot class of exoplanets. With better instruments, the atmosphere of cooler planets would come within reach. The nature of molecules present and the dynamics of the atmosphere would be different. Here, again, it is the validated models derived from automobile engine studies that would help model those distant atmospheres, the paper says.

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PLUS POINTS

Glowing beaks

Puffins have been found to have fluorescent beaks that glow under UV light. Scientists have long suspected that the well-known seabirds' colourful bills are a form of display, perhaps involved in attracting the opposite sex.

But Jamie Dunning, an ornithologist affiliated with the University of Nottingham in the UK, always suspected there may be more to their beaks than immediately met the eye.

Birds like puffins possess the ability to see not only the red, blue and green light humans can see, but also wavelengths at the UV end of the spectrum. This means they can see UV "colours" in objects humans cannot. Those colours can only be revealed to us by placing the objects under UV light. In other species this knowledge has led scientists to discover patterns and colours in feathers that are not visible to humans.

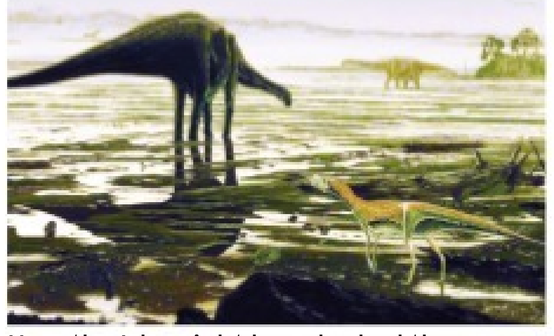
"With a puffin's bill you don't have to look at it very long to see that there's hundreds of thousands of years of sexual selection there," Dunning told The Independent. It occurred to him that while puffin beaks are colourful enough to human vision, there may be more going on in the UV spectrum. He tested this idea on a dead puffin to begin with.

Together with colleagues in Canada, Dunning has written up a description of the puffins' glowing beak, and they are currently awaiting publication of the report in a scientific journal. Having tested the fluorescent properties of dead puffins, the team wants to ensure the same effect is seen in living specimens.

For the time being the function of the puffin's glowing beak is still essentially a mystery, but he suspects it has something to do with signalling sexual prowess to other puffins.

The independent

Isle of dinosaurs



How the Isle might have looked then

Dozens of rare footprints belonging to dinosaurs made some 170 million years ago have been discovered on Scotland's Isle of Skye, offering an important insight into the Middle Jurassic era, scientists said last week.

"The more we look on the Isle of Skye, the more dinosaur footprints we find," said Dr Steve Brusatte of the University of Edinburgh's School of GeoSciences. "This new site records two different types of dinosaurs — long-necked cousins of Brontosaurus and sharp-toothed cousins of T Rex — hanging around a shallow lagoon, back when Scotland was much warmer and dinosaurs were beginning their march to global dominance."

The find is globally important as it is rare evidence of the Middle Jurassic period, from which few fossil sites have been found around the world, the university said on its website.

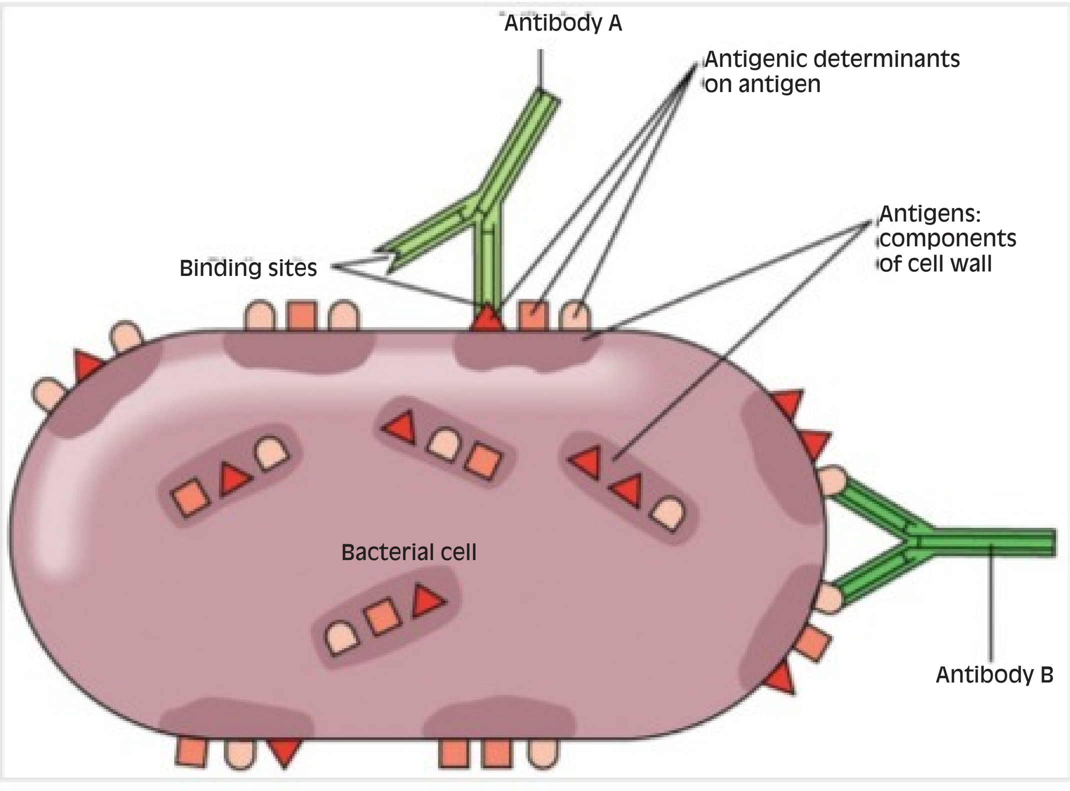
The footprints were difficult to study owing to tidal conditions, the impact of weathering and changes to the landscape, it added. But researchers managed to identify two track ways in addition to many isolated footprints. They used drone photographs to make a map of the site while other images were collected using a paired set of cameras and tailored software to help model the prints. The study, carried out by the University of Edinburgh, Staffin Museum and Chinese Academy of Sciences, was published in the *Scottish Journal of Geology*.

The straits times/ann

Interactive protectors

Antigens induce an immune response in the body, especially the production of antibodies

TAPAN KUMAR MAITRA



The name antigens (from the Greek, *anti* for against and *genos* for genus) is given to organic substances of a colloid structure (proteins and different protein complexes in combination with lipids or polysaccharides), which upon injection into the body are capable of causing the production of antibodies and reacting specifically with them. Antigens, consequently, are characterised by these properties — the ability to cause the production of antibodies (antigenicity) and the ability to enter into an interaction with the corresponding antibodies (antigenic specificity).

Antigenic substances are highly molecular compounds. They have certain properties — a specific action, heterogenicity for the body, a colloid structure, and solubility in body fluids. The breakdown of proteins to peptones, amino acids and also a deep denaturation by physicochemical effects bring about a loss of antigenic ability, while the introduction of various radicals into the protein molecule causes the loss of species specificity.

Substances composed of levorotatory amino acid isomers induce antibody production, while complexes of dextrorotatory amino acid isomers are devoid of antigenic functions.

Antigenic properties are pertinent to toxins of a plant origin (ricin, robin, abrin, cortin, et al), toxins of an animal origin (toxins of snakes, spiders, scorpions, phalangia, karakurts, bees), enzymes, native foreign proteins, various cellular elements of tissues and organs, bacteria and their toxins, rickettsiae and viruses. Not all substances (proteins and protein complexes in combination with lipids and polysaccharides) are characterised by having antigens with similar properties. There are complete and partial antigens.

Complete antigens are substances, which cause the production of antibodies in the body, and react with them in vivo as well as in vitro (foreign proteins, sera, bacteria, toxins, rickettsiae, viruses and cellular elements).

On the other hand, partial antigens are known as haptens, which do not cause the production of antibodies, but can react with them. Haptens include lipids, complex carbohydrates and other substances. The addition of proteins to haptens even in a small amount gives them the properties of complete antigens. In this case the protein carries out the function of a conductor.

It is well known that the properties of chemical, structural and functional specificity are inherent in all natural proteins. Proteins of different species of animals, plants, bacteria, rickettsiae and viruses can be differentiated by immunological reactions. The antigenic function of bacteria, rickettsiae and viruses is characterised not only by species, but also by type specificity.

The immunological specificity of antigens is linked with a determinant group found on the surface of the antigen as one or more active areas. The determinant group may be isolated in a relatively pure form, which makes it possible to improve the efficacy of vaccinal preparations significantly. Besides, inside each species of microbe there is a different amount of types, which also have specific antigenic properties. Type specificity is associated with the presence of special polysaccharide complexes in the microbial cell.

Besides species and type specificity group (generic) antigens have been revealed in closely related species. The presence of group antigens reflects the historical process of their development and genetic links.

When the antigenic structures of the host are similar to those of the causative agent, the macro-organism is incapable of producing immunity, as the result of which the disease follows a graver course. It is possible that in individual cases the carrier state and inefficacy of vaccination are due to the common character of the microbial antigens and the antigens of the person's cells.

It has been established that human erythrocytes have antigens in common with staphylococci, streptococci; organisms of plague, E coli, Salmonella paratyphi, Shigella organisms, smallpox and influenza viruses, and other causative agents of infectious diseases. Such a condition is called antigenic mimicry.

In 1911, D Forssman established that there are heterogenic or heterologic antigens (haptens) found in different species of animals (guinea pigs, dogs, cats, horses, chickens, fish and turtles). If a rabbit is immunised with an emulsion from the organs of guinea pigs, then antibodies appear in the serum of the rabbit, which react not only with the emulsion of these organs but also with sheep erythrocytes. Thus, in the organs of the guinea pig and sheep erythrocytes there is a heterogenic antigen.

It has been proven that the non-specific properties of Forssman's heterogenic antigen are associated with the presence of lipid or polysaccharide fractions closely related in composition, which bear common properties in different species of animals, plants and microbes. Antigenic properties of bacteria, toxins, rickettsiae and viruses, used in the practice of reproducing artificial immunity against infectious diseases, are of most practical importance.

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