The Open University Physics & Astronomy Society

NEWSLETTER

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STOP PRESS: Fusion Weekend 2023

After three years of the Fusion event and AGM being online, this year's meeting will be face-to-face in Bristol, as part of the Fusion weekend, on Sat/Sun Sept 9th/10th. There will be talks and visits as well as the AGM. Full details will be advertised on the website and Facebook page.

Contents

In Memoriam – Paul Everett

Just before this newsletter went to print, we heard the sad news that Paul Everett had died.

Although Paul was a chemist rather than a physicist, he will have been known to Fusion members who attended the Science Revision Weekend (SRW), formerly known as the Chemistry Revision Weekend – which, under one or other of these names, helped OU students prepare for their exams every year from 1991 to 2019. Paul came to the assistance of the original organiser, Carole Arnold, when she was struggling to keep the event going on her own in the late 1990s, and played a key role in it from then until it was forced to close in 2020 due to falling numbers.

Paul was a hard-working and unassuming man who was happy to do even the most menial of tasks, of the sort that would crop up during the weekend (one of the more amusing ones being collecting up and recycling all the Blu-Tak!) When Carole retired from the event in 2007 he took on a major role as treasurer, managing payments and refunds, and compiling the information packs handed out at registration.

The high cost and financial risk of running such a large event become increasingly difficult in later years in the face of rising costs and falling student numbers – which may have arisen from higher OU course fees and a consequent shift in the demographic, towards full-time study and away from the traditional image of the OU student as part-time self-improver – an image which Paul himself epitomised, as an OU chemistry student who became a chemist at a small cosmetics company in his home town of Cheltenham. Finally, the cancellation of an event due to Covid in 2020 resulted in heavy financial losses, which led to the liquidation of the charitable company, Science Revision Ltd, which had been set up to protect the volunteers from losses in just such an eventuality.

Tony Boshell, one of Paul's colleagues on the organising committee for the revision weekend, described him as "a good, gentle soul who will be much missed." and Digby Tarvin, another SRW colleague, recalled that Paul seemed to genuinely enjoy helping to run the event, and became so closely associated with it that "I could not imagine it continuing without Paul". On a personal note, although I left the SRW committee several years ago, I had maintained sporadic contact with Paul; we discovered a mutual interest in heritage railways, and planned a trip on the Gloucestershire-Warwickshire steam railway – but sadly it was not to be.

Jim Grozier

Exoplanets with JWST: an update

We're now just over a year on from that fantastically successful Christmas Day launch – and what a year it's been! First, we saw a textbook-perfect orbit insertion and deployment during the early part of 2022; then we watched the first images come down as the mirror was painstakingly aligned; and finally in July we saw the very first science data, and it did not disappoint.

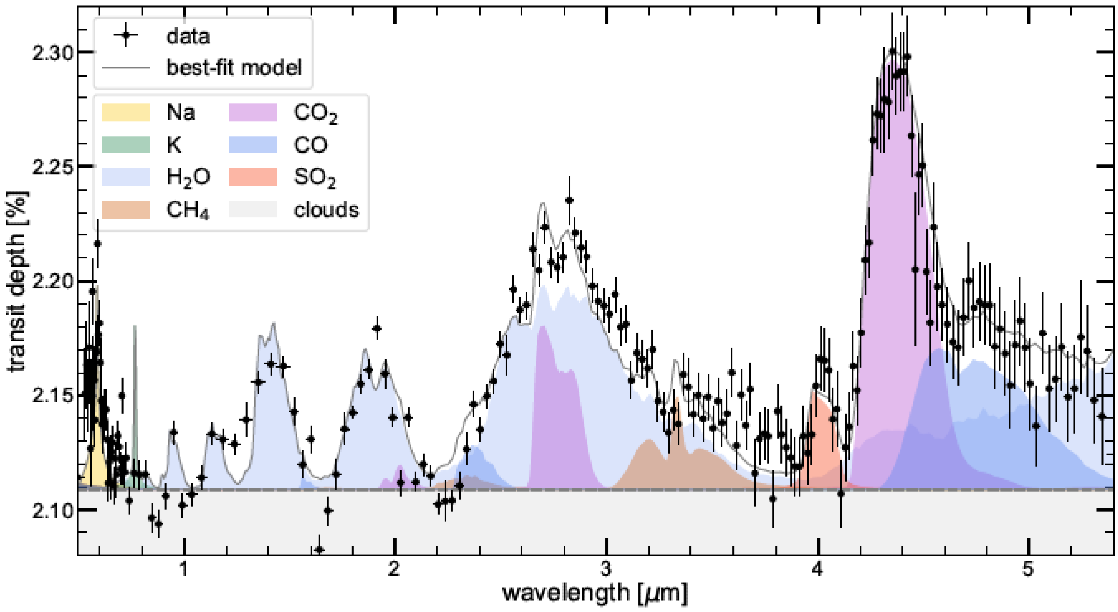
There had been a certain amount of concern that the JWST images, while critically important from a science perspective, would not pack the emotional punch of iconic Hubble Space Telescope views of the Crab Nebula and the star formation region dubbed the 'Pillars of Creation'. JWST is an infrared telescope, so it requires more postprocessing of images to generate something a little like what the eye would see if our visual range included the infrared. The concern was quickly proved to be entirely unfounded; the images from the first data release included spectacular false-colour visualisations of the Carina Nebula and Stephan's Quintet of galaxies, and more recently we have been treated to a new 'Pillars of Creation' image that more than rivals the beauty of the original.

As beautiful as these images are, I was waiting for the one dataset in the first release that didn't come with a pretty picture. This was the NIRISS observation of the transit of WASP-96b and the first glimpse we would get of an exoplanet atmosphere with the telescope. WASP-96b is a hot Jupiter, and so, as I explained in my previous article last year, is ideal for transit spectroscopy – using variations in the apparent size of the planet during transit to infer the composition of its atmosphere. Even better, we had previous observations of WASP-96b from the Very Large Telescope that implied it was likely to have a cloud-free atmosphere. Clouds have the tendency to mute and wash out gas absorption features in transit spectra, so cloud-free planets provide the best opportunity to characterise an atmosphere; however, observations so far indicate that the vast majority of planets have at least some cloud, so these ideal targets are few and far between.

The NIRISS observation revealed that cloud-free planets are even rarer than we thought; model fits to the data reveal that WASP-96b must also have some cloud in its atmosphere. The data also show an atmosphere dominated by water vapour, which is a finding we did expect. Even better though is the quality of the dataset itself – the instrument was performing every bit as well as expected.

This has been borne out by the observations the Transiting Exoplanet Early Release Science Team obtained, of another hot Jupiter WASP-39b. In this case, we didn't stop at just one instrument, but acquired four spectra across the suite of three near-infrared instruments (NIRISS, NIRCam and NIRSpec), covering the full wavelength range between 0.6 and 5 microns at a range of resolutions. This was partly to test and benchmark the instruments against each other, but also to obtain the most comprehensive spectrum yet of a transiting exoplanet. The only instrument missing from the set is the longer wavelength MIRI – but we are rectifying that, and after winning discretionary time to follow up our original programme, MIRI is observing WASP-39b as I am writing this article (14th February 2023).

Each of the individual WASP-39b spectra is groundbreaking, but my favourite image is the one below showing the NIRSpec/PRISM observation. The PRISM observing mode is the only one to cover the full near-infrared wavelength range in a single shot, albeit at fairly low spectral resolution. This image, from Rustamkulov et al. 2023, shows all the spectral features we have detected in the atmosphere of WASP-39b. Several were as expected – water vapour (H_2O), carbon dioxide (CO_2) and carbon monoxide (CO). But one in particular was not expected at all; sulphur dioxide (SO_2). For the gas to be present in the quantities needed for us to see this feature, the planet must have acquired quite a lot of rocky material during its formation, increasing its sulphur budget – but something also must be happening in the atmosphere for sulphur to end up linked with oxygen in SO_2 rather than with hydrogen in H_2S as chemical models predict. Our current theory is that water in the upper atmosphere is photodissociated – the molecules are broken apart when ultraviolet light from the star interacts with them – and the constituent pieces react with the H_2S to form SO_2 instead.

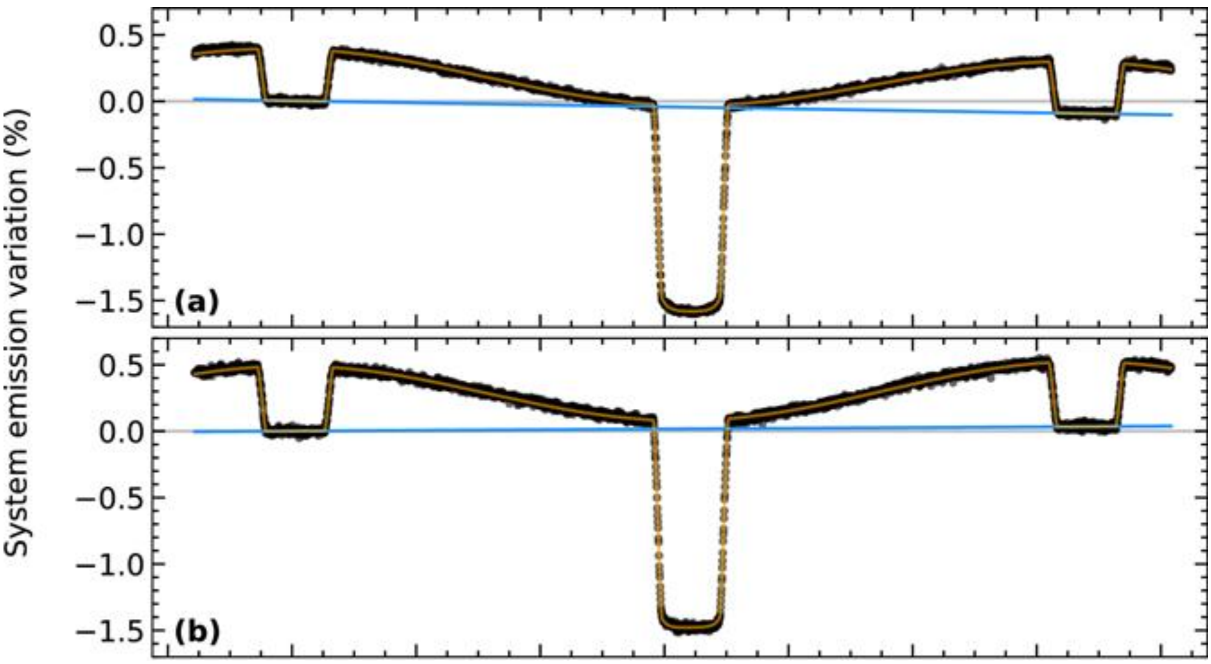


NIRSpec PRISM spectrum of WASP-39b (points with error bars), with model fit (solid black line) and contributions from the different molecules present in the atmosphere indicated by coloured shading. Taken from Rustamkulov et al. 2023, Nature, in press

Even from our very first observations, then, we have been forced to reevaluate our expectations for these hot Jupiters – which is excellent news since it means we have a lot to learn from this wonderful telescope. Modellers like myself are stepping up over the next few weeks to bring our various tools to bear on a combined spectrum for WASP-39b from all four instrument modes. It's certainly going to be a challenge.

Another observation I've been lucky enough to be involved in is a phase curve of ultrahot Jupiter WASP-121b. An ultrahot Jupiter is one that is so close to its parent star that is has an equilibrium temperature of over 2000 K. Because of the intense heating on these objects, we expect the hemisphere facing the star to have very different properties from the one facing space. Since they have such short orbital periods, we can measure the amount of light coming from the system over an entire orbit, which allows us to see the change in flux as the hot dayside rotates into view, and then rotates out again giving way to the cooler nightside. Phase curve measurements, where they are possible, allow us to construct at least a 2D map of the exoplanet. Doing this spectroscopically allows us to monitor changes in gas abundance between the dayside and nightside, as wildly differing temperatures predict different chemistry.

The phase curve of WASP-121b we have obtained using NIRSpec is, quite simply, exquisite. Even with virtually no correction for systematics, the signal from the planet is clearly visible. The difference between the peak brightness (just before the small dip of the eclipse) and the lowest brightness (just before the big dip of the transit) corresponds to a temperature difference of over 1000 K between the dayside and the nightside. Over the weeks and months to come, we will be analysing this in more detail, so stay tuned!



Phase curve measurement of WASP-121b. Time runs along the x-axis left to right. The smaller dips are the eclipses, where the planet vanishes behind the star, and the single deep dip is the transit. The blue lines indicate the slight systematic baseline offset that occurs during the observation relative to the grey line. The data have not been corrected for instrument effects. Figure from Mikal-Evans et al. (2023), ApJL, 943, L17

Jo Barstow (Open University)

Fusion Online Event September 2022

We had a full and varied program for our annual Fusion event. There were three academic talks by OU staff.

Dr Jonathan Nylk, now a lecturer in physical sciences education, gave a talk on some of his previous work, entitled 'Fantastic beams and how to make them, structured photonics for biomedical imaging,'– a history, development and future of the microscope.

'What are the big questions in particle physics' was the title of the presentation by Dr Ian Knowles, staff tutor at the OU. This covered a summary of and the problems with the Standard Model, what questions need answering and how to go about doing so.

Carole Haswell, Professor of Astronomy at the OU, researches exoplanets. We were privileged to hear about her recent cutting edge research, which has not yet been published.

Fusion and committee member, Jim Grozier, gave a fourth academic talk - 'Attribution and award in the age of big science', about the naming of units after scientists and whether we should do so.

Mark Jones, head of teaching at the OU SPS, introduced the MPhys degree and new modules; Gaynor Gardner, IOP, spoke on how the IOP supports students and societies; while Greg Aldam, a physics graduate who has worked in numerous fields before settling in finance, explained how his degree helps in his job as an actuary. The slides of Ian and Jonathan's talks are on the facebook page.

The other event of the day was the Fusion AGM, not as interesting as the talks but an essential part of the meeting.

This was the third online event, due to Covid restrictions and some ongoing concerns, but Fusion hopes that the 2023 one will be 'face-to-face' , or possibly a 'blended', event. Details will be available later in the year on the website and facebook page.

Dwyn Padfield

Underground Science – Part 2

Rustrel, France – Geomagnetism

I am walking along a narrow concrete-lined tunnel in the pitch black. It is just tall enough to let me walk upright. The only light comes from the head torch strapped to my helmet, which emits a feeble beam, enough to let me see the dust-covered paving slabs a few metres ahead of me, but insufficient to illuminate my destination. If I stop walking and listen carefully, I think I can just hear the drip-drip-drip of water at Point C, which I know lies ahead of me, but I may just be imagining it.

I have very little idea how far I still have to walk. I started counting my footsteps after passing Point B, which lies some 500 metres before Point C, but lost count after some two hundred steps. So I just have to keep going until I reach this destination, which could be another ten metres, or over two hundred. From my current position, there is no way to tell that I have not walked past Point C, in which case I am now set to walk another 500 metres until I reach the end of this safety tunnel. In a fit of fantasy, I can imagine that this tunnel could circle the world.

The *Laboratoire Souterrain à Bas Bruit (LSBB)* has an interesting history. In the 1950s President Charles de Gaulle decided that the development of an independent French nuclear deterrent was essential to safeguard the security of the Fifth Republic. Missile silos were built across the mountains of Provence. A key strategic requirement was an underground command centre able to survive a direct hit. For twenty-six years, there were always at least two officers from the French Air Force on duty inside a room called the *Capsule*. Sited deep beneath a massif and accessible by a horizontal tunnel, the Capsule was inside a cavern lined with reinforced concrete and 3cm thick steel walls. This was to shield both the mechanical shock, and the electromagnetic pulse following a nuclear attack.

After two and a half decades deterring the enemies of France, the unit was disbanded in 1992. Thus an unusual piece of real estate appeared on the local property market with some unique period features: a remote rural location away from traffic, power lines and other sources of electrical noise; 500m of rock overburden, to shield all but the most energetic cosmic radiation; and thick steel walls to block electric and magnetic noise. It was ideal for a low noise laboratory.

It is an excellent location for monitoring the geomagnetic field. The thick steel walls keep out the noise, but the signals generated by space weather processes in the ionosphere can be detected with a suitable magnetic sensor—a SQUID, or *Superconducting Quantum Interference Device*.

The tunnels are also ideal for hydrogeology research. Mapping the flow of underground water through the chaotic network of *karstified limestone*, eroded by natural acidity over millions of years, is a challenging task. The tunnels let researchers monitor the groundwater from the inside of the mountain. Wherever water drips from the ceiling, the rate is measured.

The experiment I am working on is searching for a magnetic field produced by the flow of groundwater. Water forced through rock pores will generate a magnetic field through a physics phenomenon called the *electrokinetic effect*. Can we measure it? We want to find out.

This is how I came to be walking down a narrow, concrete-lined tunnel, three hundred metres underground. Once I had set up a magnetometer next to the water flow point, the experiment was simple: wait until the flow rate changes, and then see if there is a corresponding jump in the magnetic field at the same time. For several weeks after we set up the system, the water flow was a slow and steady drip-drip-drip, which manifested itself as a flat line on our display. Eventually, the weather changed. Outside, it rained heavily, accompanied by bursts of lightning, and, a day later, after the water had drained through the cracks in the rocky ground, the flow rate shot up.

We looked at the difference between the signal recorded at the flow point, and that measured in the dryer environment of the Capsule. The conclusion I reached, after weeks of careful number crunching, was a null result. This did not mean that the effect did not exist—just that the magnitude in the rocks at Rustrel was below the sensitivity of our experiment.

Both of the research stories told here ended with null results. We have not yet found dark matter. We didn’t see the magnetic groundwater effect we looked for. This is a common outcome for deep underground experiments. It has been the same for many other big projects. Experiments searching for rare particle physics processes like proton decay or neutrinoless double beta decay have just returned new limits on the lifetime. Many researchers, who keep their feet firmly above ground, find it strange that we can search so long for effects that may not exist. Yet these projects continue, as the concepts are so important. And there have also been big discoveries. The *Sudbury Neutrino Observatory*, in a Canadian Nickel mine, and the *Super-Kamiokande* experiment in Japan discovered the neutrino oscillations, a particle physics phenomenon that went beyond the Standard Model.

Deep underground laboratories are here to stay.

Samuel Henry (University of Oxford)

FUSE 2022: 26-27 November 2022

FUSE is the Forum of University Societies Event organised by the Institute of Physics. It covers physics societies, astronomy societies and physics and astronomy societies based in the UK and the Republic of Ireland. Hence it is, in a sense, the successor to the Young Physicists' Conferences, organised by Nexus, that long-term Fusion members will remember.

The event took place over a weekend at the Institute's headquarters in London, and was attended by about 30 delegates. Another conference, IAPS4Materials – organised by IAPS, the International Association of Physics Students – was taking place at the same venue and the same time, and the delegates were able to meet and sit in on one another's meetings.

Many societies sent two delegates, so the number of societies represented was actually quite small. There were three delegations from universities in Ireland, but some previous UK stalwarts from the old days – including Sheffield, UCL and Bristol – were missing. Societies do wax and wane, of course, which is why it's important to have umbrella organisations like the IOP and IAPS to plug the gaps.

Societies gave presentations about what they have been doing, what they plan for the future and what challenges they face. Some societies were having trouble getting enough members, while others seemed OK in that respect. In my presentation I stressed that, as our members are all over the country, we can help boost other societies' attendances, and we can invite their members to our events, helping to make them viable. So I think that closer co-operation between Fusion and other societies would be of mutual benefit.

One particular way in which this would benefit us concerns observing evenings. Many of the societies represented at the event have their own telescopes, or access to university telescopes, and several attempt to hold regular observing sessions. I say "attempt" because of course they are at the mercy of the weather, and have to have fallback options (usually involving alcohol) in case of cloudy skies. If Fusion members living nearby were included in the mailing lists for these events, it could be a more fruitful way of providing observation opportunities than, say, a UK-wide Fusion event.

My overall impression of the preparations for the conference, and the conference itself, which at times seemed a bit chaotic, suggested that there is some way to go before the kind of physics student network that existed in the early 2000s, with conferences, lecture competitions, visits and a well-produced newsletter, can be re-established; but then I am not sure why it was ever "de-established"! On the plus side though, IAPS does seem to be very well organised nowadays, and is perhaps taking over, to some extent, part of the role previously played by Nexus. We shall see!

Jim Grozier

What Can Philosophy Bring to Astrobiology?

For many, the philosophy of science is a bit of a mystery. It is almost an oxymoron: philosophy would deal with unanswerable questions and science would only deal with solvable problems in the physical world. On the one hand, what science brings to philosophy seems self-evident. Astrophysical discoveries tell us, for example, that we are far from being the centre of the universe, but that we are wandering around on a small rock in an immense space filled with billions of billions of other rocks. But what philosophy brings to science is less obvious at first glance. How can a reflection on the purpose of life, for example, teach us anything about how life works?

This last question is obviously badly put and stems from a misunderstanding of what philosophy is. In fact, there is a real continuum between science and philosophy, both of which involve argued reasoning about the world in order to understand it better. But where increasingly specialised scientists are busy every day experimenting, calculating or managing their laboratories, philosophers of science are fortunate to be able to devote much more time to the study of scientific concepts, with potentially better knowledge of the results of distant fields. As summarised by (Laplane et al., 2019)**,** philosophy of science catalyses "the clarification of scientific concepts, the critical assessment of scientific assumptions or methods, the formulation of new concepts and theories, and the fostering of dialogue between different sciences, as well as between science and society".

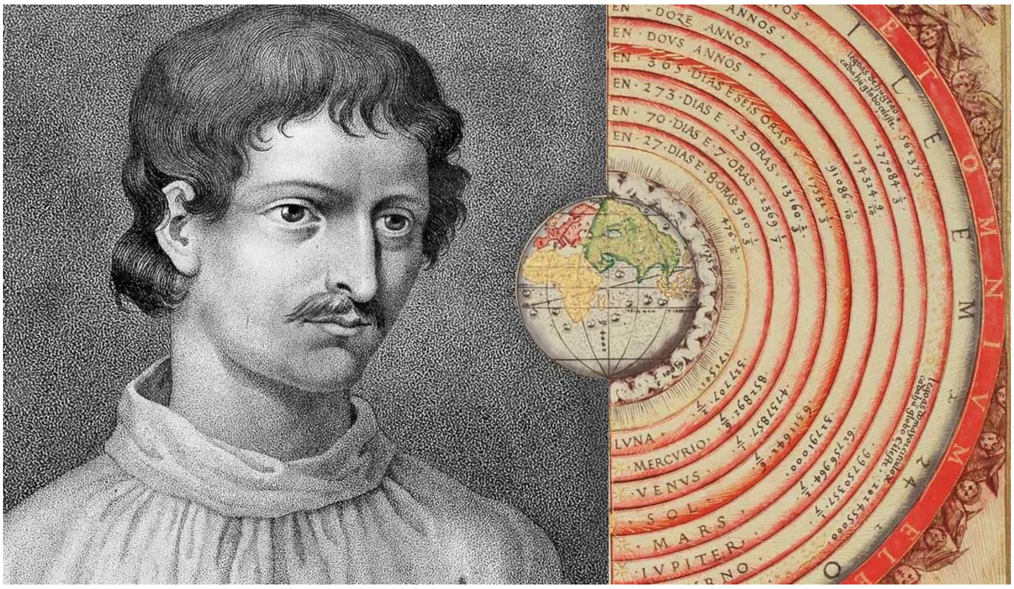


Figure 1*. Giordano Bruno, Italian philosopher and scientist sentenced to death in 1600 partly for theorizing a plurality of worlds populated by extraterrestrial life*

For these benefits to be possible, it is important to develop interdisciplinarity between the natural sciences and the humanities, as I was personally able to appreciate during my PhD. After graduating from an engineering school in life sciences, I was lucky enough to carry out a PhD in molecular biology under the co-direction of a biophysicist and a social anthropologist, and in close collaboration with a philosopher. Thanks to this synergy, I was able to explore the problem of the origin of life by carrying out biochemical experiments (Jeancolas et al., 2021), by studying the human and cultural context of the laboratory (Jeancolas, 2020), and by proposing a conceptual framework to dissociate the different interpretations of the question of the origin of life (Malaterre et al., 2022) and to elaborate conceptual tools to help building scenarios of transition from inert to living (Jeancolas et al., 2020).

Thanks to an encounter with Peter Vickers, a science first philosopher of science, I continue to explore the interface between science and the humanities in the Philosophy Department of Durham University as a post-doc. I am part of a team of two philosophers, a geologist, a biologist, an astrophysicist and a chemist, called EURiCA for "Exploring Uncertainties and Risk in Contemporary Astrobiology". Its mission is to study some of the conceptual foundations of astrobiology and to make a positive contribution to the development of this science which deals with the origin, evolution and distribution of life in the universe. And for that matter, the Open University excels in this field through the AstrobiologyOU research team.

One of our concerns is the notion of uncertainty in relation to the search for extraterrestrial life. To what extent can an observed phenomenon be interpreted as a sign of life and not as coming from an unknown abiotic phenomenon? This thorny question, which is an offshoot of the problem of unconceived alternatives (Stanford, 2019), has led us to analyse different definitions of the concept of biosignature. These fall roughly along a gradient from a weak to a strong pole. The problem of weak definitions can be illustrated by this example which considers a biosignature "as a molecule, pattern or other signal that has a non-zero probability of occurring, conditioned on the presence of a living process" (Walker et al., 2018). Here, the concept of biosignature actually becomes quickly useless. Many phenomena are not incompatible with life without being a sign of it, such as the simple presence of volcanoes on the surface of a planet.

On the other side of the spectrum we have definitions like: "A biosignature is an object, substance, and/or pattern whose origin specifically requires a biological agent" (des Marais et al., 2003). This proposal is also difficult to apply because nothing indicates that an abiotic alternative will not be found after the detection of a so-called biosignature, as the history of the discipline teaches us (Dick, 2020). To overcome these problems, we propose the following definition: "A biosignature is any phenomenon which is known can result from biological processes and whose potential abiotic causes have been reasonably explored and ruled out". This formulation does not necessarily allow us to immediately identify a phenomenon as a biosignature, but it does have the merit of integrating the necessary work of searching for alternatives in order to be able to make a decision. But when do we know that we have 'reasonably' done this work? When can we say that we have indeed detected extraterrestrial life?

Looking at the workings of other scientific disciplines can shed light on this issue. And if there is one area where the uncertainties are immense and where it is imperative to have an assessment, it is the science of climate change. For more than 20 years, IPCC scientists have used a common scale to assess the degree of confidence they have in a particular proposal. As you can see from figure 3, this framework consists of two axes. Each author of a report must individually assess the quality of the evidence supporting the proposal, but also the degree of consensus on the subject. These two assessments then result in a degree of confidence in the proposal that can be averaged over all authors. If this works for the IPCC, why not implement it for astrobiology?

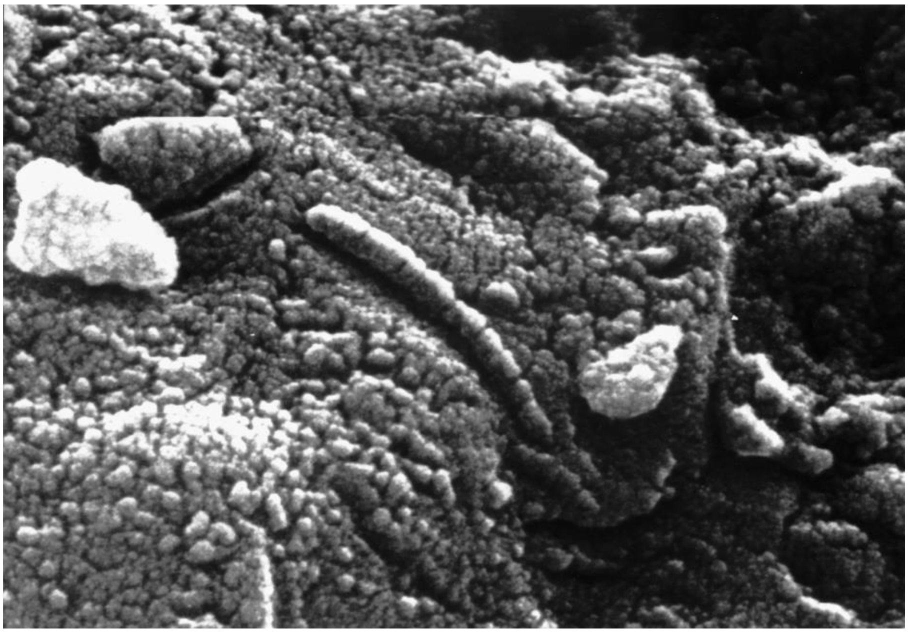


Figure 2. A microscopic picture of the ALH84001 meteorite once believed to be a sign of Martian life in the 90's.

For example, it would be enough to set up a sufficiently diverse committee of experts to be able to assess the evidence and the degree of consensus of the community. This measure of confidence in the detection of extraterrestrial life would then best take into account our progress in exploring alternative abiotic causes, which should be reflected in the degree of consensus. Because the history of astrobiology also shows us that the community is particularly sceptical of any announcement of the detection of extraterrestrial life, and that the search for alternative causes immediately follows any announcement that is serious enough.

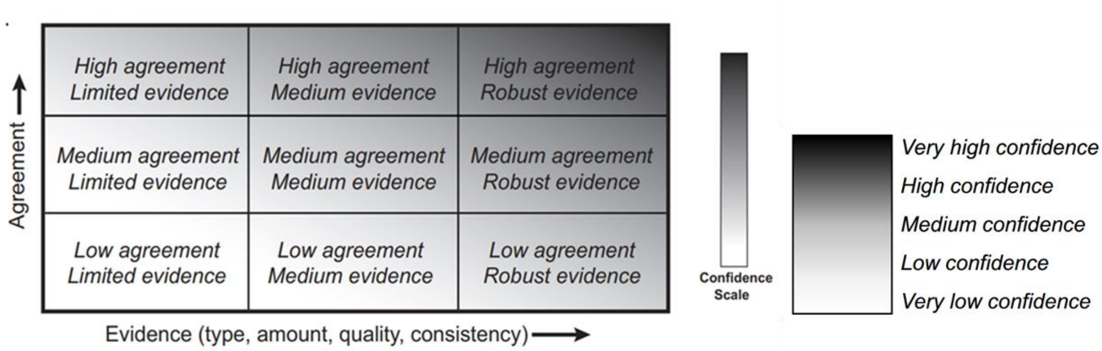


***Figure 3**. The IPCC framework to assess uncertainties. Image from (Mastrandrea et al., 2010)*

Uncertainty related to unconceived abiotic alternatives is not the only source of uncertainty in astrobiology, far from it. The origin of life on Earth will probably never be known and who knows what life forms populate the Universe? Our ignorance of the reality of life in the universe might then justify astrobiologists straying off the beaten track and conducting what might be called fringe or maverick research projects, one extreme of which is illustrated by the search for extraterrestrial technologies. But it seems that the funders of the discipline, such as NASA, are more conservative than they appear (Vickers, 2020) and would fund research mainly on the basis of expected results to ensure some return on investment. This is quite understandable as maverick research carries an intellectual risk and is likely to be unsuccessful, unlike step-by-step incremental research. In fact, this risk-taking is mostly justified if there are no safer ways to achieve similar results. And this may not be the case in astrobiology after all. To assess this, we have studied the extent to which intellectual risk-taking is already contributing to the advancement of the discipline.

To do this, I selected a sample of the most important advances in astrobiology over the last 20 years and asked the corresponding authors about the research process behind them via a survey. The breakthroughs cover different topics in astrobiology ranging from the discovery of exoplanets to the discovery of the metabolic pathways of the last universal common ancestor. From 40 responses, I was able to establish that about the same number of researchers took low, medium or high intellectual risk and that the relative impact[1] of papers is significantly correlated with the risk-taking declared by the authors. I then interviewed 10 of them to better understand qualitatively their research and their opinion on the state of the discipline. Interestingly, they show a diversity of practices and opinions that do not lead to a consensus, except that 8 of them state that their breakthroughs are the result of exploratory research leaving room for potential surprises.

However, the most cautious scientists, for example, seek to minimise the risk in order to ensure publications for their team members, whereas the most risk-takers insist on the importance of the results they are aiming for in order to conduct their research at the margins of the mainstreams. The scientists interviewed also expressed a diversity of opinions on the state of the discipline, with half complaining that there is not enough risk-taking and the other half stating that the state is satisfactory, or that there is even too much research, which some do not hesitate to describe as 'foolish'. As a result, this study supports that to foster significant breakthroughs in astrobiology, it is important to maintain a risk-balanced portfolio with a significant proportion of exploratory projects.

These are just a few examples of philosophy of science work that can help astrobiology to develop. However, even if interdisciplinarity is more and more present in speeches, it still struggles to be followed by concrete actions, especially when it comes to breaking down the boundaries between humanities and natural sciences. Hopefully, the work we are doing at EURiCA will help to convince people of the value of this synergy.

Cyrille Jeancolas (University of Durham)

[1] in terms of number of citations weighted by field and year of publication.

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Physics Feuds Throughout History: Oxford, 25 February 2023

We all love a good feud, don't we? We are encouraged to think in binaries: true/false, left/right, man/woman … so it's no surprise that the best stories in the history of science are about conflicts between rival camps, each camp headed by a champion, whom you either love or hate. But there again, we also know that the popular versions of these stories are always over-simplified. So, in enthusiastically booking my place for this fascinating free event, I was expecting to hear, from experts who have studied the small print, the familiar warning that "it wasn't quite a simple as that". But in the event, of the five talks, only one followed that particular template.

Galileo vs the Catholic Church

This was "Deconstructing the Copernican and Galilean Controversy with the Catholic Church", by Anna Maire Roos of the University of Lincoln. She did not deny that there was conflict between Galileo and the Church, but described references to a feud as "overblown" and the popular account of it as "simplified". She described first the Aristotelian model of the universe and the accompanying principle that objects behave according to their inherent natures, and according to aesthetic properties such as beauty, rather than external physical laws. However, this Earth-centred model could not easily explain the retrograde motions of the planets – a phenomenon that falls under the remit of *astronomy* (how bodies move) rather than *cosmology* (the natures of the bodies themselves). To explain it, Ptolemy had postulated a complex motion whereby each body describes an *epicycle*, whose centre rotates on a *deferent* – in rather the same way as we now regard the moon as orbiting the earth while the earth revolves around the sun, if you could take the earth itself away, so that the moon orbited a mere geometrical point.

Enter Copernicus in the mid-16th century. His theory was not quite as revolutionary as is widely thought, since apparently Copernicus believed, erroneously, that his sun-centred model (which could explain retrograde motion) was simply a development of an existing sun-centred model put forward by Pythagoras, who had in fact referred to a "central fire" in his model – *not* a "central sun". In fact, Copernicus's model was not rejected by the church, since it was seen as only a hypothesis, and was lacking any proof of its fundamental tenet, namely the motion of the earth. It was, of course, realised that this motion would lead to parallax in the observation of the stars, and the failure to detect parallax was interpreted, at the time, as evidence against Copernicus's model, rather than (as we now know) due to the vast distances to the stars and the correspondingly small parallax angles.

With the invention of the telescope, however, Galileo was able to amass more evidence against the classical view – in particular, the first observation of orbiting objects that were definitely *not* orbiting the earth (Jupiter's moons), the phases of Venus, and the "imperfect" appearance of the lunar surface. But it was a bad time to be challenging the wisdom of the Catholic church, which was on a war footing following the rise of Protestantism. Nevertheless, Pope Urban VIII, who took office in 1622, encouraged Galileo to publish his ideas as long as they were treated hypothetically. Many people would have been satisfied with such a compromise, but not Galileo, whom Professor Roos described as having an “abrasive personality” and “an ego the size of Florida”. When he did publish his “Dialogue Concerning the Two Chief World Systems” the participants in the dialogue were thinly disguised caricatures of Galileo himself (“Salviati”) and the Pope (“Simplicio”) with the open-minded “Sagredo” keeping score. The Pope interpreted this as a personal insult, and Galileo was tried in 1633 and imprisoned – not in a dungeon but in a “rather pleasant villa” – but nevertheless, it was still imprisonment. He died in 1642.

Galileo was not the first or the last scientist to fall victim to his own overinflated ego. In fact, one might argue that the possession of such a personality is an essential requirement for the advancement of unpopular scientific ideas, and that history suggests that such people are needed for science to progress. We might even cite, as corroborating evidence, other individuals mentioned in talks at this event, such as Isaac Newton, Martin Ryle and Fred Hoyle. But, as Stephen Blundell pointed out in his final summing-up of the event, one can also point to others of equal stature but with far less combative personalities, such as Christopher Wren and Paul Dirac.

Matter and Space in ancient Greece

Andy Gregory, of University College London, showcased a less well-known story in the history of science – the dispute between the atomists Democritus and Leucippus, on the one hand, and Aristotle on the other, over the question of the composition of matter, and whether there is such a thing as empty space. In contrast to Parmenides, who had held that there was no such thing as empty space and therefore there was only one “thing” (since if there were more than one thing, the spaces between the things would be empty) Leucippus argued that there were indeed many things, and between them there was a void.

Aristotle, however, did not believe in the possibility of empty space. Instead of atoms, he thought the world was made up of *qualities* which are comparable but not quantifiable. Take away the qualities and you get *prime matter* – matter without any qualities. It exists only *potentially*. The world is densely packed and there is no vacuum. Luckily, in ancient Greece there was no equivalent of the Inquisition to punish you if you held the “wrong” ideas!

Einstein vs Bohr

The “feud” between Einstein and Bohr was more of a well-mannered academic rivalry than a feud, between two giants of 20th century physics who, according to the speaker, Reinhard Werner of Leibniz University in Hannover, had great respect for each other. Their disagreement is well known, and could perhaps be better described as a “feud” between ideas than between individuals. Werner contrasted his two protagonists, pointing out that while Einstein was a “master detector of clashes of principles”, Bohr simply ignored the clash between his model of the atom and electromagnetic theory to successfully predict the spectrum of deuterium. And while the Aspect experiment on non-locality found in favour of Bohr, this dispute is probably best couched in terms of rival *models* of the universe, rather than making claims about some unobservable “reality”.

Newton, Hooke and Leibniz

In the case of Isaac Newton, there was no clash of ideas – the bitter disputes between him and, respectively, Hooke and Leibniz, did not involve disagreements about the nature of the universe, but merely about “who got there first”. Rob Iliffe, the Chair of the History Faculty Board at Oxford University – a rare achievement for a historian of science – is an expert on Newton. He started with some biographical facts, including the bizarre statement that “Newton was born in the same year as Galileo died, but in the place where Galileo died Newton was born in the following year”. Luckily, the rest of the talk was much easier to understand!

When Newton stated that “nobody in their right mind” could doubt that light was particulate, Hooke objected that the particulate theory of light was merely a hypothesis; but for Newton, it was more than a hypothesis – it was *absolutely certain*. He developed a hatred for the public sphere, and believed that the best way to do science was – to quote Iliffe – “in private, with like-minded, smart people who agreed with everything he said” whereas Newton saw the public sphere as a place where “the vulgar misunderstand that which they have no hope of comprehending”. This was ironic, given that the whole ethos of the recently-founded Royal Society (of which Newton was President from 1703-27) was that experiments should be performed in the presence of observers – who, while they were not exactly the general public, were not necessarily uncritical admirers either.

When Henry Oldenburg, the editor of *Philosophical Transactions*, published debates about Newton’s theories, Newton “retreated back to Cambridge, physically and mentally, and devoted himself to alchemy and theology” although he did occasionally intervene in scientific debates. A dispute with Hooke followed after Hooke accused him of plagiarism, and Newton in turn accused Hooke of turning science into “a litigious lady”.

A similar dispute developed when Leibniz published his work on the calculus. Newton had also, of course, “invented” the calculus but had not published his work. Newton described Leibniz’s calculus as inferior to his own, and accused him, through his followers, of being a plagiarist. It was during the dispute with Leibniz that Newton made the famous statement that he did not “feign hypotheses” – he saw his own philosophy as mathematically certain. As Iliffe put it, Newton’s own actions (e.g. keeping his work private) “made inevitable the very kind of feud that he himself professed to despise”.

Hoyle vs Ryle

The final talk was on the rivalry between Fred Hoyle and Martin Ryle in the 1950s and 60s. It was given by Simon Mitton, who, as one of the three biographers of Hoyle (the other two being Jane Gregory and Hoyle himself) was in a good position to comment on this topic. As fairly recent history (I can remember reading about the controversy myself in a scientific strip cartoon published in the *Sun* newspaper, in the days when it was actually a fairly decent broadsheet) the story is probably familiar to many readers.

Mitton’s talk included a long introduction to the dispute, going back to Einstein and the cosmological implications of general relativity, and featuring the many other participants in that story. Consequently there was not much time for the details of the feud itself. But basically, Ryle – a radio astronomer – supported the “hot big bang” theory in which the universe originates in a singularity and expands, so that it “evolves” – its appearance changes in time. Thus, by observing the most distant galaxies, whose light (including radio emissions) was emitted earlier in the life of the universe than from nearby sources, one can theoretically determine whether the universe has indeed evolved. Hoyle, with his colleagues Bondi and Gold, proposed the rival Steady State theory, in which matter is continually coming into existence, and the universe does not evolve. Ryle initiated several surveys of radio sources, claiming that they supported his theory, but Hoyle disputed that. The rivalry became very personal, with Ryle at one stage setting up a press conference in which he put Hoyle literally "in the spotlight" and invited him to challenge Ryle's claims. Eventually the dispute was settled in favour of the Big Bang theory by the discovery of the cosmic microwave background radiation in 1965.

Ryle and Hoyle both had strong idiosyncratic personalities (while Hoyle was perhaps the proverbial "stubborn Yorkshireman", Ryle was quick to anger, as I heard from a former colleague of his whom I met in the context of a Fusion visit to the Mullard Radio Astronomy Observatory near Cambridge, where Ryle and others worked, several years ago). This might explain why their rivalry was such a destructive one, in contrast to the friendly competition between Einstein and Bohr. No doubt parallels could be drawn between either Hoyle or Ryle and Newton, in terms of personality type. So maybe it is all a case of what kind of person you are.

Physics Feuds in Perspective

But are there other factors that exacerbate the situation? Well, undoubtedly the system of rewarding individuals for important work in academia – with the Nobel prizes at the pinnacle of that system – emphasises individual achievements at the expense of the community as a whole, and thus can transform a healthy and friendly competition into a bitter rivalry, even though the age of the "lone gentleman scientist" is long gone, and probably never existed in the first place, as Steven Shapin's seminal paper "The Invisible Technician", based on the work of Robert Boyle in the 17th century, has shown. This distorts the whole process of doing scientific work. At the 2022 Fusion AGM I gave a talk entitled "Attribution and Award in the Age of Big Science" to a very small audience, its size no doubt limited partly by the rather boring title and also by the early hour (it started at 9am). In that talk I highlighted a number of pitfalls of emphasising the importance of individuals in science, and suggested that it was about time we started honouring entire communities for the contributions they make, and downplaying the roles of individuals. Yet physics seems to be firmly in thrall to the awards system, as can be seen from the frequency of mailings about "prizes" sent out by the Institute of Physics and no doubt other bodies as well. Isn't it time for a culture change?

Jim Grozier

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Name Search

Bohr	Born	Curie	Dirac	Feynman	Gallileo
Hawking	Joule	Kepler	Leavitt	Newton	Ohm
Pauli	Rees	Rubin			

F	V	D	B	E	A	C	L	C	J	S	P
E	H	O	O	E	L	I	L	A	G	H	N
Y	W	T	U	D	B	C	S	R	L	P	M
N	E	W	T	O	N	E	A	I	K	H	Y
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X	N	A	R	M	P	N	W	H	J	P	N

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What is it and What is it For?

Answer

Demonstration conductor for electrostatics. Used for showing that the electric field around surfaces with small curvature is greater than that from large curvature. Would have been used in conjunction with a small square of metal on an insulating handle (called a "proof plane"), used to transfer charge from a region of the conductor to an electroscope, to show that there is more charge on the more curved parts.

Celebrating 35 Years of IAPS

Authors: Zlatan Vasović and Alexia Beale

Image Credit: Harvey Sapigao

This year the International Association of Physics Students (IAPS) is celebrating its 35th anniversary. IAPS is an association of physics students and student societies from around the globe, working to promote peaceful collaborations and share their love of physics. With over 90,000 represented students, IAPS provides a community to support physics students in their professional and social development.

It all began in 1985, when four Hungarian physics students, Levai, Horváth, Budai and Van, joined forces to organise a meeting with their colleagues from the other countries. Their effort turned into the International Conference for Students of Physics (ICSP) in 1986, attended by students from eight different countries. Realising the event's success, attending students decided to form an organization at the next conference in 1987, conveniently called the International Association of Physics Students. The conference itself was also renamed to the International Conference of Physics Students (ICPS) to follow suit. Both names still stand today, while their legacy grows.

IAPS organises a wide range of different activities throughout the year, ranging from conferences, talks and workshops to social activities and outreach events. Registration is open for IAPS' annual conference, ICPS, will be held in Baguio and Manila, Philippines in September (https://www.icps2023.com/). PLANCKS is an exciting theoretical physics competition for teams of Bachelor's and Master's students, with guest lectures and social activities added on top.

A fundamental part of IAPS are its outreach activities, most notably the annual School Day. Every year in November, members of IAPS visit schools on World Science Day to demonstrate physics experiments. This year's theme was Physics for Sustainable Development. For UNESCO's International Day of Light, IAPS provides the IAPS Light Grant, a form of financial support for outreach or educational activities which focus on the science of light and its technological applications.

IAPS also has several informal groups which meet on Sundays, usually at 1pm UTC. Students can listen, play and discuss international music in the newly formed Music Group; try different recipes at the Cooking Day sessions; and seek support in the Mental Health Chats. To celebrate the 35th Anniversary, IAPS has launched a new group "History of IAPS" and composed a song in celebration of the anniversary. There are plans for more events throughout the year too.

All IAPS activities are neatly reported in jIAPS, the Journal of IAPS, published at least once per year. The journal is an unusual combination of event reports, scientific articles, interesting topics for students and creative content, all perfectly mixed together. jIAPS also organises an annual Article Contest and Creative Contest, where physics students from all over the world can submit entries with a chance to win waived registration fees to ICPS and see their work published in jIAPS.

Any Bachelor's, Master's or PhD student who is a member of the IOP is automatically a member of IAPS. To join the IAPS Discord server or get involved with any part of IAPS, just send an email to ec@iaps.info. You can find out more about IAPS at its website https://iaps.info/ and follow us on social media at https://instagram.com/iaps_physics/, https://www.instagram.com/j.iaps/ and https://twitter.com/IAPS_physics.

PLANCKS 2022 in Munich, © DPG / Heitz 2022

What is it and What is it For?

See you at Fusion Weekend, Sat/Sun September 9/10!