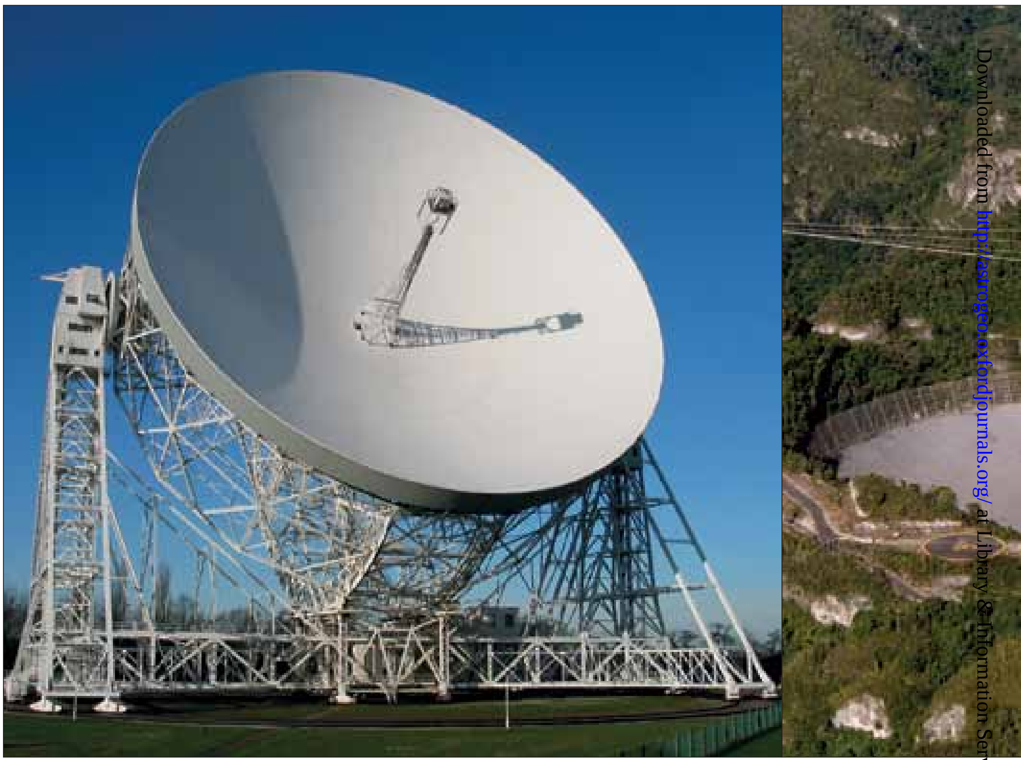
Promoting SETI i

MEETING REPORT **What does the UK presently do in the search for extraterrestri for the future? Alan Penny reports on a meeting of UK academics active in SE Astronomy Meeting in Scotland – and the formation of the UK SETI Research**



1: The Lovell telescope (left) and the Arecibo telescope (right) were used in the Project Phoenix SETI search in 19

Work in the UK on the search for extraterrestrial intelligence (SETI) is limited and is entirely self-funded – that is, research by UK academics using their own time to publish. There is no dedicated effort and no actual searches in progress. Should this state of affairs continue, or should there be a change? The UK lags behind other nations in performing SETI searches. The US is the frontrunner, with the SETI Institute, the Radio Astronomy Group at Berkeley, and Paul Horowitz at Harvard all undertaking major search programmes. Argentina, Italy, France and Australia have all hosted significant efforts. The sole UK search activity was during the period from 1998 to 2003 when, with funding from the SETI Institute, the University of Manchester used the Lovell Telescope to take part in the SETI Institute's Project Phoenix survey. UK activity now consists of theoretical papers and search-programme analyses.

The 12 UK academics who have published on SETI met in July this year to discuss the situation and decided to take the first steps towards a more respectable presence for the UK in the SETI world. Before the meeting they established the UK SETI Research Network (UKSRN; http://seti.ac.uk) whose aim is to promote academic SETI in the UK. The group was very pleased when the Astronomer Royal Prof. Martin Rees agreed to become the network's patron.

Taking the opportunity offered by the National Astronomy Meeting at St Andrews, the group used two of the 75-minute sessions to discuss their own work and then used a third session to discuss the way forward for the UKSRN.

Large search analyses

Tim O'Brien (University of Manchester) described how Jodrell Bank's role in SETI dates back to the seminal paper by Cocconi and Morrison (1959). Their proposal to search for radio signals from extraterrestrial civilizations was inspired by the capabilities of new instruments such as Jodrell's 250-foot diameter Mark I radio telescope. Much later the Lovell Telescope did take part in SETI, working with the Arecibo Telescope in the SETI Institute's Project Phoenix from 1998 to 2003. Jodrell Bank is currently completing commissioning of the e-MERLIN array of seven radio telescopes, including the Lovell Telescope, connected by optical fibres and stretching over 217 km from Jodrell Bank to Cambridge. At the focus of the synthesized telescope is the new e-MERLIN correlator, a specialized supercomputer which samples and combines signals from the individual telescopes. O'Brien described the capability of this new system for SETI programmes and reported on progress in initial test observations.

Ian Crawford (Birkbeck College) went on to say that scientific interest in the Moon is undergoing a renaissance, and multiple reasons exist for renewed human and robotic exploration of the lunar surface. Although the main scientific reasons for exploring the Moon relate to planetary science questions unrelated to SETI, an ambitious programme of lunar exploration may advance SETI in at least three ways:

- The lunar farside provides a radio-quiet environment unique in the inner solar system, and SETI would benefit from a lunar radio astronomy infrastructure.
- The lunar regolith may preserve extraterrestrial artefacts. As well as macroscopic objects that may have been deliberately left on the Moon, these might more plausibly include micron-sized fragments of artificial materials (e.g. exotic alloys) ejected by radiation pressure from planetary systems harbouring spacefaring civilizations. Even non-detection of such particles may permit quantitative limits to be placed on the prevalence or otherwise of technological civilizations in our galaxy (and thereby constrain inferences drawn from the Fermi Paradox).
- Building up a scientific and industrial infrastructure on the Moon is a potential stepping stone to developing future capabilities (from lunar and/or space-based interferometric telescopes to robotic interstellar probes) that will advance the search for life in the universe in the future. Progress in all these areas will be greatly facilitated by a human presence on the Moon.

In the endeavour to detect evidence of ETI in the solar neighbourhood, **Eammon Ansbro** (Kingsland Observatory) suggested that instrument technologies exist that allow the formation of a scientific search strategy to carry out a search for interstellar robotic probes of possible extraterrestrial origin within the solar system. The range of hypothetical probe features and/or characteristics and of currently available detection technologies influence both search strategy and instrument selection. He proposed a strategy, including observatory design, with the goal of providing an economical, flexible and robust path towards collecting reliable data with the potential of adding to solar system knowledge as well as potential ETI detection. Establishing a robotic detection system would permit observational sensitivity, multiple bandwidths and high-speed processing. A scientific search method for robotic probe(s) must use multiple instruments concurrently because multiple characteristics may be present. However, with multiple instruments and sensors, the data fusion, management

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and organization processes are more complicated and analytically challenging. But it is also more scientifically sound thanks to the potential for correlations, and of greater inherent scientific value because of the richer potential for discovery of unexpected natural phenomena as well as exploring the ETI hypothesis. The speaker offered a proof-of-concept proposal for instrumentation to show a design for the purpose of collecting scientific data on anomalous observational phenomena that is suitable for the application of rigorous analytical techniques.

Duncan Forgan (University of Edinburgh) then discussed the detection of ETI based on their use of stellar engines. Stellar engines are defined as megastructures or macro-engineering projects designed to leverage a significant fraction of a star's energy output to generate work. The Class A stellar engine (also known as a Shkadov thruster) is a spherical arc mirror, designed to use the impulse from a star's radiation pressure to generate a thrust force, perturbing the star's orbit around the galactic centre. If this mirror obstructs part of the stellar disc during the transit of an exoplanet, it can be detected by studying the shape of the transit light curve, presenting another means by which the action of extraterrestrial intelligence can be discerned. Modelling the light curves produced by exoplanets transiting a star which possesses a Shkadov thruster shows how the parameters of the planet and the properties of the thruster can be disentangled. The speaker estimated the *a priori* probability of witnessing such a transit, given the existence of the Shkadov thruster, and speculated on the utility of this detection technique as a serendipitous SETI search method in current and future exoplanet transit surveys.

Martin Dominik (University of St Andrews) then considered SETI outside our galaxy. Gravitational lensing of compact emitters by Milky Way stars has the potential to yield huge magnifications, provided the angular alignment between foreground and background objects is sufficiently small. This might lead to short putative SETI signals arising from extragalactic civilizations, which due to their nature do not repeat. These would allow us to look deep into the universe, therefore dramatically increasing the search space. On the other hand, the universe is mostly empty. If, however, a substantial number of Wow!-like signals happen to be observed, then it would be possible to test if they are related to gravitational lensing by Milky Way stars because, if so, their distribution on the sky would follow a characteristic pattern.

Theoretical ideas

William Edmondson (University of Birmingham) extended his argument (Edmondson 2012) explaining how the functional specification of the brain can be considered to be that it serves the Sequential Imperative – the requirement that organisms with brains need those brains to link the sequential "external world" of action and behaviour with enduring mental representations. This two-way link is necessary for any complex organism: perception requires rebalancing away from sequencing, and behaviour requires rebalancing into sequences. The argument in relation to any beings we might consider to be ETI is that we can reasonably suppose certain characteristics of their "biology" including the need for a brain and for that brain to have certain properties. The most important functional property of an ETI's brain is that it serves the Sequential Imperative (regardless of its neural architecture or biological basis). This chain of reasoning is set out, with some fresh thinking in respect of both language and cognition.

John Elliott (Leeds Metropolitan University) considered what sort of intelligences we are searching for. In the pursuit of detecting intelligent life beyond our own biosphere, we have (for pragmatic reasons) focused on efforts that implicitly anthropomorphize detectable phenomena. While developing such methods furthers our capabilities, it still leaves areas on the search spectrum unexplored and potentially "blind" to post-biological, i.e. machine, intelligence. Although the speaker was not discussing rationales for searches to detect non-biological sentience, he did investigate the likely signatures and contrasting structures such non-biological communicators may present. If a signal is detected, the initial categorization and assessment will focus on analysing the constructs that comprize it, to ascertain whether structures indicate signs of information content: a fundamental signature of intelligence. To ensure that our systems are capable of encompassing such intelligent communicators, we need to investigate both the contrasts and similarities of such non-biological communication and how this extends the known spectrum. The speaker presented initial findings from investigating a range of known machine-communication phenomena and discussed how such contrasting forms of information exchange can aid, extend and refine our detection and decipherment capabilities.

Stephen Baxter (British Interplanetary Society) then asked how we should prepare an unmanned probe with general scientific objectives for the possibility of detecting ETI at the target system. The Pioneer and Voyager probes carried messages in case of contact with ETI. The probability of a probe making a first detection of ETI may be low, but it seems pragmatic to prepare for the possibility. The speaker considered how a probe might detect signs of ETI at the target system, and indeed how ETI might detect a probe. Contact with ETI is a low-probability, high-impact event and the philosophy should be that existing systems, especially communications and science suites, should be adaptable, rather than dedicated systems added to the design. The speaker then sketched out options after detection. At present we have no publicly agreed policies regarding the management of this kind of contact. The present SETI Detection Protocol and the proposed SETI Reply Protocol deal with a distant contact from Earth of ETI. The case of a space probe making direct contact would demand a more sophisticated policy. Such a policy, balancing the possible benefits of a positive contact on the one hand with threats to the security of mankind following a negative contact on the other, should be developed before the launch of a probe.

Anders Sandberg (University of Oxford) focused on extragalactic SETI and colonization scenarios, little analysed compared to their intragalactic counterparts. He presented an exploratory engineering study of the feasibility and requirements of extreme long-range colonization using automated probes, and the impact this has on the Fermi question. He found that, given certain technological assumptions, the resources found within a single solar system are more than enough to launch long-range colonization in such a way that eventually all reachable parts of the universe are touched, and that the timespan and energy expenditures are small enough to be easily overlooked by remote observers. A high fan-out strategy reduces risks of goal divergence between the probes. It appears likely that a species able to perform interstellar colonization can also perform extragalactic colonization on a huge scale. Given the accelerating expansion of the universe, early colonizers gain a large advantage in reach: the Milky Way could have been reached by colonizers from between millions and billions of galaxies, depending on their speed and time of origin. This makes the Fermi question stronger: any answer involving a low-probability filter needs to reduce the probability correspondingly. The exception is "already here" answers such as the Zoo hypothesis; they are unchanged or strengthened. The alternative is to assume a surprisingly low technology ceiling in all cases.

Austin Gerig (University of Oxford) argued that, given a sufficiently large universe, numerous civilizations almost surely exist. Some of these civilizations will be short-lived and die out relatively early in their development, i.e. before having the chance to spread to other planets. Others will be long-lived, potentially colonizing their galaxy and becoming enormous. What fraction of civilizations in the universe are long-lived? The "universal doomsday" argument states that long-lived civilizations must be rare because if they were not, we should find ourselves living in one. Furthermore, because long-lived civilizations are rare, our civilization's prospects for long-term survival are therefore poor. The speaker discussed developing the formalism required for universal doomsday calculations and showed that while the argument has some force, our future is not as gloomy as the traditional doomsday argument would suggest, at least when the number of early existential threats is small.

William Edmondson gave a poster presenting the thinking behind a proposal for SETI searches (Edmondson and Stevens 2003). The scheme looks for alignments between "Habstars", stars suitable for life-bearing planets (Turnbull and Tartar 2003) and pulsars, assuming that an ETI might consider a line-up between Earth, (ETI host) star and pulsar a "special direction". A civilization would direct its SETI search towards stars in such special directions, and so might target the Earth. There are now some 860 exoplanets known; it makes sense to consider two elaborations of the original proposal. First, it is worth re-examining specific Habstars, to see if exoplanets have been detected around them. If so, they merit further examination. Secondly, it is also sensible to consider alignments of known exoplanets.

Alan Penny (University of St Andrews) gave a poster about the history of SETI, presenting a lesson on what to do if in your research you stumble on what seems to be evidence for extraterrestrial intelligence. In the winter of 1967 Cambridge radio astronomers discovered a new type of radio source of such an apparently artificial nature that for a few weeks some members of the group had to seriously consider whether they had discovered an extraterrestrial intelligence. Although their investigations lead them to a natural explanation – they had discovered pulsars – they had discussed the implications if it was indeed an artificial source: how to verify such a conclusion and how to announce it, and whether such a discovery might be dangerous. In this they presaged many of the components of the SETI Detection Protocol.

Anders Sandberg's poster discussed the group of proposed explanations for the Fermi paradox within the "deadly probes scenario", where some civilizations produce self-replicating devices that prevent other civilizations from coming into being. Whether this kind of scenario works as an explanation depends on whether it is stable and compatible with our own observations (including our own existence as observers). These conditions were analysed in more detail, including through a minimalist model of competing probes: probes with finite sensing and action radius are spread out in space, trying to replicate to replace normal attrition losses but in doing so incurring risk of detection from opposing probes. Different strategies were examined, finding the conditions where incumbent civilizations can retain their advantage versus newcomers. The difficulties of quorum sensing mean that rapid widespread replication seems to be the stable strategy, making the scenario a less likely explanation across much of the parameter space. Anthropic considerations also restrict this scenario: our existence as relatively late observers is incompatible with deadly probe systems effective enough to work as Fermi paradox explanations.

The way forward

In the third session, the UKSRN members discussed how to advance the study of SETI in the UK. It was agreed that the formation of the network and the get-together for these sessions had been beneficial in providing impetus for the individual members in their work. Also agreed was that the UK had a strong history in tackling the major scientific questions and it was anomalous that we are so backward in SETI. The UK has access to advanced radio telescopes – e-MERLIN, LOFAR and, in the future, SKA – and so a small amount of funding for people to run piggyback or dedicated searches using any of these could be very productive.

The present membership of the UKSRN shows such a wide-ranging, albeit limited, coverage of search concepts and theoretical studies that there is scope for collaborations in several fields. As SETI has many aspects outside astronomy, such as linguistics, the study of civilizations, philosophical and religious aspects and the nature of intelligence, funding from public and private institutions and from individuals active in all these areas is a possibility. If a single grant proposal in any of these were successful and the resultant project carried out thoroughly, then the community view of SETI could be transformed.

Clearly the UKSRN needs to encourage an increase in the status of SETI so that young researchers will feel they might make a career in it. This could be either by their host institution backing them or, more ambitiously, by getting grants. SETI also provides significant opportunities for work in outreach. The present rather homogenous nature of the UKSRN would benefit by being broadened in terms of age, status and gender. There is scope for links to SETI groups in other countries and to other UK activities such as astrobiology, exoplanetology, instruments, sociology and linguistics. Beyond the intrinsic value of the SETI search, there are several reasons that the UKSRN could bring forward in support of funding: the technology spinoffs such as citizen science projects such as BOINC; public interest and understanding of science; and links to the other fields of study discussed above. Although the detailed allocation of funds is rightly a matter for the scientists, polls have shown public interest in the search for extraterrestrial intelligence, and so inclusion of SETI within the astronomy budget could result in an improved public support of astronomy funding. This would be aided by greater outreach activities by UKSRN members.

The session ended with three action items: to continue these new contacts made during this meeting, to plan for another meeting next year, and to produce a report on "SETI in the UK". ●

Alan Penny is an honorary reader in the School of Physics and Astronomy at the University of St Andrews, and co-ordinator of the UK SETI Research Network.

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