Kavli-IAU Symposium (IAUS 387)
April 15-19, 2024

(Toward) Discovery of Life Beyond Earth and its Impact

ORGANISING COMMITTEE

Chair:
Hermine Landt *(Durham University, UK)*

Members:
Heda Agic *(Durham University, UK)*
Daniel Angerhausen *(ETH Zuerich, Switzerland)*
Federica Bianco *(University of Delaware, USA)*
Chris Cowie *(Durham University, UK)*
Martin Dominik *(University of St. Andrews, UK)*
Jacob Haqq Misra *(Blue Marble Space Institute of Science, USA)*
Sohan Jheeta *(NoRCEL, UK)*
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Chris McKay *(NASA Ames Research Center, USA)*
Lucas Mix *(Durham University, UK)*
Carol Oliver *(UNSW Sydney, Australia)*
Mazlan Othman *(Academy of Sciences, Malaysia)*
Istvan Praet *(Durham University, UK)*
George Profitiliotis *(TU Delft, The Netherlands)*
Margaret Race *(SETI Institute, USA)*
Richard Wilman *(Durham University, UK)*

WEBSITE
https://kavli-iau-2024.durham.ac.uk

Executive Summary and Science Highlights

From our origins, humans have been inspired by pinpoints of light in the night sky. They cause us to wonder about our existence. Who are we? What are we doing here? Where did we come from? And, where are we going? The physicist Enrico Fermi famously asked “Where is everybody?” Thinking life must arise with some regularity, he marvelled that we saw no evidence of it among the stars – the Fermi Paradox. Despite impressive investment and activity in space exploration over the years, the question remains unanswered.

Until 1995, the only known planets orbited our Sun. Now we have evidence for over 5,000 exoplanets orbiting other stars, and we expect to find hundreds of billions more, at least one for every pinpoint of light. In the 1960s, Frank Drake began a search for radio signals, capable of crossing the interstellar distances. Advances in astronomy and computing have expanded that search, resulting in a much wider survey of the sky and allowing citizens to participate in SETI, the Search for Extraterrestrial Intelligence. The space age also brought opportunities to explore our own Solar System with more powerful telescopes and sophisticated space probes. Planetary atmospheres can now be interrogated, near and far, for the signs of life. A new era of exploration has begun, rich in data derived from these new technologies. We can search the universe, looking for life and, in the process, learning more about our ourselves, our planet, our species, and perhaps our significance.

This decade sees a once-in-a-lifetime investment of both capital and labour into the ‘Search for Life Beyond Earth.’ Research communities, governments and philanthropists alike are set to explore. NASA’s Apollo program showed that sufficient commitment of resources can lead to breakthroughs. Their progress, culminating in the Moon landing, inspired many to become astronomers. Both NASA and ESA have active and planned missions focused on the detection and characterisation of exoplanets. Most large observatories have invested in planetary astronomy and “Big Data” approaches, including the upcoming Legacy Survey of Space and Time (LSST) at the Vera C. Rubin observatory and the radio Square Kilometer Array (SKA). Meanwhile, new Machine Learning (ML) algorithms will make the search for technosignatures feasible at scale.

We still do not know if there is life beyond Earth or how probable it may be. But if it exists, we might find it (or it us) as early as tomorrow. And, there or not, found or not, the search itself has a profound impact on humanity. What would it mean for our civilisation, if we do find something? Will it improve our lives or threaten our very existence? Beyond science, the ‘Search for Life Beyond Earth’ raises complex questions of policy, law, philosophy, and theology. It challenges us to think critically about life as a category and as a thing of value.

We are not prepared for a discovery. We need to bring together diverse expertise to plan how we will assess evidence and communicate what we know (and don’t know) with the public. We should plan early, setting out impact assessments, protocols, procedures and treaties that allow us to act responsibly as individuals and communities and as a species. Any outcome will have to be presented to ‘Planet Earth.’ So great a task will challenge established scientific hierarchies and media and bring about new ways of public engagement.

The Kavli-IAU symposium 2024 presented a comprehensive overview of the current activities in the search for life beyond Earth, a truly multi-disciplinary and international endeavour with important impact for humanity as a whole. Although the symposium was a hybrid meeting allowing also for on-line participation, the large majority of participants (~75%) attended in-person. Many had gone through great effort to obtain UK visitor visas and/or to travel despite the difficult geopolitical situation that emerged over the weekend before the symposium. We had a total of 123 participants from 33 different countries. The five days of the symposium were thematically structured, aiming to give a flavour of the whole spectrum of activities in the search for life beyond Earth. The days of the symposium were furthermore moving along a scale of increasing uncertainty in our scientific knowledge as well as capacity to deal with important social consequences arising from the search for life beyond Earth. Since science communication is a strong element in this endeavour, more so than in any other science, the symposium embedded science communication and science journalism throughout the week. The Kavli-IAU symposium was well advertised, by the IAU but also on other platforms and within diverse networks. We had always a positive response from the invited speakers we approached and had an oversubscription factor of ~5 for our solicitation of contributed talks. As a result, the selected contributed talks were of a very high standard, both in contents and delivery. A novel aspect in IAU symposia was the prominent role given to debates and enriching workshops. In addition, poster contributions were not physically placed at the venue but in a Virtual Gallery with augmented reality.

Day 1 covered astrobiology in the wider sense, aimed at answering the general question of “What do we know about life?”. Two invited talks on Astrobiology and Exoplanet atmospheric science were interleaved with seven contributed talks. The day ended with a debate on “Our definition of ‘life’ and its impact on the evidence” with four panellists presenting their expert view on the subject. Day 2 covered novel ideas for searches for life beyond Earth, including aspects of our search missed so far, maybe because they were too bold to think of. The invited talks on this day were concerned with the Fermi Paradox, with “Life as we do not know it (yet)” and Planetary Protection. The day ended with a discussion of the Great Filter, which is a reframing of the Fermi Paradox. The middle of the week, on Day 3, represented the culmination of the subject of the symposium, with the impact from our search for life beyond Earth discussed in a wider multi-disciplinary context by combining views from anthropology, theology, ethics, law and art. In addition to four invited talks by experts from these disciplines another six experts served as panellists in a 90 min discussion entitled “Life as a cosmic phenomenon”. This intensive day was followed by only a short programme for Day 4, which featured the concept of the Post-Detection Hub recently established at the University of St Andrews, UK. The future aspects in the search for life beyond Earth were then discussed during the last symposium day. Science communication and science journalism, although integrated throughout the programme being such an important component in the search for life beyond Earth, which will affect humanity as a whole and so will need to be communicated effectively to it, featured prominently on this very last day. It was presented in its different forms, going from science journalism, science communication and storytelling to beliefs and reactions of the public and the different types of press.

Two ‘Futures’ workshops were offered to participants in order to practise ‘resilience and flexibility’ and ‘reaction scenarios given a positive detection’. A short presentation on Risk Communication was an integral part of the longer Futures II workshop. These two workshops were inspired in their design by the UN Futures Lab, which is a network that empowers the UN System and beyond to use futures thinking and strategic foresight in planning, policy- and decision-making. The excursion for symposium participants was on the afternoon of Day 4 to Hadrian’s Wall, a former defensive fortification of the Roman province of Britannia built in AD 122 to try to keep the Scots out. The British weather did not let us down and gave us driving rain for it. Many benefitted from the ‘Resilience and flexibility’ workshop the day before and, despite the weather, continued to climb up to look over the extensive Border plains. Afterwards, all relaxed in the evening over a sumptuous symposium dinner.

One of the main purposes of the Kavli-IAU symposium was to facilitate discussions and interactions between the different stakeholders engaged in the search for life beyond Earth. We found that this aim was reached. Participants followed the well-prepared talks and presentations with high interest and were eager to talk to each other in the coffee and lunch breaks, with many new collaborations forged between them during and after the symposium. It turned out that the strong science communication aspect of the symposium played a very important role in facilitating interactions; by providing a common ground between the different (and even disparate) disciplines it served as a kind of glue between participants, effectively creating a coherent and united audience in this respect.

We also run free public engagement events in connection with the Kavli-IAU symposium. During the week before the symposium, in collaboration with Durham University’s Street Cosmos, we held a public event on Astrobiology at the Merryoaks Community Centre. Dr Hermine Landt (the Chair of the SOC) delivered a half-hour lecture on Biosignatures, followed by an hour of paper craft activities for children led by artist Helen Schell. On the Wednesday evening during the symposium week, we offered a public lecture on Astrobiology entitled “Life in the Universe”, which was delivered by Prof Dr Dirk Schulze-Makuch, Professor for Planetary Habitability and Astrobiology, Technical University Berlin, Germany, and held in the largest lecture theatre of Durham University.

Finally, we had press representatives from Nature Astronomy, the Danish newspaper Weekendavisen, and Stardusts attending the Kavli-IAU symposium. Cambridge University Press and CRC Press sent a collection of books and accompanying voucher codes, which we displayed for participants. Exhibition stands were staffed by NoRCEL, Europlanet Society and the Blue Marble Space Institute of Science (BMSIS). Besides being sponsored by the Kavli foundation and the IAU, the symposium also received sponsorship from NASA and the Breakthrough Initiatives. We thank 4wardFutures for providing the innovative Virtual Gallery for posters.

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Final Programme

Sunday, April 14

18:00 – 20:00 Reception and registration

Monday, April 15
What do we know about "life"? – Uncertainty: Low

Session chair: Hermine Landt		
09:00 – 09:10	Welcome	Vice-Chancellor & Warden *Durham University, UK*
09:10 – 09:30	Introduction	Lucas Mix *Durham University, UK*
09:30 – 10:30	Life out there, expectations and reality **(Invited)**	Frances Westall *CNRS, France*
COFFEE BREAK		
11:00 – 11:20	Emergence of life: Importance of formation of organic molecules of life	Sohan Jheeta *NoRCEL, UK*
11:20 – 11:40	From laboratory simulation facilities to the search for life beyond Earth	Eva Mateo-Martí *Centro de Astrobiologia, Spain*
11:40 – 12:00	Surviving the cosmos: Biomolecule stability beyond the Earth	Pallavi Kajrekar *University of Edinburgh, UK*
12:00 – 12:20	Using linguistics and information theory to assess the diversity, complexity and decoding of interstellar messages	Saeed Jafari *Space Generation Advisory Council, Iran*
LUNCH BREAK		
Session chair: Heda Agic		
14:00 – 15:00	Exoplanet atmospheres in the era of JWST and ARIEL **(Invited)**	Giovanna Tinetti *University College London, UK*
15:00 – 15:20	Venus Phosphine: Updates and lessons learned	David Clements *Imperial College London, UK*
15:20 – 15:40	Extending the habitable zone due to subglacial water	Amri Wandel *Hebrew University of Jerusalem, Israel*
15:40 – 16:00	Just when have we discovered life beyond Earth?	Peter Vickers *Durham University, UK*
COFFEE BREAK		

16:30 – 16:45	Communicating the (uncertainty in the) known **(Invited)**	David Whitehouse *Science writer, UK*
16:45 – 17:30	Discussion: Our definition of "life" and its impact on the evidence	Chair: Nigel Mason *University of Kent, UK* Panellists: Sohan Jheeta *NoRCEL, UK* Juan Pérez-Mercader *Harvard University, USA* Dirk Schulze-Makuch *TU Berlin, Germany* Terence Kee *University of Leeds, UK*

Tuesday, April 16
Can we detect "life" beyond Earth? – Uncertainty: Medium

Session chair: Lucas Mix		
09:00 – 09:45	The Great Silence reconsidered: Reexamining the Fermi Paradox in the age of discovery **(Invited)**	Stephen Webb *Science writer, UK*
09:45 – 10:30	Life as we do not know it (yet) **(Invited)**	Arik Kershenbaum *University of Cambridge, UK*
COFFEE BREAK		
11:00 – 11:20	How weird is "weird" life?	Philipp Spillmann *University of Cambridge, UK*
11:20 – 11:40	Equivocal encounters: 'Oumuamua and the prospects for disagreement about artifacts	Anthony Milligan *King's College London, UK*
11:40 – 12:00	What are we actually looking for as evidence of life on Mars?	Armando Azua-Bustos *Centro de Astrobiologia, Spain*
12:00 – 12:45	Planetary protection **(Invited)**	John Rummel *Friday Harbor Partners LLC, USA*
LUNCH BREAK		
Session chair: Andjelka Kovačević		
14:00 – 14:20	Making habitable worlds: Planets versus megastructures	Raghav Narasimha Ponnaganti *Indian Institute of Astrophysics*

14:20 – 14:40	Searching for intelligent life in gravitational wave signals	Luke Sellers *University of California LA, USA*
14:40 – 15:00	Simulating the characteristics of extra-terrestrial civilizations that encounter Earth	Kevin Knuth *University of Albany, USA*
15:00 – 15:20	Searching for false negatives: On the necessity of extraterrestrial participation for human recognition and beyond	Niklas Döbler *University of Bamberg, Germany*
15:20 – 15:40	Escaping the Great Filter: The future of civilisation and the search for technosignatures **(Invited)**	Jacob Haqq Misra *Blue Marble Space Institute of Science, USA*
15:40 – 16:00	How probable is Gaia? **(Invited)**	Arwen Nicholson *University of Exeter, UK*
COFFEE BREAK		
16:30 – 16:45	Communicating the gaps and closing them **(Invited)**	David Whitehouse *Science writer, UK*
16:45 – 17:30	Discussion: The Great Filter	Chair: Richard Wilman *Durham University, UK* Panellists: Arwen Nicholson *University of Exeter, UK* Jacob Haqq Misra *Blue Marble Space Institute of Science, USA*

Wednesday, April 17
Are we prepared for the societal implications of a detection or null result? – Uncertainty: High

Session chair: Richard Wilman		
09:00 – 09:45	The Problem/s of Preparation: On ambiguity, proliferating possibilities, Eureka's shadows, and unspectacular pragmatism **(Invited)**	Kathryn Denning *York University, Canada*
09:45 – 10:30	The challenging implications for theology and ethics **(Invited)**	Jacques Arnould *French Space Agency*
COFFEE BREAK		

11:00 – 11:45	International Space Law **(Invited)**	Les Tennen *Law Offices of Sterns and Tennen, USA*
11:45 – 12:30	Anticipating the Alien: Creating visionary science fiction **(Invited)**	Stephen Baxter *Science fiction writer, UK*
LUNCH BREAK		
Session chair: Carol Oliver		
14:00 – 15:30	Discussion: Life as a Cosmic Phenomenon (in Science, Anthropology, Theology, Law, Ethics and Art)	Chairs: Martin Dominik *University of St. Andrews, UK* Istvan Praet *Durham University, UK* Mazlan Othman *Academy of Sciences Malaysia* Panellists: Ricky Lee *University of Notre Dame, Australia* Olli-Pekka Vainio *University of Helsinki, Finland* Shoaib Malik *Independent researcher, UAE* Erik Persson *Lund University, Sweden* Perig Pitrou *CNRS, France* Daniela de Paulis *SETI Institute, USA*
COFFEE BREAK		
16:00 – 17:30	Workshop: Futures I – Resilience and flexibility	George Profitiliotis *TU Delft, The Netherlands*
19:00 – 21:00	**Public Lecture:** Life in the Universe	Dirk Schulze-Makuch *TU Berlin, Germany*

Thursday, April 18
Preparing for post-detection

Session chair: Martin Dominik		
09:00 – 10:00	Preparing for the discovery of extra-terrestrial life – The SETI Post Detection Hub **(Invited)**	John Elliott *University of St. Andrews, UK*

10:00 – 10:30	Finding intelligent life and first contact scenarios: Towards public awareness and engagement and the impact of discovery	Shirin Shater Zadeh Yazdi *Shahid Beheshti University, Iran*
COFFEE BREAK		
11:00 – 12:30	Workshop: Futures II – What are we missing?	George Profitiliotis *TU Delft, The Netherlands* Carol Oliver *UNSW, Australia* Andreas Schwarz *TU Illmenau, Germany*
LUNCH BREAK		
13:00 – 17:00	Excursion to Hadrian's Wall	
18:30 – 21:00	Symposium dinner	

Friday, April 19
The future

Session chair: Nigel Mason		
09:00 – 10:00	The future of SETI **(Invited)**	Steve Croft *UC Berkeley, USA*
10:00 – 10:30	Extraterrestrial intelligent life: What the public believes	Chris Impey *University of Arizona, USA*
COFFEE BREAK		
11:00 – 11:30	The media: friend and/or foe? Exploring the cosmic narrative, from a science journalist's perspective **(Invited)**	Nadia Drake *Science journalist, USA*
11:30 – 12:00	Future tools for communication and engagement **(Invited)**	David Whitehouse *Science writer, UK*
12:00 – 12:30	Mini-Workshop: Communicating our conclusions	Carol Oliver *UNSW, Australia*
LUNCH BREAK		
Session chair: Jacob Haqq Misra		
14:00 – 14:30	Teaching by imagining Life Beyond Us: Science fiction for outreach and education	Julie Nekola Nováková *Charles University, Czech Republic*
14:30 – 15:30	Discussion: The future is our future	Chairs: Hermine Landt *Durham University, UK* Federica Bianco

		University of Delaware, USA Panellists: David Grinspoon *NASA, USA* Mike Edmunds *Royal Astronomical Society, UK* Eleni Chatzichristou *European Research Council, Belgium* James Davenport *University of Washington, USA*
COFFEE BREAK		
16:00 – 16:20	Uncharted Territories: Distilling insights and outcomes from IAUS 387 Life Beyond Earth	Andjelka Kovačević *University of Belgrade, Serbia*