Book Review: Extraterrestrial Languages
Daniel Oberhaus

Reviewed by John I Davies

The search for extraterrestrial intelligence (SETI) and possible communication with extraterrestrial intelligence (CETI) are naturally of interest in wider interstellar studies - though i4is has not been involved in this field directly. If we are to understand ETI we must have a means of information interpretation. If the pulsar "beep" had contained some pattern it would have been necessary to interpret it. In this book Daniel Oberhaus demonstrates that a journalist can "do science". John Davies takes a look at a major addition to the subject.

1 Introduction

Principium has featured SETI in major articles since *Retrospective: The Search for Extraterrestrial Intelligence*, in Issue 5, June/July 2013 but the topic of extraterrestrial languages has only been dealt with occasionally, for example in the review of the film, *Arrival*, by Patrick Mahon, in Issue 16, February 2017. Mr Oberhaus' presentation at IAC 2019 was summarised in *Chomsky in the cosmos: Lessons from neurolinguistics for the design of messages for extraterrestrial intelligence* in Issue 29, May 2020. So we largely enter uncharted waters in this review. Page references are to the MIT Press hardback edition, 2019 (mitpress.mit.edu/books/extraterrestrial-languages).

2 The Book

2.1 History

Oberhaus starts with a summary of the history of CETI. Humanity began to worry seriously about communicating with extraterrestrial intelligences (ETIs) in the 19th century. Oberhaus gives a quick tour of ideas from the false discovery of canals on Mars to the proposal by Gauss to demonstrate Pythagoras by planting crops in a triangle and squares in Siberia. Later Marconi sent radio messages to Mars. Perhaps the first serious attempt to devise a means of communication with ETI was by the British biological statistician Lancelot Hogben [1]. The next major work was Freudenthal's Lincos language in 1960, *Lincos, Design of a Language for Cosmic Intercourse,* and the early messages sent from the Arecibo dish by Carl Sagan and Frank Drake (of the famous equation) in 1978. The two Voyagers, of course, carried Sagan's message in 1977. A second language was devised by Ollongren and published in *Astrolinguistics* in 2013. Ollongren based this on Lincos and on Church's Lambda Calculus [2].

COVER ILLUSTRATION inspired by the numbers portion of a Cosmic Call message designed by Stephane Dumas and Yvan Dutil, sent from the Evpatoria radar in Ukraine on May 24, 1999.

Credit: MIT press
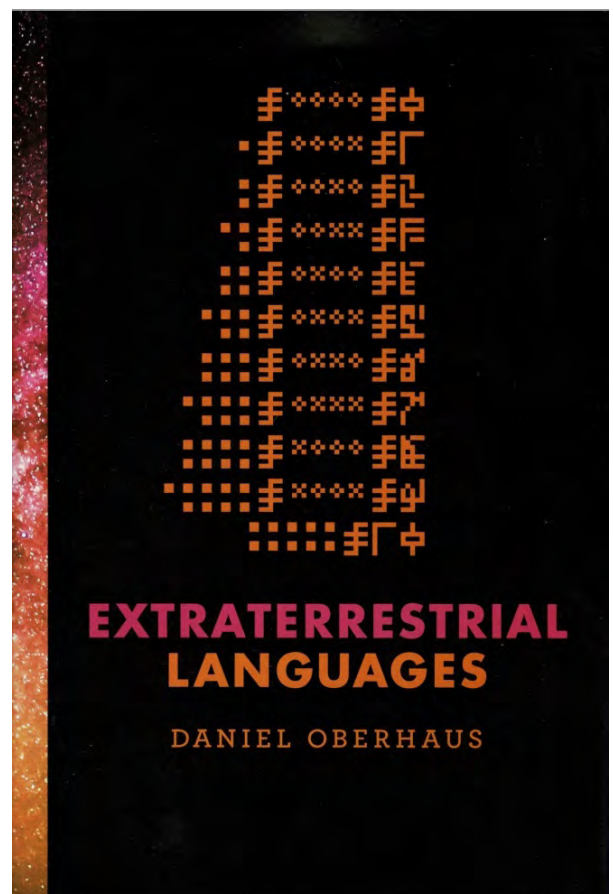
[1] See P29 May 2020 page 38, a review of *Chomsky in the cosmos: Lessons from neurolinguistics for the design of messages for extraterrestrial intelligence* by Oberhaus in IAC 2019 which memtioned Hogben's address to the British Interplanetary Society in 1952.

[2] The Calculi of Lambda-Conversion, Princeton University Press, 1941 archive.org/details/AnnalsOfMathematicalStudies6ChurchAlonzoTheCalculiOfLambdaConversionPrincetonUniversityPress1941.

2.2 From SETI to METI

Oberhaus suggests an analogy with Quine's thought experiment (page 26) about communicating with an uncontacted tribe (en.wikipedia.org/wiki/Indeterminacy_of_translation) though this demands a dialogue of some sort. This is likely to be a very slow one given that our nearest intelligent neighbours are multiple light years away (unless of course someone invents Ursula Le Guin's fictional ansible, an instantaneous communicator en.wikipedia.org/wiki/Ansible). It seems to this reviewer that we are much more likely to have a situation similar to the decipherment of early Egyptian texts, but without a handy Rosetta Stone (en.wikipedia.org/wiki/Rosetta_Stone). Oberhaus cites Chomsky and the concept of a universal, human, grammar and concludes that alien languages are unlikely to have that property (page 29). But suggests that John McCarthy and Marvin Minsky's ideas of universality of logic imply that it might not be so hard since all natural languages have hierarchical recursive syntax (page 31).

Minsky wrote extensively (pages 33-35) on this and was optimistic about communication with ETIs.

2.3 Aliens on Earth

Animal communication has been much studied and Oberhaus cites the early work of Lilly with dolphins [1]. The subject has not gone away - *Lessons from Studying Nonhuman Animal Communication*, Denise Herzing, report from IAC 2019, Principium 29, May 2020, page 36.

Oberhaus suggests, following Chomsky, that human language has the unique property of hierarchical structure, unlike animal communication (page 48).

He goes further "Although we can attempt to make up for our inability to naturally mimic dolphin whistles by artificial means like CHAT, at the end of the day we are still indoctrinating the dolphins into the symbolic regime rather than learning the meaning of dolphinese". This sounds close to the view embodied in John Searle's Chinese Room Argument (plato.stanford.edu/entries/chinese-room/) - that mere appearance of sentience is not sufficient to establish it; in the case of an apparent ETI we would never be able to establish that it was truly sentient. There have been many refutations of this view, see the Stanford article cited here but perhaps the strongest one was articulated by Alan Turing in 1950, 30 years before Searle, that this argument from "mere simulation" might apply to any of us, that it raises the perennial philosophical problem of Other Minds (plato.stanford.edu/entries/other-minds/) and given that "the only way by which one could be sure that machine thinks is to be the machine and to feel oneself thinking" and thus "it is usual to have the polite convention that everyone thinks" (A M Turing, *Computing Machinery and Intelligence,* Mind 49, 1950). Our apparent ETI may or may not be an automaton but we cannot assume we will ever determine this and thus, like Turing, we will have to be polite! Neither Turing nor Searle appear in the index to the book.

Oberhaus introduces information theory into discussion of animal communication via the work of McCowan, Doyle and Hanser [2] and the idea of a Zipf slope (word use frequencies in a text form a straight line when plotted from most frequent to least frequent).

Oberhaus (pages 49-50) applies Shannon entropy (en.wikipedia. org/wiki/Shannon's_source_coding_theorem) to possible ETI signals and suggests that Shannon and Zipf analysis would lead to opposite conclusions if applied to signals such as a bitmap image and a Fibonacci sequence. He quotes Weaver "To be sure, this word information in communication theory relates not so much to what you do say, as to what you could say" [3].

Monument to Claude Shannon at Murray Hill, New Jersey, with the Shannon–Hartley channel capacity equation and Shannon's signal entropy equation.

Credit: IEEE Spectrum

[1] The *Mind of the Dolphin; a nonhuman intelligence*, Doubleday, 1967.
Lilly became a cultish figure with some bizarre ideas about universal consciousness.

[2] McCowan, Doyle and Hanser have written extensively on this -
 scholar.google.co.uk/scholar?hl=en&as_sdt=0%2C5&q=mccowan+doyle+hanser.

[3] *The Mathematical Theory of Communication,* Claude E Shannon, Warren Weaver, The University of Illinois Press. 1964, *Recent Contributions to the Mathematical Theory of Communication*, Warren Weaver, 2.2. *Information* pure.mpg.de/rest/items/item_2383164/component/file_2383163/content.

2.4 Cosmic Computers and Interstellar Cats

Oberhaus introduces us to some early thinking on possible messages, some of which led to the 2003 "Cosmic Call" from the Arecibo radio telescope (page 57). Marvin Minsky suggested sending a computer (in practice a computer program) based on the AI received and, disastrously, implemented in Fred Hoyle's story *A for Andromeda* for BBC television.

Scene from *A For Andromeda* by Fred Hoyle.

credit: BBC Television

Julie Christie as Andromeda and Peter Halliday as John Fleming with the computer in the background.

The computer is constructed according to a message received from an ETI. The computer kills its operator, Christine, and creates Andromeda as its agent.

Note the flashing lights - those were the days!

The 2003 "Cosmic Call" message included an early "chatbot", Ella, which included the ability to play "Atlantic City blackjack".

Oberhaus describes a controversy between application of Markov processes (predictability of messages based on earlier messages) and Chomsky's linguistic ideas - going on to theorise that a civilisation significantly more advanced than humanity would almost certainly have developed artificial general intelligence, AGI (pages 58-59, for a discussion of this in the interstellar context see *Sending ourselves to the stars?* in Principium 12 and 13, February and May 2016).

One obvious approach to communicating with an ETI would be to send some existing text in a multiplicity of human languages. The high level of redundancy in human languages would allow the ETI to find some common interpretation (page 62).

A more recent attempt to produce a "self-bootstrapping" system like Hoyle's Andromeda is Cosmic OS by Paul Fitzpatrick of MIT. Oberhaus explains its ancestry stretching from Alonzo Church (of the Church-Turing theorem) and his Lambda Calculus and the early programming language LISP. Fitzpatrick's work is ongoing (people.csail.mit.edu/paulfitz/cosmicos.shtml). A more radical idea would be to send the code of human DNA (page 68, echoes of Hoyle again! The fate of the resulting "person" looks bleak to me.)

2.5 Is there a language of the universe?

Oberhaus returns to Hogben's ideas (page 72). The notion of pointing and speaking the noun for the thing pointed to (echoes of Hollywood's "Me Tarzan, you Jane") doesn't seem to work very well when the round trip time between conversationalists is at least eight years. Hogben was thinking of Mars, of course, where the delays are minutes, not years.

Science and, more especially, mathematics looks universal but Oberhaus cautions against mathematical Platonism, a controversial idea [1] (page 78-80). The book wanders a bit here - Oberhaus is clearly not a mathematical Platonist.

He gets back to ETs with Cockell's thought that, in a universe with consistent physics, aliens would be likely to look like us (*The Equations of Life: How Physics Shapes Evolution* (2018) Basic Books/Atlantic Books). The argument that DNA is almost as fundamental as physics did convince this reviewer.

[1] Platonism in the Philosophy of Mathematics /plato.stanford.edu/entries/platonism-mathematics/.

2.6 Towards a Lingua Cosmica

The problem of bootstrapping appears again (page 93). How can we explain our language without a language in which to explain it? Seen in these terms we would get an infinite regression. Oberhaus sees only two clear attempts to invent a "robust Lingua Cosmica": Freudenthal's Lincos and Ollongren's revision of it. Lincos was used in the first of the two Cosmic Call messages, in 1999 from Ukraine using "the most powerful planetary radar available on Earth at the time" (page 100) [1].

Oberhaus asserts that "it would be difficult to overstate the importance of the 1999 Cosmic Call message in reigniting interest in interstellar communication" (page 103).

Ollongren's second generation Lincos was a redesign using logic rather than mathematics as the foundation. Oberhaus includes a 21 page appendix explaining how Ollongren's work relates to Church's Lambda Calculus.

2.7 How to talk in space

Oberhaus considers the means by which messages may be transmitted (page 111) starting with the messages contained in the Pioneer and Voyager probes. Inevitably this is a case of "message in a bottle" - cast into an ocean far more vast than our own tiny Atlantic and Pacific. So we look to electromagnetic radiation as our means of message transport. He suggests that a narrowband signal should be sought, looking in a quiet part of the electromagnetic spectrum. Here we are heading into SETI, a vast subject and not Oberhaus' main focus.

Is it possible that an ETI is using some sort of spread-spectrum or even Ultra WideBand (UWB) transmission? There may be a limit (page 121) around 200 kHz pointed out by Seth Shostak. More about this in the sidebar: Wideband SETI.
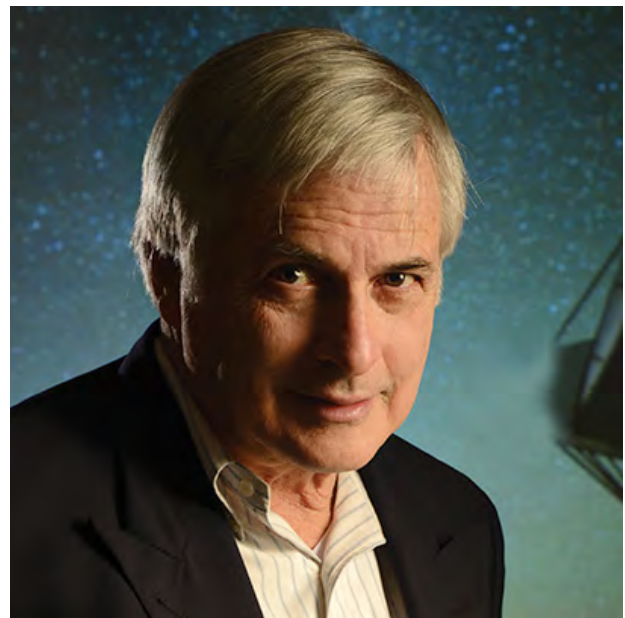
Seth Shostak, Senior Astronomer, SETI Institute, https://www.seti.org/our-scientists/seth-shostak Credit: SETI Institute

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Wideband SETI

SETI at Wider Bandwidths? Astronomical Society of the Pacific Conference Series, Volume 74. *Progress in the Search for Extraterrestrial Life*, 1995. David Messerschmitt makes the case in: *Interstellar communication: The case for spread spectrum*, Acta Astronautica, Volume 81, Issue 1, December 2012, Pages 227-238 (open access at arxiv.org/abs/1111.0547). Thus providing "robust immunity to radio-frequency interference (RFI) of technological origin in the vicinity of the receiver while preserving full detection sensitivity in the presence of natural sources of noise". But "This strategy requires the receiver to guess the specific noise-like signal, and it is contended that this is feasible if an appropriate pseudorandom signal is generated algorithmically." Messerschmitt earlier set out the engineering design principles upon which this judgement is based: *Design of interstellar digital communication links: Some insights from communication engineering*, David G Messerschmitt, Ian S Morrison, Acta Astronautica, Volume 78, September–October 2012 (open access at escholarship.org/content/qt4w59f2wk/qt4w59f2wk_noSplash_6d49b5b9b5ff6ca0aa0dd2454d8b10fe.pdf).

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[1] Oberhaus describes Lincos as "intended to be encoded in unmodulated radio waves". This would be a neat trick if it wasn't a contradiction. If the waves are not modulated then they carry no message.

Oberhaus gives us a run through the (mostly well known) issues of what frequencies to expect - such as the "Waterhole" at 1.42 GHz (page 121, en.wikipedia.org/wiki/Water_hole_(radio)). He explains some basics of modulation including some more sophisticated concepts such as quadrature amplitude modulation (QAM) and frequency-shift keying (FSK) and the problem of a clock signal leading to use of Manchester encoding (en.wikipedia.org/wiki/Manchester_code). The transmit power requirements at galactic distances look daunting and Oberhaus cites (page 127) a 2009 Seth Shostak piece, *When Will We Find the Extraterrestrials?* [1]. He takes a look at optical SETI and briefly mentions Breakthrough Listen (but I assume he wrote this before the results began to arrive in volume).

2.8 Art as universal language

Oberhaus extends his range here. The problem of labelling nuclear waste disposal sites for generations who have lost the historical record of them leads to a discussion of universal graphics symbols. Cosmic iconography anyone?

He suggests that even music is not universal in human cultures (page 144) though he does describe the work of Alexander Zaitsev on the Cosmic Call message including his Teen Age Message (en.wikipedia.org/wiki/Teen_Age_Message). He cites Zaitsev in support of the idea that analogue signals are inherently more efficient than digital (page 147). This looks to this reviewer like a serious misunderstanding [2].

2.9 The many futures of METI

Oberhaus moves on to Messaging ETI. He recalls an early controversy following Frank Drake's 1974 Arecibo transmission. UK Astronomer Royal Sir Martin Ryle wrote to the president of the International Astronautical Union asking that the organisation formally ban the practice of interstellar messaging (page 155) [3]. Ryle later wrote directly to Drake saying it was "very hazardous to reveal our existence and location to the Galaxy; for all we know, any creatures out there might be malevolent—or hungry."

If anything, METI has become even more controversial since then. The metaphor is "shouting in a jungle" and Oberhaus cites a number of authorities on the adverse effects on technically primitive cultures on contact with more technically advanced ones. A recent and widely read fictional example is in the "Dark Forest" metaphor in *The Three Body Problem* and its two sequels by Liu Cixin. Oberhaus argues, with justifying citations, that the danger from unintentional messages (eg powerful radar) is minimal give the low probability of their reception (page 159). The inverse square law is our friend in this case; contrast the case of The Interstellar Downlink, discussed elsewhere in this issue.

Oberhaus cites Billingham and Benford in support of the idea that these unintentional signals would tend to cancel each other out [4] . Oberhaus uses the Square Kilometre Array as an example of the receiver which might be used by an ETI. This is surely short sighted? Once we have significant in-space manufacturing capability, perhaps in 50 or 100 years, the scale of radio telescopes would presumably be limited only by the ability to combine the signals received across the area covered.

[1] In *Engineering & Science,* Spring 2009, calteches.library.caltech.edu/715/2/Extraterrestrials.pdf.

[2] Oberhaus pages 146-147 "A further benefit of an analog interstellar signal over digital methods can be seen in the drastically reduced transmission times." and "the theremin concert portion of the Teen Age message would take only fourteen minutes using analog encoding as opposed to nearly fifty hours of transmission time for the equivalent message encoded digitally (Zaitsev 2008)", The paper cited is *Sending and searching for interstellar messages*, Acta Astronautica, Volume 63, Issues 5–6, September 2008. The identically titled paper (citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.557.3564&rep=rep1&type=pdf) presented at 58th International Astronautical Congress, Hyderabad, India, 24 - 28 September 2007. IAC-07-A4.2.02 contains no reference to this.

[3] Citing Drake and Sobel's book *Is anyone out there? : The scientific search for extraterrestrial intelligence*. Delacorte Press 1992.

[4] *Costs and Difficulties of Large-Scale 'Messaging', and the Need for International Debate on Potential Risks*, John Billingham, James Benford, 2011, arxiv.org/abs/1102.1938: "Picking up signals from commercial radio and television broadcasts is difficult." and "What little detectable power reaches space is from many sources, not at the exact same frequencies, but in bands constrained by regulation by governments. Therefore, they are not coherent, so phase differences cause them to cancel each other out at great range."

In the relatively short term, for example, "...a swarm of hundreds to thousands of satellites, working together as a single aperture synthesis instrument deployed sufficiently far away from Earth to avoid terrestrial RFI" has already been proposed by Bentum et al of TU Delft, see their Roadmap below.

Four phase roadmap to Orbiting low Frequency Antennas for RadioAstronomy (OLFAR).

Credit: Bentum et al/TU Delft

From *A roadmap towards a space-based radio telescope for ultra-low frequency radio astronomy*, Bentum et al, article in press - Advances in Space Research (2019), cas.tudelft.nl/pubs/bentum19asr.pdf.
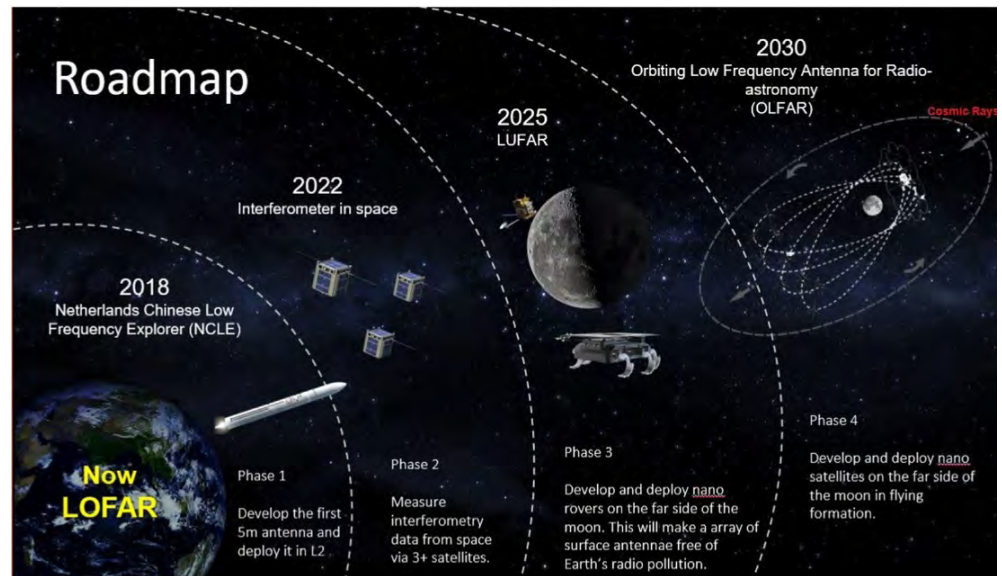
Oberhaus suggests that most critics have been concerned about intentional transmissions and describes the San Marino Index, a sort of rule of thumb to assess the risk of a transmission. Like the Drake equation these attempts to think systematically about ETI are still the best we can do in our present state of knowledge.

In all of this Sagan's question "Who speaks for Earth?" remains fundamental. Oberhaus discusses attempts to reduce cultural and even species bias in METI (page 167) and wraps up by doubting if we want to tell ETIs the truth about ourselves.

2.10 Appendices

Oberhaus includes appendices on The Arecibo Message (5 pages), The Cosmic Call Transmissions (13 pages), Lincos (10 pages) and The Lambda Calculus and its application to astrolinguistics (21 pages). I'll leave these, especially the latter, to specialists!

3 Conclusion

Overall this is a fine introduction to the subject, particularly for a comparative newcomer to the subject like this reviewer. Much of the detail is fascinating but if there is an overall fault it is that it is too wide ranging. Much of the discussion of SETI and METI is available elsewhere. And there are a couple of significant mistakes in communications technology. A narrower focus on the language problem specifically might have made a better book.

> ## "It's extra-terrestrial – not like us"
>
> Much has been discussed about first contact with ETI, if and when it happens. Poet John Cooper Clark has approached the subject from his usual dry point of view in *(I Married A) Monster From Outer Space*-
>
> > We walked out – tentacle in hand
> > You could sense that the earthlings would not understand
> > They'd go.. nudge nudge …when we got off the bus
> > Saying it's extra-terrestial – not like us
>
> johncooperclarke.com/poems/i-married-a-monster-from-outer-space
>
> But we can't recruit him to the interstellar studies just yet. He loves allegory and he was no doubt commenting on a different sort of xenophobia.

4 Earlier reviews

The book was published one year ago, in October 2019, and has been widely reviewed.

4.1 Science magazine

(American Association for the Advancement of Science)

Andrea Ravignani, in *Efforts to communicate with extraterrestrials call into question the universality of language, math, and culture*, 4 November, 2019 (blogs.sciencemag.org/books/2019/11/04/extraterrestrial-languages/), suggests that Oberhaus has narrowed his view of language to Noam Chomsky's theory of generative linguistics. "Oberhaus is balanced in mathematics and computer science but anthropology, developmental psychology, and animal cognition are largely absent".

He recommends alternative views, notably Arik Kershenbaum (www.zoo.cam.ac.uk/directory/dr-arik-kershenbaum) to balance this.

Andrea Ravignani is at the Artificial Intelligence Lab, Vrije Universiteit Brussel, where he researches on vocal communication and rhythm in seals and humans.

4.2 The Economist

In *How to talk to aliens, The challenge says a lot about talk among people, too* (www.economist.com/books-and-arts/2019/11/28/how-to-talk-to-aliens), the Economist briefly summarises the book and ends with "the world's 7,000-odd tongues are vastly closer to one another than anything to be found out there". I did not spot this assertion in the book.

4.3 London Review of Books

Nick Richardson, a former editor at the London Review of Books (LRB), and now a software engineer, reviewed *Extraterrestrial Languages* in LRB Vol. 42 No. 12, 18 June 2020 (www.lrb.co.uk/the-paper/v42/n12/nick-richardson/we-re-not-talking-to-you-we-re-talking-to-saturn#).

The review is titled *We're not talking to you, we're talking to Saturn* [1], a reference to a 19th century satire of SETI by the French humorist Tristan Bernard in which humanity, on receiving an unintelligible message from Mars, writes huge messages across the Sahara. The dialogue goes -

'I beg your pardon?'
'Nothing.'
'What are you making signs for then?'
'We're not talking to you, we're talking to the Saturnians.'

This sets the tone for the review by Richardson, which is tongue-in-cheek (or "pas sérieux" perhaps?) with occasional lapses into useful summaries of Oberhaus' book. The reviewer quotes the visible proof of Pythagoras in the book but does not credit it to Gauss. And he mentions 'Story of Your Life', by Ted Chiang (source of the film, *Arrival*, see above) and an interesting example of a fictional attempt to communicate with very alien aliens - but which is not mentioned by Oberhaus.

[1] The story is *Qu'est-ce qu'ils peuvent biennous dire? (What exactly can they tell us?)* see *The pioneers of interplanetary communication: From Gauss to Tesla*, Florence Raulin-Cerceau, Acta Astronautica 67 (2010) 1391–1398, citing Bernard in: *Contes de Pantruche et d'Ailleurs*, Paris, 1897,

Contes de Pantruche et d'Ailleurs, 1897 cover,

Credit: archive.org