55. Wow!

THE SEARCH FOR extra-terrestrial intelligence, or SETI, is motivated by the belief that intelligent life is likely to emerge under conditions similar to those on Earth. Detailed studies started with Cocconi & Morrison (1959).

Loosely connected but not implicit in such searches are various unproven and somewhat inconsistent postulates. Amongst these are the 'anthropic principle' (which suggests that no assertion can be made about the probability of intelligent life based on a sample set of one, viz the Earth); the 'mediocrity principle' (which, given the existence of life on Earth, asserts that life typically exists on Earth-like planets throughout the Universe); and the 'fine-tuning hypothesis' (which asserts that the natural conditions for intelligent life are implausibly rare).

Attempts to quantify the probability that intelligent life exists elsewhere in the Galaxy include consideration of the Drake equation (formulated by Frank Drake in 1961), and consideration of the *Fermi paradox*. Resolution of these questions may still lie far in the future.

THE FERMI paradox is the question famously posed by physicist Enrico Fermi in 1950: *'If other advanced civilisations exist, where are they?'*. Alternatively formulated as *'If alien civilisations existed, they would be here'*, or as the 'Great Silence' problem, it is a deceptively simple question that presents a challenge for theories assuming a naturalistic origin of life and intelligence. Objectively, scientists attempt to weigh the evidence for or against the existence of other intelligent civilisations.

According to current understanding, there is no evidence at present which contradicts the hypothesis that life arose on Earth due to such extraordinarily improbable events that it is unlikely to have arisen elsewhere within the observable Universe. But the converse is also true: there is no evidence at present which contradicts the hypothesis that life arose on Earth due to such ordinary and probable events that it is likely to have arisen in many other places within the observable Universe.

As the 19th century Scottish essayist Thomas Carlyle gloomily remarked on looking at the night sky: *'A sad spectacle. If they be inhabited, what a scope for misery and folly. If they be not inhabited, what a waste of space.'*

ALTHOUGH SETI is often thought of as lying outside of today's mainstream scientific research, many searches have been undertaken. Early surveys, from the 1980s, including ones supported by NASA, searched for continuous and pulsed radio or microwave signals that could have been generated by alien civilisations. Recent efforts have also searched for intense optical pulses, as could be generated by targeted high-power lasers.

While many of these searches have been discontinued, others are being actively pursued, notably by the SETI Institute (using the Allen Telescope Array at Hat Creek), and by the 'Breakthrough Listen' initiative (using the Green Bank and Parkes radio telescopes).

OVER THE YEARS there have been several false alarms and unconfirmed events. The 'SETI episode' in the 1967 discovery of pulsars is recounted by Penny (2013). Here, the Cambridge radio astronomy group became the first to confront the 'contact' problem which the SETI community faces in its 'detection and reply protocols'.

Otherwise, most of the 'interesting' signals so far detected have been transient and non-repeatable, perhaps the first points in a growing database of signals used to construct a probabilistic argument for their existence.

WHEN SCIENTISTS DISCOVER a completely new celestial phenomenon, efforts focus on attempting to interpret it in terms of known physics and natural processes. Theoreticians and observers will contribute their different expertise. Ultimately, a widely accepted explanation must satisfy the laws of physics, be verifiable, and have predictive power.

In 1967, the discovery of 'pulsars' – extremely regular and rapid radio pulses originating from specific points on the sky – could not immediately be attributed to any known celestial phenomenon. Now known to be generated by rapidly spinning neutron stars, the discoverers initially considered that the signals might have been generated by an alien civilisation.

But an enormous edifice of theory and observation of pulsars, all fitting within our detailed models of stellar evolution, can now discard such a non-physical origin.

I WILL MENTION two other examples of recently discovered celestial phenomena which probably have a purely physical explanation, but which have aroused interest as being possible alien techno-signatures, and where Gaia is contributing to a more complete picture.

My first example is the 'interstellar traveller' Oumuamua, the first object moving through our solar system known to have originated from another star system, and described in more detail in a previous essay (#25). Discovered in 2017, it is a highly elongated body some 100 metres in size, considered by some at the time to be a possible alien techno-signature.

But its existence, and its passage through our own solar system, now appears to be fully consistent with what we now know about the formation and evolution of other exoplanetary systems. Ongoing work using the enormous Gaia data base of star positions and space motions is contributing to the challenge of pinning down its likely progenitor stellar system.

MY SECOND EXAMPLE is the curious 'Boyajian's star' (KIC–8462852), discovered in the Kepler satellite data by the Planet Hunters project from its unusual light-curve (Boyajian et al. 2016). The star shows pronounced dimming by up to 20%, lasting between 5–80 days, and with an irregular cadence and unusual profile. Considerable speculation accompanied the unusual light curve, with interpretations ranging from occulting clouds of exocomets, to a 'swarm of alien megastructures' – and hence an outstanding SETI target (Wright et al. 2016).

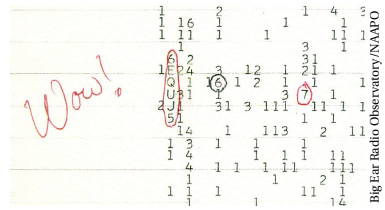
Other stars with similar light curves would help to elucidate its nature and, today, Gaia is actively contributing to this search. Twenty one further candidates from wide-field variability surveys have recently been identified as possible 'dippers' (Schmidt 2019).

Accurate distances for all of these new candidates from the Gaia Second Data Release (DR2) in 2018 show that these objects are all located in two restricted regions of the Hertzsprung–Russell diagram: some being near the main sequence with masses near that of the Sun, and the others in the red giant region near the evolutionary track for 2 solar mass stars. Again, improved constraints will come from future Gaia data releases.

PULSARS WERE NOT the first examples of strange signals detected by radio astronomers. Indeed the technology and radio pioneer Nikola Tesla claimed to have detected interplanetary transmissions during his work in Colorado Springs in 1899.

Tesla wrote, in 1901, that: *'The changes I noted were taking place periodically, and with such a clear suggestion of number and order that they were not traceable to any cause then known to me… The feeling is constantly growing on me that I had been the first to hear the greeting of one planet to another.'*

ANOTHER EXAMPLE of Gaia's contribution to the field is in the context of the famous 'Wow!' signal of 15 August 1977, detected at Ohio State University's 'Big Ear' radio telescope. It was a strong 72-second anomalous signal at 1420 MHz – the emission frequency of neutral hydrogen, which physicists Philip Morrison and Giuseppe Cocconi speculated might be the preferred medium of extra-terrestrial communications.



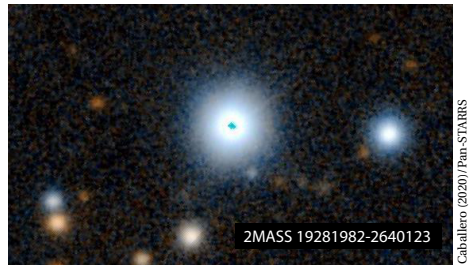
The 'Wow!' signal was so-named because Jerry Ehman, the astronomer who analysed the data print out, annotated the signal with the word 'Wow!'. The signal was never repeated, and it remains unexplained.

Observatory director John Kraus described it in a letter to astronomer Carl Sagan: *'The Wow signal is highly suggestive of extraterrestrial intelligent origin, but little more can be said until it returns for further study'*. Kraus and others searched for stars that could be the source of the signal, writing *'We checked star catalogs for any Sun-like stars in the area and found none'*.

A detailed report, *'The Big Ear Wow! Signal: what we know and don't know about it after 20 years'*, was written by Ehman in 1997 (`www.bigear.org/wow20th.htm`).

THE GAIA CATALOGUE is, of course, far more extensive, and far more detailed, than the star catalogue that Kraus had access to in the 1970s.

And amateur astronomer Alberto Caballero has now used Gaia DR2 to identify a possible stellar origin: out of 66 G and K stars in the likely sky region, one has sufficient information to infer that it closely resembles our Sun, i.e. the same temperature, radius, and luminosity. The object, 2MASS 19281982–2640123, lies in the Sagittarius constellation, at a distance of 1800 light-years (Caballero 2022). It is not yet known whether this, or other stars in this part of the sky, are accompanied by planets.



In 2012, on the 35th anniversary of the Wow! signal, Arecibo Observatory beamed a digital stream towards Hipparcos stars HIP 34511, HIP 33277, and HIP 43587, comprising 10 000 Twitter messages solicited by National Geographic. No replies have been reported so far.