The Fermi paradox

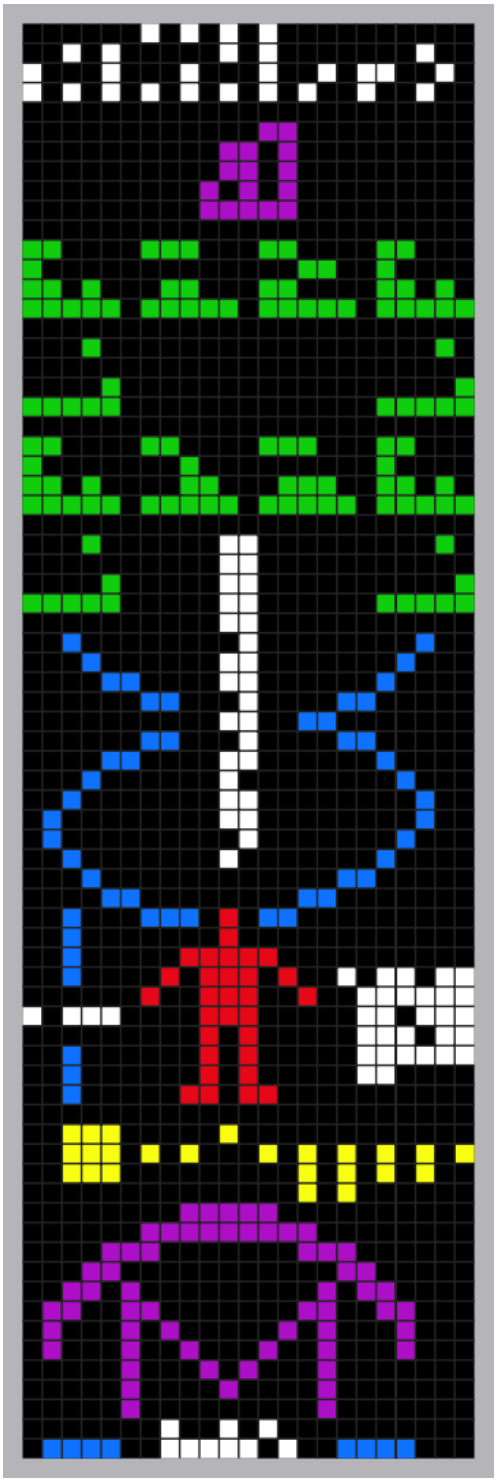
In our galaxy, the Milky Way, there are over 100 billion stars. Around us, we have discovered 100 billion more galaxies: we have not yet been able to see beyond them. Therefore, doing a simple multiplication, today we know that there are more than 10,000 billion stars in the Universe. With such large numbers, there is a very high probability that there may be other habitable planets. There is a strong possibility that other forms of life may exist somewhere in the universe and we can reasonably think that there may also be many intelligent forms of life. However, if there are intelligent civilisations in the universe, why haven't we encountered them yet? Why haven't they ever sent us a signal? This is the question that Nobel prize winner for Physics Enrico Fermi asked in 1950, a question known as the *Fermi Paradox*.

The Milky Way

In 1961, in answer to Fermi, the American astrophysicist Frank Drake devised a formula to estimate how many extraterrestrial civilisations with technology suitable for communicating with us may exist in our galaxy alone. The equation takes into account seven parameters. By estimating them at the most reliable value and multiplying them with each other, it turns out that we are not likely to be alone in the galaxy. Indeed, around us there may be dozens, if not hundreds of civilisation able to send us a message, even just a call to hear if we exist and if we are well.

Anyway, where are they? The problem is not where, but when they are. Our galaxy is incredibly vast. It is shaped like a disk with a diameter of 100,000 light years. It means that a ray of light takes 100,000 years to travel from one side to the other at a speed of 300,000 km a second. Our solar system is located at 28,000 light years from the centre of the galaxy: thus, we are more or less midway between the edge and the centre. In such a gigantic system, if the planets with intelligent aliens are distributed like seeds in a field, the distance between us will be enormous. Consequently, a message launched today from Earth at the speed of light would reach our neighbours thousands or millions of years from now. And vice versa, today we would receive an alien call made when dinosaurs were grazing on our planet or, if we are lucky, when Galileo was scrutinising the skies with his telescope: that message would be the voice of a civilisation that may no longer exist. We will never know.

Despite these many difficulties, we keep listening. The antennas of the SETI (Search for Extra-Terrestrial Intelligence) project have been probing the skies since 1979 in search of an anomalous signal that might be an alien message. SETI was created on the wishes of Frank Drake and Carl Sagan, who was very famous as an astrophysicist and even more so as a science communicator and writer. SETI has been listening to the skies for over forty years. However, to date all is quiet.



A graphic representation of mankind's first attempt at using radio waves to actively communicate our existence to alien civilisations.

However, what if someone simply decides to drop in here on Earth? Science fiction is full of interstellar journeys, but if sending a message is complicated, developing the technology required to travel across space is even more unlikely. Even if it were to travel at the speed of light, a spaceship would take a very long time to reach us: would the crew manage to survive? Perhaps, aliens may travel faster than light. Yet, according to the Theory of Relativity, the speed of light is an insurmountable limit: how could they succeed? For example by crossing through a space-time gap.

Black holes are places in space with an extremely strong gravitational field, which prevents everything they contain, including light, from coming back out. These dense and compact celestial bodies are full of mass, yet so small they distort space and time until they turn into a trap for matter and energy. There is a black hole at the centre of the Milky Way, as big as the solar system but weighing more than one billion times more than our Sun. A teaspoonful of black hole would weigh as much as the Earth. Whatever ends up in a black hole, including light, cannot get out any more. However, in the 17th century the great French chemist Antoine-Laurent de Lavoisier claimed that nothing is created nor destroyed in the Universe. Consequently, whatever is captured in a black hole must end up somewhere. Indeed, the Theory of Relativity does not exclude that there may be special passages within a black hole between different areas of space and time, even very far from each other. These are known as *wormholes*, like the holes that worms make in fruit. Just like a hole that allows a worm to go from one side of an apple to the other, a *wormhole* would make it possible to cover light years in a very short time. Such a passage is widely used in science fiction films but, in reality, the gravitational force of a black hole would crush a spaceship and all that would remain of the crew would be a horrible subatomic slime.

Earth and Proxima b compared (in a representation on the right). Credits: scienzenotizie.it

Let's get back to reality. The space probe *New Horizons* is the fastest man-made object ever built. It left Earth on 19th January 2006, photographed Jupiter and Neptune's satellites and on 14th July 2015 took some spectacular pictures of Pluto. Now it is travelling towards the edge of the solar system, where there are only asteroids. The probe took nine years to cover over the 5 billion km between us and Pluto, travelling at the surprising speed of 58,536 km per hour (16.26 km per second). The star *Proxima Centauri* is the closest to us. It is more than 4 light years away and is small and red. Around this star rotates *Proxima b*, a planet that is probably rocky, with dimensions similar to those of our planet. The possibility that *Proxima b* may be suitable to support some form of life, given that there may be liquid water on its surface, has been long discussed. Anyway, perhaps we will never know: even the very fast *New Horizons* probe would take 75 thousand years to reach the planet. To be certain that we are not alone in the universe, we can only hope that up there there is someone smarter than us who wants to let us know that they exist.

By Andrea Bellati