This story began to unfold forty years ago and still continues. This is the story of Voyager 1 and 2.

In the early 1970s, the National Aeronautics and Space Administration (NASA) of the USA conceived a mission to make a grand tour of the first two outer planets of the solar system – Jupiter and Saturn. Although astronomers have observed these planets through ground-based telescopes over several decades, there were still many mysteries to unravel.

To accomplish this objective, two twin spacecraft Voyager 1 and Voyager 2 were built to flyby these planets and conduct close-up studies of the planets and their moons. The onboard instruments included television cameras, infrared and ultraviolet scanners, magnetometers, plasma detectors and cosmic ray charged particle detectors.

Since the voyagers had to go quite far away from the Sun to conduct their studies, the solar radiation intensity was too low to use solar panels to generate electricity to power the spacecraft. Hence, each spacecraft was powered with three thermoelectric generators which by converting the heat energy generated by the decay of the radioisotope Plutonium-238 to electricity, produced...
Voyager 1 was launched on 5 September 1977 and Voyager 2 a few days earlier on 20 August 1977. Originally the mission was planned to last only for five years. But as the mission progressed, NASA added more flybys to include the remaining two outermost planets Uranus and Neptune in the mission. The five-year lifetime was extended to 12 years by remote-controlled reprogramming.

Communication from and to the spacecraft takes place through Deep Space Network sites equipped with giant radio antennas. Three such sites are situated around the globe: Madrid in Spain, Canberra in Australia, and Goldstone in California, USA. Strategic placement of these sites, equidistant from each other at approximately 120 degrees on the longitude ensures constant communication with the spacecraft. If one spacecraft goes below the horizon at one site, another site picks up the signal and carries on the communication.

By 1990, the twin spacecraft between them explored all the four giant outer planets their rings and moons and have made some astonishing discoveries. Nine volcanoes have been discovered on Jupiter’s moon Io. These were the first ever active volcanoes found beyond the Earth. They are the first spacecraft to detect lightning on a planet (Jupiter) other than Earth; to detect the presence of an ocean beyond Earth (at Jupiter’s moon Europa); to image the rings of Jupiter, Uranus and Neptune and multiple moons of all the four outer planets; and to discover nitrogen-rich atmosphere beyond our own home planet (at Saturn’s moon Titan).

The presence of magnetic field on Uranus – though such fields are known to exist on other planets – was not known until Voyager’s arrival there. The mission also reported that while the magnetic field in other planets is oriented approximately along the rotational axis, in Uranus the magnetic poles are closer to its equator.

**Interstellar Mission**

The most fascinating feature of the Voyager Mission is that even after exploring all the outer planets of the solar system, the spacecraft are continuing their journey far beyond the solar system into the interstellar space – the space between the stars. The interstellar space is not just void. It is filled with material ejected by the death of nearby stars millions of years ago and high energy cosmic ray particles and is dominated by strong magnetic forces.

The solar system consisting of the Sun and all the planets, the asteroids, comets, and the Kuiper Belt objects is also known as the Heliosphere. It is an enormous magnetic bubble enveloping not only the Sun and all the planets but also the solar wind. Solar wind is a stream of low energy charged particles, mostly electrons and protons, ejected in all directions from the Sun. It fills the heliosphere.

Beyond is the heliopause extending to a distance of about 18 billion km from the Sun – the outer most boundary of the solar wind, where the interstellar medium restricts the outward flow of the solar wind and confines it within the magnetic field of the heliosphere.

The Voyager 1 and Voyager 2 are now on a new mission to explore the interstellar space. The objective of the Interstellar Mission is, in addition to establish the boundary of the heliopause, to characterise the environment of the interstellar space by measuring its magnetic field, abundance of low energy particles, plasma investigations and interstellar cosmic ray measurements. With these, astronomers hope to gather more information about the interstellar space. In addition, the Voyagers have also become space-based ultraviolet observatories and their unique location in the universe gives the astronomers an opportunity to observe the celestial objects that emit ultraviolet radiation.

On 25 August 2012, Voyager 1 left the solar system and entered the interstellar space. Voyager 2 is expected to do so in a few years. As of February 2017 Voyager 1 was at a distance of 20.6 billion km from the Sun and Voyager 2 at 17 billion km.

How do the astronomers on Earth know when the spacecraft has entered the interstellar space? Scientists define the beginning of the interstellar space as the place where the Sun’s constant flow of material and magnetic field (Solar wind) stops affecting its surroundings. Hence, the entry into interstellar space is indicated by at least three parameters. One is the drop to near zero of low energy particles that originate from inside the heliosphere. Second, an increase and levelling off of the high energy particles (cosmic rays) from outside the solar system. The third and even more defining parameter that confirms the spacecraft’s move into interstellar space will be the shift in the magnetic field from an East-West direction to North-South Direction.

Instruments in the spacecraft continuously monitor these parameters and communicate through the Deep Space Network sites. It takes about 16 hours and 38 minutes to transmit radio signals one way.

The spacecraft are speeding away from the solar system at the rate of about 54,000kmph. Astronomers estimate that the Voyagers have enough electrical power to operate at least until 2020 by which time they will be at 22.1 and 18.4 billion km from the Sun respectively. No communication will be possible thereafter. However, even after the nuclear power sources dry out, thanks to the remarkable engineering, they will otherwise be in good condition.

Barring any catastrophic collision, they are expected to continue their boundless journey on their own in the...
vast expanse of space. In about 40,000 years Voyager 1 will drift within 16 trillion km from the star AC+79388 in the constellation of Camelopardalis and Voyager 2 will pass about 17 trillion km from the star Ross 248 in the constellation of Andromeda. In about 269,000 years Voyager 2 will pass 40 trillion km from Sirius, the brightest star in the sky. Ultimately the Voyagers, wandering eternally, complete an orbit around the centre of the Milky Way galaxy every 225 million years!

The Golden Record
Are we the only intelligent life in this universe? May be there are others somewhere in the far corners of the universe. The Voyagers have yet another fascinating task to carry out – to communicate the story of our planet Earth to the extra-terrestrials, who might one day find these spacecraft.

For this, each spacecraft carries a time capsule, which consists of a phonograph record on a 12-inch gold plated copper disc. The record is encased in a protective aluminium jacket with a cartridge and a needle. One side of the record depicts, in symbolic language, the origin of the spacecraft with reference to 14 pulsars whose positions in the universe and their pulsation periods are precisely known. On the same side is also indicated how the record is to be played.

On the other side of the record 115 images from various parts of the globe are encoded in analog form. They cover a wide range of human activities – bringing up children, schooling, sports, eating, drinking, houses and buildings (including the famous Taj Mahal), animals – both domestic and wild, modes of transport, progress in science and technology and so on. Instructions are given as to how to decode them.

The remainder of the record is an audio designed to be played at 16-2/3 revolutions per minute. It contains a variety of natural sounds of the Earth such as made by the surf, wind and thunder, birds, whales and other animals. This is followed by music – both Eastern and Western classics and a number of ethnic music.

The music from India is a 3.5 minute piece of Hindustani music “Jaat Kahan Ho Akeli Gori” (“where are you going, beautiful girl”), which was taken from a record made in 1963, sung by Surshri Kesarbai Kerkar in Bhairavi raga. Kesarbai Kerkar was a legendary singer of the mid-20th century belonging to the Jaipur-Atrauli Gharana. She was awarded Padma Bhushan by the Govt. of India in 1969. The song was recommended to Carl Sagan by the ethnomusicologist Robert E. Brown, who believed it could be the finest recorded example of Indian classical music. Unfortunately Kesarbai Kerkar died the same year that Voyager was launched.

The Golden Record also contains spoken greetings from the Earth-people. The greetings are recorded in 55 languages, which include the Indian languages Bengali, Gujarati, Hindi, Kannada, Marathi, Oriya, Punjabi, Rajasthani, Telugu, and Urdu. Also included are messages from the then US president Jimmy Carter and the UN Secretary General Kurt Waldheim.

The protective aluminium jacket in which the Golden Record has been encapsulated is plated with a small drop of ultra pure sample of an isotope of uranium. The isotope Uranium-238 has a half-life of 4.468 billion years, which means that half the number of the uranium atoms decay to its daughter elements in that period of time. Thus, by measuring the amount of daughter elements in the Uranium-238 sample, the extraterrestrial recipients can calculate the time elapsed since the spot of uranium was placed on the jacket and thus the epoch of the launch.

While designing the Golden Record Carl Sagan noted, “The spacecraft will be encountered and record played only if there are advanced space faring civilizations in the interstellar space. But launching of this bottle into the cosmic ocean says something very hopeful about life on this planet.”

Readers may recall that before Voyager, NASA had launched two spacecraft Pioneer 10 and Pioneer 11 in 1972 and 1973 respectively. After exploring the outer planets Jupiter and Saturn and the asteroid belt during their long mission, they have been cruising silently in interstellar space. Now with the two Voyagers, there are four Earth-ambassadors out in the interstellar space, waiting to bump into some extraterrestrial intelligence.