Voyager and Solar Probe Missions Beckon Mankind: 'Reach for the Stars!'

by Janet G. West

> *No pessimist ever discovered the secrets of the stars, or sailed to an uncharted island, or opened a new heaven to the human spirit.*
>
> —Helen Keller

May 29—For the first time in human history, mankind's reach extends across and beyond the solar system: With the Parker Solar Probe (see **Figure 1**), we are at the very closest that a spacecraft has ever approached to the Sun, and in Voyager, humanity has crossed the threshold into interstellar space, about 122 AU from Earth, or some 11,340,608,490 miles away. These missions were developed by some of the best minds in the scientific community (which includes interns and laymen, as well as the PhDs), and, in the case of Voyager—developed over forty years ago.

The dedication and intellectual effort to solve the many problems on space missions is the same quality, intensity and ardor needed to solve the economic, food and health crises we face, which are intertwined. Now, more than ever, humanity would do well to adopt the attitude, "Failure is not an option!" How do we prepare for future missions, on Earth and in space, both manned and unmanned? How do we educate future scientists, engineers and explorers, scientifically and culturally?

The intellectual effort and mission-orientation of the engineers, technicians, researchers and scientists who designed and executed the two missions can show us a pathway by which we can unleash new powers of creativity in our fellow citizens.

FIGURE 1

The Parker Solar Probe

NASA

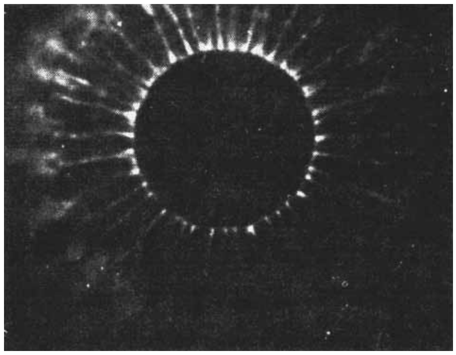
The Sun Sneers at Newton

The Parker Solar Probe (PSP) was launched on August 12, 2018 and is on an approximately 7-year mission. It has completed three of its planned 24 orbits of the Sun, of which seven will use a gravity assist from Venus. During its final orbit, expected to occur in 2025, it will come within *3.8 million miles* of the Sun; closer than the orbit of Mercury. It is also currently the fastest spacecraft and will approach 430,000 mph in its final orbits. (A detailed discussion of its instruments and mission can be found *EIR* Vol. 45, No. 44, November 2, 2018.)

The PSP downloads data after every orbit, and the most recent data, made available on April 14, 2020, reveals startling discoveries about the Sun's behavior and other activity in several areas. The next round of data is expected to be made available to the public in November 2020.

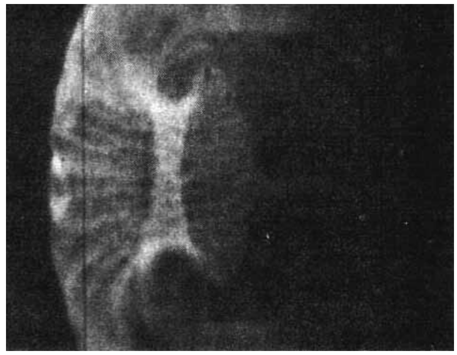
One of the first anomalies noted about the Sun many years ago is that the corona is much hotter (approximately 3 million degrees F) than the surface (a mere 10,000 degrees F). How does that happen? This is one of the questions to be illuminated by the PSP, but is still unanswered. One of the theories under discussion proposes that there are thousands of tiny explosions called "nanoflares," that can reach temperatures of 18 million degrees Fahrenheit and could be heating the atmosphere. Both spectrographs and X-ray observations have confirmed the presence of super-hot plasma on the surface, but further research will be required.

FIGURE 2A



Fusion

FIGURE 2B

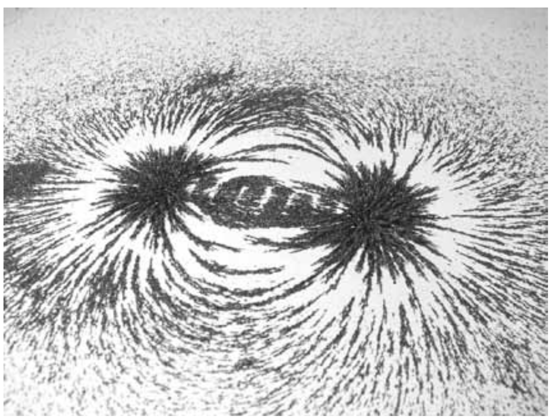


Fusion

Plasma filaments emerging from the Sun like spokes (2A), revealed by occulting the Sun's disk at the camera, and filamentary structures in a laboratory-generated plasma (2B).

One of the promising missions that could bring us closer to the answer is the [Magnetospheric Multiscale Mission] (MMS), launched by NASA in 2015 to study the dynamic magnetic fields surrounding the Earth, and how those fields interact with the Sun's magnetic fields. That could perhaps show some process that would explain the super-heating of the corona. Some of that interaction is visible in the auroras, also known as the Northern and Southern Lights.

MMS consists of four identical spacecraft that orbit the Earth and pass through its magnetic field area, primarily studying a little-understood event called "magnetic reconnection." In data recently released, it was revealed that the PSP encountered a similar phenomenon in 2019.



Magnetic field lines are revealed by the bunching and orientation of iron filings on a surface held just above a magnet.

Although you may be familiar with the classic example of "magnetic field lines" using iron filings on a piece of paper placed on top of a bar magnet, there are no "lines" in space; like the use of latitude and longitude lines on a globe, these lines don't exist in reality, but are used to illustrate action or interactions in the observable universe. When considering this illustration, one should think of these "lines" as extending into three-dimensional space.

Magnetic reconnection is unique to plasma—plasma is the fourth state of matter and consists of ionized (charged) particles; this makes up the stars, fills space and accounts for about 99% of the observable universe. So, understanding plasma's behavior is not only essential for space travel, but also for mankind to harness it for abundant, clean energy in the form of fusion power:

> Reconnection occurs when magnetic field lines cross and release a gigantic burst of energy. It is a fundamental process throughout the universe that taps energy stored in magnetic fields and converts it into heat and energy in the form of charged particle acceleration and large-scale flows of matter. However, magnetic reconnection can only be studied in situ in our solar system, and it is most accessible in near-Earth space, where MMS will study it.

Other insights into this process can be viewed through some of the anomalies that occur in a plasma, in trying to achieve fusion. As the plasma is energized by a laser beam, organized, paired filaments begin to appear at the outer edges. These filaments are vortices that rotate in opposite directions, and "... the energy density of the plasma in these filaments is thousands of times greater than the energy density of the initial background plasma." This action has been observed on the Sun in the solar prominences, See **Figure 2A** and **Figure 2B**.

Now, with the PSP, we can study this process within the solar wind, which might give more clues regarding coronal heating and other dynamics. Some of the other discoveries in the recent data indicate that the solar wind is much more turbulent than previously thought, with some CMEs (coronal mass ejections) and clumps of plasma being pushed far out into space, while other CMEs fall back to the surface of the Sun. Recent data has revealed "switchbacks"—magnetic field lines that doubled back on themselves fully 180 degrees in a matter of seconds; they came in clusters and were in sync with fast-moving plasma particles. Along with that, "island-like" structures were observed within CMEs, which structures would remain stable for some minutes; these CMEs were expelled initially at speeds of 50 km/second, and then sped up!

The reason for this increase in velocity is currently unknown. According to the Second Law of Thermodynamics, an energetic system is supposed to become more and more entropic—more diffused, more chaotic. Instead, what we see is a system becoming more and more organized. According to Justin Kasper, principal investigator for SWEAP—short for Solar Wind Electrons Alphas and Protons—at the University of Michigan in Ann Arbor,

> Waves have been seen in the solar wind from the start of the space age, and we assumed that closer to the Sun the waves would get stronger, but we were not expecting to see them organize into these coherent structured velocity spikes. We are detecting remnants of structures from the Sun being hurled into space and violently changing the organization of the flows and magnetic field. This will dramatically change our theories for how the corona and solar wind are being heated.

In a paper published in *Nature* magazine on December 4, 2019, the authors hypothesized that,

> Alfvénic fluctuations are a promising candidate for such a process because they are seen in the corona and solar wind and contain considerable energy … We find that Alfvén waves organize into structured velocity spikes with duration of up to minutes, which are associated with propagating S-like bends in the magnetic-field lines. We detect an increasing rotational component to the flow velocity of the solar wind around the Sun, peaking at 35 to 50 kilometers per second—considerably above the amplitude of the waves. These flows exceed classical velocity predictions of a few kilometers per second, challenging models of circulation in the corona and calling into question our understanding of how stars lose angular momentum and spin down as they age.

Another recent discovery was that tiny bursts of fast-moving particles were observed for the first time. These include both electrons and ions, and can be accelerated by the Sun's activity to nearly the speed of light. These particles carry a great deal of energy and can damage spacecraft electronics and threaten astronauts—especially those outside the protection of Earth's magnetic field. But, by the time they reach Earth, they can be dispersed enough that the means of identifying the process that accelerated them can be difficult to carry out.

Since the PSP is less than 4 million miles away from the Sun at the perihelion of its closest solar orbit, it can measure these particles just after they've left the Sun; already the PSP instruments have measured previously unknown particle events. Its instruments have also measured a rare type of particle burst, which contains a high number of heavier elements. So, the more we understand about these high-energy particles, the better we can protect our space explorers and electronic technology.

David McComas, principal investigator for the Integrated Science Investigation of the Sun suite, or IS⊙IS (⊙ is the astronomical symbol for the Sun), at Princeton University in New Jersey, reports:

> It's amazing—even at solar minimum conditions, the Sun produces many more tiny energetic particle events than we ever thought. These measurements will help us unravel the sources, acceleration, and transport of solar energetic particles and ultimately better protect satellites and astronauts in the future.

One physicist in particular, who works on the PSP mission, when asked during a public webinar what surprised him most about the PSP mission so far, commented, "The solar panels folded back when we needed them to do so, and the heat shield has protected the instruments magnificently!" (Translation: *"It didn't melt!"*)

Others take a more refined view of the mission.

FIGURE 3

NASA

Voyager 1 is carried aloft by a Titan IIIE rocket.

FIGURE 4

NASA/JPL-Caltech/KSC

The protective launch shroud is lowered onto Voyager 2.

Nicola Fox, director of the Heliophysics Division at NASA Headquarters:

> The Sun is the only star we can examine this closely. Getting data at the source is already revolutionizing our understanding of our own star and stars across the universe. Our little spacecraft is soldiering through brutal conditions to send home startling and exciting revelations.

The Voyager Interstellar Mission

> *Voyager did things no one predicted, found scenes no one expected, and promises to outlive its inventors. Like a great painting or an abiding institution, it has acquired an existence of its own, a destiny beyond the grasp of its handlers.*
>
> —Stephen J. Pine, professor emeritus, School of Life Sciences, Arizona State University

The Voyager mission was a true "first" in human exploration, equivalent to Magellan's circumnavigation of the Earth, and Neil Armstrong's first step of mankind on the Moon.

Voyager 1 and Voyager 2 are now known together as the "Voyager Interstellar Mission." They were both launched during the summer of 1977 from Cape Canaveral atop a Titan-Centaur rocket—Voyager 2 on August 20, Voyager 1 on September 5, with a faster and shorter trajectory than Voyager 2. This was the year of the first Apple computer and the maiden flight of the Space Shuttle atop a Boeing 747 airliner; the first CRAY computer was shipped to Los Alamos National Laboratory; and Jimmy Carter was the President of the United States. Ironically, many of the scientists currently tracking Voyager 1 and 2 weren't even born when the mission began. See **Figure 3**, a Titan-Centaur rocket; and **Figure 4**, the encapsulation of one of the Voyagers.

They are identical spacecraft; each consists of a decahedral bus, about 18 inches in height and nearly six feet across. A 12-foot-diameter parabolic high-gain antenna is mounted on top of the bus. The majority of the scientific instruments were mounted on a science boom extending out from the spacecraft, to prevent magnetic or electronic contamination from the craft itself. They each have a mass of about 1,592 pounds. And, each has three computers—with a total capacity of about 24,000 bytes!

Each is a stunning achievement in technology and engineering:

• They each comprise 63,000 individual parts, many of which (like transistors) contain smaller parts and have extremely complex electronic circuitry.

• Their computers are programmed with seven fault protection routines, each capable of managing a multitude of possible failures; the spacecraft can place themselves in a safe mode in seconds or at most a few minutes.

• They were designed—and are protected—to withstand the massive radiation dose during the fly-by of Jupiter.

• They can point their scientific instruments on the scan platform to an accuracy of better than 1/10 degree.

• The magnetometers are mounted on a 43-foot fiberglass boom; the orientation of their sensors was controlled to an accuracy better than two degrees.

• A set of small thruster rockets controls the attitude of the spacecraft and make trajectory corrections; each has a thrust of about three ounces; the rocket that lifted them aloft had a thrust of over 2 million pounds.

• They are powered with a Multi-Hundred Watt Radioisotope Thermoelectric Generator (MHW-RTG), which uses the heat caused by the decay of a radioisotope to generate power for the spacecraft. This gave each craft about 470 watts of power at the time of launch.

The Golden Records

Each carries a Golden Record (see **Figure 5**), a 12-inch gold-plated copper phonograph record, containing greetings in 55 languages, 115 images, sounds of Earth: volcanoes, birds, a chimpanzee, surf, and crickets, as well as of a tractor, Morse code, a Saturn V lift-off; and an eclectic selection of music from around the globe. It also contains written messages from then President Jimmy Carter and UN Secretary General Kurt Waldheim.

What is most notable about the record are the instructions for its use, especially the time scale used for it to be deciphered. The record includes diagrams showing the solar system's position in relation to 14 pulsars, whose precise periods are given.

In the far right bottom corner, there is a diagram showing the simplest and most abundant element in the universe, hydrogen. The drawing shows the hydrogen atom in its two lowest states; a connecting line and the digit 1 indicate that the time interval associated with the transition from one state to the other is to be used as the fundamental time scale needed to play the record and to have the pictures decoded properly. There are other fascinating aspects as to how this record was produced to allow an intelligent form of life to translate it, which the reader is encouraged to investigate further.

NASA/JPL

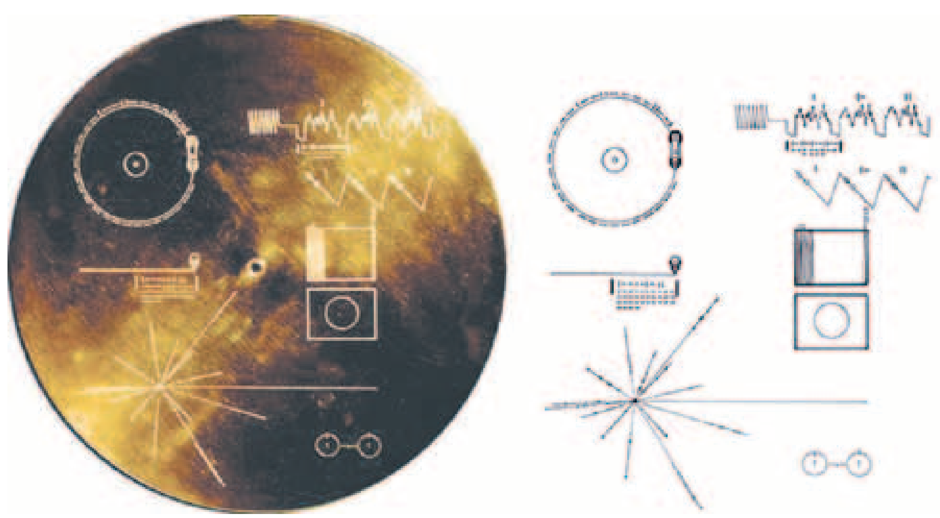
A dish antenna for communicating with the Voyagers is under construction, July 1976.

But, why use the hydrogen atom for the time scale? Hydrogen is the most abundant element in the universe, having one proton and one electron. Although we conventionally speak of the "spin" of the electron, this is used as a means of visualization; the electron has angular momentum, and responds to a magnetic field. It doesn't spin like a planet might.

As reported in a *Scientific American* article, Morton Tavel, a retired physics professor from Vassar College, explained it this way:

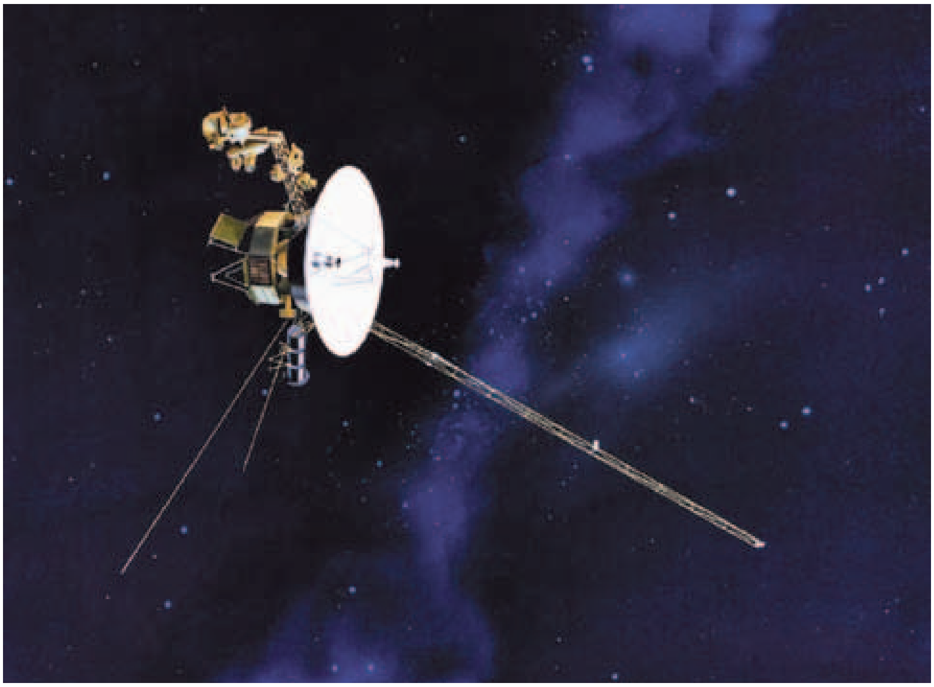
> When certain elementary particles move through a magnetic field, they are deflected in a manner that suggests they have the properties of little magnets. In the classical [Newtonian physics] world, a charged, spinning object has magnetic properties that are very much like those exhib-

FIGURE 5



JPL/NASA

The Golden Record, mounted on the exterior of both Voyager spacecraft.



NASA

An artist's rendition of one of the two identical Voyager spacecraft.

ited by these elementary particles. Physicists love analogies, so they described the elementary particles too in terms of their "spin."

Unfortunately, the analogy breaks down, and we have come to realize that it is misleading to conjure up an image of the electron as a small spinning object. Instead we have learned simply to accept the observed fact that the electron is deflected by magnetic fields. If one insists on the image of a spinning object, then real paradoxes arise; unlike a tossed softball, for instance, the spin of an electron never changes, and it has only two possible orientations. In addition, the very notion that electrons and protons are solid "objects" that can "rotate" in space is itself difficult to sustain, given what we know about the rules of quantum mechanics. The term "spin," however, still remains.

So, with that understanding, if we look at events that occur in a hydrogen atom, the electron will sometimes "flip" and reverse its "spin." This reversal releases electromagnetic energy in a predictable range, at a wavelength of 21 cm, also known as the "hydrogen line" in astronomical spectra. Since this is a known and invariant physical measurement, and given the abundance of hydrogen, any intelligent life-form would also know this measurement. Geometry, physics and music appear to be truly "universal" languages.

The Grand Tour

How far away are the Voyager spacecraft now? Voyager 1 was eventually sent on trajectory in a "northerly" direction out of the plane of the solar system and is now more than 11 billion miles from Earth. Or, to put it another way, astronomers use the "Astronomical Unit" (AU), which is the mean distance from Earth to the Sun, or about 93 million miles. Neptune is about 30 AU from Earth; Pluto is a mean distance of about 39 AU. By comparison, Voyager 1 is currently at a distance of about 125 AU and travelling at about 34,500 mph! Voyager 2 is about 118 AU away from Earth. To put things into galactic perspective: one light-year is a measure of distance equivalent to about 63,241 AU; the center of our own galaxy is about 25,000 light-years away.

Their original mission was to conduct close-up studies of Jupiter and Saturn, Saturn's rings, and the larger moons of the two planets:

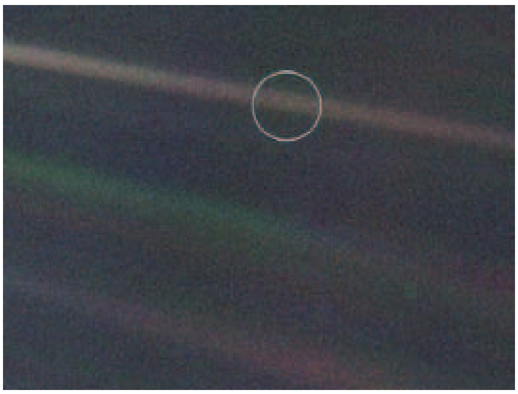
> Each Voyager had as its major objectives at each planet to: (1) investigate the circulation, dynamics, structure, and composition of the planet's atmosphere; (2) characterize the morphology, geology, and physical state of the satellites of the planet; (3) provide improved values for the mass, size, and shape of the planet, its satellites, and any rings; and (4) determine the magnetic field structure [of each] and characterize the composition and distribution of energetic trapped particles and plasma therein.

Although originally planned to only investigate Jupiter and Saturn, scientists at NASA's Jet Propulsion Laboratory (JPL) collaborated in a determined way to take advantage of a rare alignment of the outer planets in the late 1970s and '80s, which would allow a minimum use of propellant and flight time to tour the planets of Jupiter, Saturn, Uranus and Neptune. This arrangement of the planets occurs about every 175 years.

The Voyager crafts exploited this alignment to obtain a "gravity assist," a technique first demonstrated in 1973-74 during NASA's Mariner 10 Venus/Mercury mission; as the craft executed a flyby of each planet, its flight path would be altered by the gravity of a planet, and its velocity increased enough to deliver it to the next destination. This principle allows a spacecraft to swing from one planet to the next without the need for large onboard propulsion systems; it resulted in the reduction of flight time to Neptune from 30 years to twelve!

Researchers and engineers at JPL studied more than 10,000 trajectories before selecting the two that would allow the closest flybys of Jupiter (with a focus on its moon Io) and of Saturn (especially its rings and its moon Titan); the flight path for Voyager 2 was chosen to allow the option to send it on to Uranus and Neptune.

Voyager 1 began its approach to Jupiter in January 1979 and transmitted about 1,500 photographs; it discovered that Jupiter has a very faint ring system. Its atmosphere puzzled scientists as well as amateurs—how could it be so turbulent, and yet maintain stable features, such as the Great Red Spot, over hundreds of years?



NASA Astrobiology Institute

The Pale Blue Dot, Planet Earth (in the circle), as photographed from 3.7 billion miles away by Voyager 1 on February 14, 1990.

It swept past one of Jupiter's moons, Io, and for the first time we saw another planetary body in our solar system with volcanoes. It began its flyby of Saturn on November 12, 1980 and discovered three new moons. Its trajectory, which was designed to send the spacecraft close to Titan and then behind Saturn's rings, was bent northward out of the plane of the solar system (the ecliptic plane). As the craft was exiting the plane, at a distance of about 4 billion miles, it was commanded to turn back one more time and snap a photo of Earth, which became known as is the famous "Pale Blue Dot" photo.

Voyager 2 reached Jupiter on July 9, 1979 and Saturn on August 15, 1981. It took photos of some of Jupiter's other moons, such as the icy Europa, which created more questions regarding the nature of its geology. Voyager 2's trajectory was aimed towards Uranus, and when it was determined that all of its instruments were operating perfectly, NASA secured additional funding and authorized JPL to continue on to Uranus, and then Neptune.

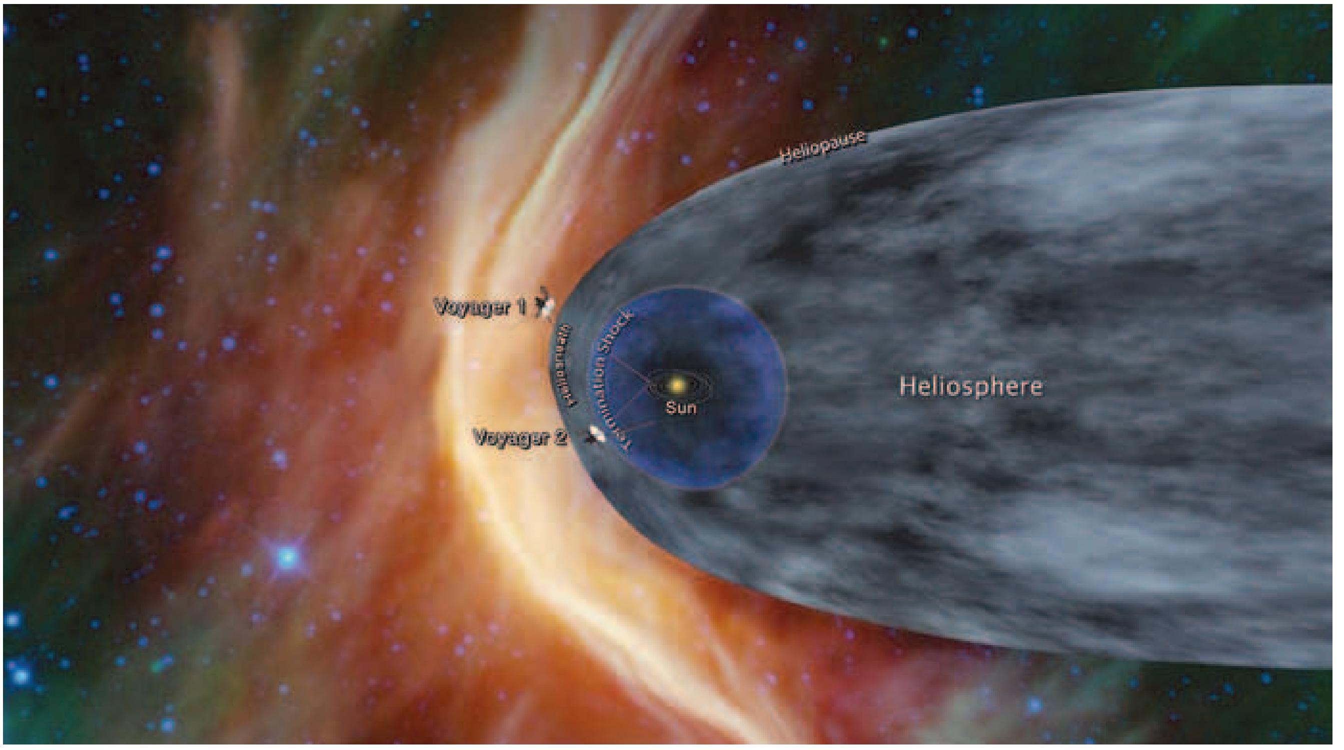
It returned stunning photos and other data of both planets, their moons and magnetic fields, and discovered that both of these outer gas planets have rings similar to that of Saturn, only much fainter and more tenuous. Bear in mind that when data was transmitted from the Voyagers, the photo didn't appear all at once, but like on a television screen, it arrived line by line—it took a long time to download! These are still the only photographic images we have of the outer gas giants.

The analysts and mission engineers had an inkling that Neptune had cloud cover, but they were unprepared for its spectacular weather patterns—it has the fastest winds ever detected in our solar system: 1,500 mph (2,400 km per hour)! They also discovered that unlike Earth, its magnetic field was about 47 degrees off from the rotational axis and rotates independently from the planet and at a faster rate! After Voyager 2's closest approach to Neptune on August 25, 1989, it flew southward below the ecliptic plane, on a path taking it into interstellar space, crossing the "termination shock" at the boundary between the heliosphere (containing the solar wind) and interstellar space, about 18 years later.

In 2017, some of Voyager 1's attitude control thrusters—which keep the spacecraft oriented towards Earth for communications—were noticeably degrading and losing performance. The engineers at JPL decided to try an unusual solution: fire up the back-up thrusters! Amazingly, after 37 years of sitting dormant in the harsh environment of space, the thrusters fired up and performed perfectly, adding a few years to Voyager 1's lifespan.

In January 2020, one of Voyager 2's autonomous systems responded as it was programmed to do, but in the process created unexpected complications. There was an unexplained delay in the execution of a maneuver, which left two systems that consumed high amounts of power operating at the same time; in response, Voyager 2 turned off the power to the scientific instruments. The mission team quickly analyzed the issue, and were able to shut off one of the high-power systems, and turned the science instruments back on; by March 2020, due to the hard work of mission operators and engi-

FIGURE 6



JPL/NASA

An artist's rendition of the heliosphere, showing the Sun, termination shock, heliosheath, and heliopause.

neers, all systems were back on line and functioning normally.

The Solar System Almost *Breathes*

The structure of our solar system and the outer reaches of the Sun's influence are roughly depicted as a huge series of nested bubbles. The solar system is the innermost portion, then the termination shock—the boundary between the influence of the solar wind and the interstellar wind. The heliosheath is the outer region of the heliosphere, just beyond the termination shock—where the solar wind begins to bunch up as it opposes the interstellar wind—but still within the heliosphere. There are different theories as to what shape the heliosphere takes—spherical or egg- or comet-shaped; the heliosphere (see **Figure 6**) is the volume defined by the effects of the solar wind (which does exert a force), and is thought to extend far behind the termination shock.

As the entire bubble system moves through interstellar space, it creates a bow shock in front of it (similar to the wave caused by the bow of a ship moving forward through the water). The theoretical "boundary" of the heliosphere is a narrow region called the "heliopause," in which the forces of the solar wind and interstellar wind are thought to be in balance. There are still many unanswered questions as to the dynamics, the magnetic fields, the role of cosmic rays, and the general structure of the entire heliosphere.

Solar activity (sunspots, flares, CMEs) affects the boundaries of the heliopause; these "boundaries" are neither solid nor fixed—they ebb and flow with the Sun's activity, like a bubble or a living organism. The plasma outside of the heliopause is about twenty times denser and is much hotter than within it; the reasons for this are as yet unknown; "conventional physics" would imply that the plasma would become more diffuse. Voyager 1 also measured the magnetic field to be stronger, and of the same polarity as within the heliosphere. This astounded the scientists and technicians working on the mission—they had expected the polarity to be *opposite* that of the heliosphere. They also found that the pressure from the solar wind changes at the boundary, and that the speed of sound is about one thousand times faster than on Earth.

"Wait a minute," you say. "*Everyone knows* there's no sound in space! No one can hear you if you scre—!" If you mean sound that can only be heard with the human ear, you're right. Sound does need some kind of medium through which to propagate, and in space, molecules are so distant from one another that sound as we know it can only carry as far as there is gas or another medium which supports it.

The means by which the speed of sound changes in the area of the heliopause is unknown. The sound that does exist in some interstellar space is at a much lower frequency than is audible. The wavelengths can be extremely long and slow-moving, extending out only as far as interstellar gas and dust can carry them, in the range of *infrasound*. Normal human hearing can extend down to about 20 Hz; there is a black hole about 250 million light years away that drones steadily at about 57 octaves below Middle C.


NASA/CXC/NGST

An artist's illustration of the Chandra X-ray Observatory.

According to a Gizmodo posting, "There Actually *Is* Sound in Outer Space":

> We know this [sound of the black hole] because in 2003, NASA's Chandra X-ray space telescope spotted a pattern in the gas that fills the Perseus Cluster: concentric rings of light and dark, like ripples in a pond. Astrophysicists say those ripples are the traces of incredibly low frequency sound waves; the brighter rings are the peaks of waves, where there's the greatest pressure on the gas. The darker rings are the troughs of the sound waves, where the pressure is lower.
>
> Hot, magnetized gas rotates around the black hole, more or less like water swirling around a drain. All that magnetized material in motion generates a powerful electromagnetic field. The field is strong enough to accelerate material away from the brink of the black hole at nearly the speed of light, in huge bursts called relativistic jets. These relativistic jets force gas in their path out of the way, and that disturbance produces deep cosmic sound waves.

In September 2013, NASA held a press conference at which it released the first recording made by Voyager 1 of sound in interstellar space. As NASA officials explained,

> The sounds are produced by the vibration of dense plasma, or ionized gas; they were captured by the probe's plasma wave instrument.... There were two times the instrument heard these vibrations: October to November 2012 and April to May 2013. Scientists noticed that each occurrence involved a rising tone. The dashed line [on the graph] indicates that the rising tones follow the same slope. This means a continuously increasing density....

At the same press conference, Don Gurnett, principal investigator for the Voyager plasma wave investigation, stated: "When you hear this recording, please recognize that this is an historic event. It's the first time that we've ever made a recording of sounds in interstellar space."

Additionally, the various space probes zooming through the cosmos can capture radio emissions from various sources, such as the sound of plasma waves, Jupiter's magnetic fields, or radio emissions from Saturn. Even Earth generates sounds, especially during particularly strong earthquakes—these can generate infrasound waves that reverberate up into the atmosphere, and which can be detected by satellites. So, perhaps the spheres produce music, after all.

Another form of compression and rarefaction—which is still theoretical—is that of gravitational waves; but unlike other waves, they don't move physical material—according to the Theory of Relativity, they are thought to compress and expand space-time itself. In 2017, the Laser Interferometer Gravitational-Wave Observatory (LIGO), detected that gravitational waves are produced when two neutron stars which are orbiting one another, begin to merge together due to the decay of their orbits. This effect was consistent with Einstein's Theory of Relativity, which predicted that gravitational orbits would decay over long periods of time. To find out more, and to hear the sound of two black holes colliding, please visit LIGO's website.

In December 2004, Voyager 1 crossed the "termination shock," the boundary in the heliosphere where the solar wind slows to subsonic speed, causing compression, heating, and changes in the magnetic field; it navigated the turbulent heliosheath, and in August 2012, became the first man-made spacecraft to cross into interstellar space as it crossed the heliopause and on out of the heliosphere; Voyager 2 followed in December 2018. Voyager 1 is still collecting and transmitting data on what it's detecting in that region, especially on the activity of cosmic rays.

A Boundary of Bubbles

Astronomers and astrophysicists had presumed that the boundary between the heliosphere and the heliopause was "smooth," a boundary that was essentially unchanging as it enveloped the solar system and functioned very much like a shield to keep out cosmic rays. It was thought that the solar wind and magnetic fields of the Sun would slow and then flow back out evenly across the solar system. But, because Voyager 1 and Voyager 2 not only exited the heliosheath at different locations and trajectories, but also during different phases of the solar maximum/minimum, their instruments detected different thicknesses of the heliosheath, and both detected an anomaly that astonished the cosmologists: the boundary appeared to be "frothy." This flies in the face of conventional magnetohydrodynamic models.

The magnetic field of the Sun doesn't extend out across the heliosphere in a smooth arc; it sweeps out three-dimensionally as the Sun rotates, creating a swirl of troughs and crests, like a vortex. (See **Figure 7**.) Of course, the swirls are not static, but in constant motion outward with the Sun's rotation.

As the waves rotate outwards, as they near the heliopause, they begin to bunch up on each other, and begin to overlap. The two Voyagers detected a huge ocean of magnetic bubbles at the boundary; each bubble appears to be sausage-shaped and is about 100 million miles across (161 million km). Rather than functioning like a hard boundary, this layer of bubbles functions more as a membrane. It appears that some cosmic rays zip right through it towards the solar system, while others are forced to bounce around the magnetic bubbles for some time, before finally moving inward towards the Sun. For the most part, the heliosphere appears to modulate cosmic rays—slowing or deflecting them—before they can reach the inner planets. And, even, once in the region of the inner planets, cosmic rays are further modulated by Earth's atmosphere and magnetic fields.

Researchers have created different scenarios to explain this behavior, but they don't fully understand it, and must wait for more sensitive and sophisticated instruments to tell more of the story. This is a crucial area for space travel as a whole; we must be able to devise methods to shield a spacecraft and its crew from the most harmful cosmic rays.

FIGURE 7

NASA/Werner Heil

An artist's depiction of the heliospheric current sheath (the Parker Spiral).

Voyager 1 is the first spacecraft to detect the heliopause, which is the boundary between the end of the Sun's magnetic influence, and the beginning of interstellar space. It is traveling about 320 million miles a year, and Voyager 2 is traveling at about 290 million miles a year. Both spacecraft will continue to study ultraviolet sources among the stars, and the instruments will persevere in exploring the boundary between the Sun's influence and interstellar space; they are projected to transmit for about another decade. Next encounter for Voyager 1: a star in the constellation *Ursa minor*; for Voyager 2, it will come within about one light-year of a star in the *Andromeda* constellation—both some 40,000 years from now.

Human Nature and the Cosmos

> *What a piece of work is a man, how noble in reason, how infinite in faculties, in form and moving how express and admirable, in action how like an angel, in apprehension how like a god!*
>
> —*Hamlet*, Act II, Scene 2,
> by William Shakespeare

Many space explorers who have had the opportunity to view Earth from the vantage point of the Moon, or from the International Space Station (ISS), or from orbit, have expressed in many ways how this perspective has changed them. It is known as the "over-perspective" or the "overview effect." (See **Figure 8**.)

Chris Hadfield, a Canadian retired astronaut and engineer, described it this way in a posting on Pocket:

> It sneaks up on you, because you're busy and you're doing stuff. Your emotions almost end up somewhere behind you, because things are happening so fast. One of the reasons we take so many pictures is we don't have time to see what we're looking at. And you know if you don't somehow record this right now, you're going to miss it, and hopefully you'll have time later to look at it.
>
> So, sometimes when you're looking back at something you did, you realize what just happened. It was when I took a picture, actually, of Karachi, Pakistan, and I read what I wrote about it the next day, which was: "There are 6 million of us living in Pakistan." And I realized that that part of the world had become *us* for me.

And, in the same posting, the reflections of former NASA astronaut, Jerry Linenger:

> You go through the launch and it's just chaos—it's just *power*. You think, "Wow, mankind *built* this thing—it's incredible! This thing's getting me to 17,500 miles an hour." All that part is incredible. So you catch up with everything; you do all the things your brain has to do: switches, make sure everything's correct, make sure the spacecraft's working.
>
> But it's when you have that reflective moment, when you just float over the top of a window. In my five months on the Russian Space Station, I had some opportunities where, for 90 minutes, I would just levitate over a window … [looking at the Earth and thinking about all civilizations]….
>
> You just have this incredible view of the universe, of Earth, and a little reflection of yourself as a human being, telling yourself, "Wow, I'm in space. What mankind just accomplished is incredible."

FIGURE 8

NASA/Harrison Schmitt

Earth, as observed from Apollo 17, December 1972.

Others in the same posting describe sharing a meal (rehydrated vegetables and meat) on a mission, in which there were Germans, French, African-Americans, Asian-Americans—and the first female commander—all breaking bread at about 17,500 mph (orbiting every 90 minutes), in which they could all point out their countries, but which left one of them, Leland Marvin, in awe:

> That's when I think I really got my over-perspective. I thought it would be when I did this task of installing the Columbus laboratory, but

NASA

One of the five Goldstone antennas near Barstow, California that form one part of NASA's worldwide Deep Space Network.

that paled in comparison to the human piece of us sharing and breaking bread and seeing the planet in that way.

Edgar D. Mitchell, Lunar Module Pilot, Apollo 14 expressed it more forcefully:

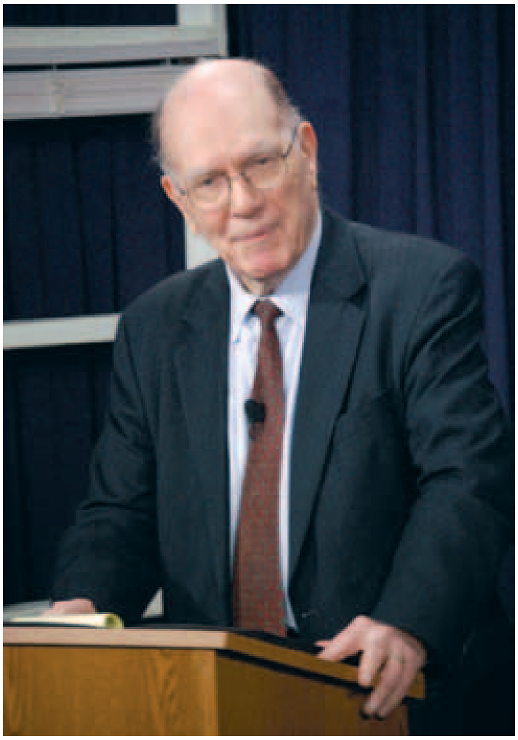
> You develop an instant global consciousness, a people orientation, an intense dissatisfaction with the state of the world, and a compulsion to do something about it. From out there on the Moon, international politics look so petty. You want to grab a politician by the scruff of the neck and drag him a quarter of a million miles out and say, "Look at that, you son of a bitch!"

Towards a New, More Perfect Paradigm

However, one doesn't need to go into space to experience this transition in perspective, but rather to expand the space in one's heart, for all of humanity. A recent international conference organized by the Schiller Institute on the weekend of April 25-26, 2020 demonstrated how musicians, physicists, diplomats and other representatives from dozens of countries across the planet, could come together under the leadership of Helga Zepp-LaRouche, chairman of the Schiller Institute, to deliberate on the fundamental changes that must take place in the near future in the arena of economics and culture, to shift the world into a new paradigm, if mankind is to survive the current dangerous crises.

Among many other important points, several speakers from different countries and cultures emphasized that the Chinese term for "crisis" contains two meanings: "danger" and "opportunity." Let us seize the opportunity now, to transform our world for the better.

Starting in March 2020, one of the links in the Deep Space Network, the 230-foot-wide radio antenna in Canberra, Australia, will be upgraded over several months. The Deep Space Network consists of three stations—one each in Australia, California and Spain—which communicate with various missions 365/24/7. Besides playing a critical role in communicating with the Voyager Mission for several years to come, they'll provide critical communication and navigation support to future Moon and Mars missions, as well as the planned Artemis missions.



EIRNS/Stuart Lewis

Lyndon LaRouche, conducting a webcast in 2011.

Voyager 1's transmission—traveling at the speed of light—takes about 19 hours one way, and Voyager 2 about 16 hours. (By comparison, the data from the Rovers on Mars can transmit in 20 minutes.) All unessential equipment on the spacecraft, such as the cameras, have been turned off to save power. As it is, the power supply is at about 20 watts; communications will continue until the power sources can no longer transmit. On that poignant day, even our most powerful instruments will not find any signal as they scan the heavens.

Just as many of the scientists, engineers and technicians associated with the Voyager mission weren't even alive at the time of its launch, so now, too, there may be newborn babies somewhere in the world—perhaps from Mali, Haiti, or Laos—who will be the next Beethoven, the next Einstein, the next LaRouche. Let us work together to solve the horrific crises of the day, and again lift our eyes and our spacecraft to unexplored horizons. When great minds and hearts collaborate together on a mission, mankind can accomplish miracles.

People from across the globe have expressed in many types of media over the last decades how deeply moved they are to consider that in the Voyager Interstellar Mission, a part of humanity will continue on its journey through the cosmos for tens of millions of years, perhaps surviving even our Sun. As human beings are not merely a sum of the elements that make up our bodies, so even our spacecraft are not simply the nuts and bolts that hold them together, and perhaps they, and the creative processes of the people that designed, built, and maintain their missions could be considered in more poetic terms, perhaps those of Percy Bysshe Shelley:

To a Skylark

Hail to thee, blithe Spirit!
Bird thou never wert,
That from Heaven, or near it,
Pourest thy full heart
In profuse strains of unpremeditated
art.

Higher still and higher
From the earth thou springest
Like a cloud of fire;
The blue deep thou wingest,
And singing still dost soar, and
soaring ever singest.

In the golden lightning
Of the sunken sun,
O'er which clouds are bright'ning,
Thou dost float and run;
Like an unbodied joy whose race is
just begun.

The pale purple even
Melts around thy flight;
Like a star of Heaven,
In the broad daylight
Thou art unseen, but yet I hear thy
shrill delight,

Keen as are the arrows
Of that silver sphere,
Whose intense lamp narrows
In the white dawn clear
Until we hardly see, we feel that it is
there.

All the earth and air
With thy voice is loud,
As, when night is bare,
From one lonely cloud
The moon rains out her beams, and
Heaven is overflow'd.

What thou art we know not;
What is most like thee?
From rainbow clouds there flow not
Drops so bright to see
As from thy presence showers a rain
of melody.

Like a Poet hidden
In the light of thought,
Singing hymns unbidden,
Till the world is wrought
To sympathy with hopes and fears it
heeded not:

Like a high-born maiden
In a palace-tower,
Soothing her love-laden
Soul in secret hour
With music sweet as love, which
overflows her bower:

Like a glow-worm golden
In a dell of dew,
cattering unbeholden
Its aerial hue
Among the flowers and grass, which
screen it from the view:

Like a rose embower'd
In its own green leaves,
By warm winds deflower'd,
Till the scent it gives
Makes faint with too much sweet
those heavy-winged thieves:

Sound of vernal showers
On the twinkling grass,
Rain-awaken'd flowers,
All that ever was
Joyous, and clear, and fresh, thy
music doth surpass.

Teach us, Sprite or Bird,
What sweet thoughts are thine:
I have never heard
Praise of love or wine
That panted forth a flood of rapture
so divine.

Chorus Hymeneal,
Or triumphal chant,
Match'd with thine would be all
But an empty vaunt,
A thing wherein we feel there is
some hidden want.

What objects are the fountains
Of thy happy strain?
What fields, or waves, or mountains?
What shapes of sky or plain?
What love of thine own kind? what
ignorance of pain?

With thy clear keen joyance
Languor cannot be:
Shadow of annoyance
Never came near thee:
Thou lovest: but ne'er knew love's
sad satiety.

Waking or asleep,
Thou of death must deem
Things more true and deep
Than we mortals dream,
Or how could thy notes flow in such
a crystal stream?

We look before and after,
And pine for what is not:
Our sincerest laughter
With some pain is fraught;
Our sweetest songs are those that tell
of saddest thought.

Yet if we could scorn
Hate, and pride, and fear;
If we were things born
Not to shed a tear,
I know not how thy joy we ever
should come near.

Better than all measures
Of delightful sound,
Better than all treasures
That in books are found,
Thy skill to poet were, thou scorner
of the ground!

Teach me half the gladness
That thy brain must know,
Such harmonious madness
From my lips would flow
The world should listen then, as I am
listening now!