INTRIGUE AND POTENTIAL OF SPACE EXPLORATION

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Since astronomy is the oldest of the sciences, it stands to reason that this science has the greatest potential for advancement through space exploration.

From the dawn of intelligence, people have looked looked up at the heavens and have wondered and wondered and wondered — and I say that was the beginning of space exploration. At first they worshiped the sun, the heavens, especially the sun and the moon, for they realized that they depended upon the sun for light and heat by day, and upon the moon for light at night. You will find in the fourth chapter of Deuteronomy, the 19th verse, "And lest thy lift up thine eyes into heaven and when thy seek the sun and the moon and the stars, even all the rest of the heaven should be driven to worship them and serve them."

Also, we have the development of astrology. Of course, we have no use for astrology — it is pure fortune-telling. But it did serve a purpose in the development of astronomy. The ancient people saw that when certain objects were in the heavens, certain planets, things happened here on the earth — as a sort of echo of the heavens, as they thought. Today, we know that this is connected with seasons and positions, and does not have any direct influence as the ancients thought.

Astronomy was then used for practical purposes, time, calendar, and navigation. But all through the ages people have asked, "What does it all mean? Where are we in the universe? What is the position of man in this universe?"

At first the ancients thought the earth was at the center of everything. Man was supreme; earth was at the center and stationary. They had various ideas about the shape of the earth; i.e., flat, or saucer-shaped (because it had to have a rim or people would fall off), drum-shaped or log-shaped, but Pythagoras, in the sixth century B.C., believed in the sphericity of the earth. Now, I am sure, when I studied history and geography I thought that Columbus was the first person who thought the earth was round. However, Pythagoras, 2000 years before, had the idea of a spherical earth. In fact, Ptolemy had written the "Almagest" in A.D. 150; since it was the textbook that Columbus used in the University of Pavia, he was taught that the earth was a sphere. Little did Pythagoras or Columbus know that we would have astronauts photographing the moon and earth as round — as a sphere! You never know with these discoveries, what is going to happen 1 or 2000 years later.

The ancients tried to measure as best as they knew how. They did not have very much equipment, but did have the gnomon, a vertical stick. They measured the lengths of the shadows and were able to determine the winter solstice when the shadow was long, and the summer solstice when the shadow was short and the sun was highest in the sky. Halfway between the solstices we have Thales in the sixth century B.C., trying to measure the apparent diameter of the sun. He did not have a good timing device, but he had set up a ratio between the time when the western edge of the sun touched the western horizon and completely disappeared, and the time it took the sun to cross the sky; he got 1/720 of a circle. This was not bad; we still have a half degree today.

The ancients made measurements just as good as they could with the knowledge and equipment they had. Philolaus and other Pythagoreans, in the fifth century B.C., were very much interested in the moon; they thought there were lunar inhabitants, who were more intelligent, 15 times stronger, and 15 times more beautiful than people here on earth.

Copernicus was bold enough, in 1543, to take the earth out of the center and call it a planet like the other planets revolving around the sun. He was followed by Galileo, who brought about big advances in astronomy when, in 1609 and 1610, he started his telescopic observations. The story goes that the telescope had come in for military purposes and that Galileo succeeded in obtaining a telescope and turned it to the moon. It is somewhat questionable whether or not Galileo was the first person who did this, but he most certainly is credited with it. He saw the craters on the moon, those holes, but many people would not look through his instrument. They said, he put things in the tube; they said, if those holes are there they had to be filled with a crystal substance; because of its appearance the moon had to be smooth.

Galileo also turned the telescope to the Milky Way and saw that it was made up of stars. He did not realize what a bearing that fact would have on the structure of the galaxy later. He also looked at the sun where he saw sunspots. He discovered the four satellites of Jupiter. He was not able to make out the rings of Saturn but he thought there was something there and referred to them as "ears."

A contemporary of Galileo was Kepler, who stated his laws of planetary motion. Also, Sir Isaac Newton, in 1687 in the "Principia," stated his law of gravitation. How little did Kepler and Galileo, in the 17th century, realize what use would be made of that law in our space exploration through celestial mechanics. As celestial mechanics developed, we are coming up to the last century. At this point in time, photography is developing. The moon was photographed in 1840, the first star on July 17, 1850, and then we have spectroscopy. Spectroscopy proved to be very important to astronomy 100 years ago, but it is just as important today. In space astronomy, we send up spectrographs to analyze, and to find out what elements are there. I used to tell my students that they could change their little verse "Twinkle, twinkle, little star" to "Twinkle, twinkle, little star, need I wonder what you are?" With my spectroscope I can see helium and hydrogen. Up to that time you could look through the telescope and photograph objects, but you could not find out what they were made of; it took the spectrograph to analyze that light.

We come on up into our century, and, of course, as the telescopes got bigger, we found that the atmosphere was troublesome. "Bad seeing," we call it is astronomy when we are talking about this. The bigger the telescope was, the worse the "seeing," because the motion of the atmosphere was magnified. So we have our big telescopes, such as those at Mt. Palomar and Mt. Wilson, up on mountaintops to get as far as possible above the atmosphere. It was found that for the spectrograph also, the atmosphere was very troublesome, because there was only a very small portion of that spectrum that showed up: about 3900 to 7000 Å. All that ultraviolet and infrared could not be seen.

Briefly, that is the history of astronomy before space astronomy came in. More specifically, radio astronomy came into use. The beginning of that period was around 1931, I think, when Karl G. Jansky was working with radio in the Bell Telephone Laboratories. He had background static and could not account for it; there were bursts of static every 24 hours, to be exact, every 23 hours 56 minutes, and he realized he was getting these radio frequencies from space, because that was the rotation of the earth. Radio astronomy expanded in that we could reach farther and farther into space. It was not until 1950 that radio astronomy really advanced; in fact, the fifties became a great period for radio astronomy and for the beginning of space astronomy. We began to launch some balloons. I believe Schwarzschild sent up a balloon, in the latter part of 1950, to about 80 000 ft, to photograph the sun. The photography, at that height, was great above the atmosphere. About that time, there was also a balloon sent up to study the spectrum of Venus, and a little water vapor was detected in 1959, on Venus, with that balloon.

When Sputnik went up in 1957, a whole new era opened up in astronomy; the entire picture of astronomy changed. I say that at that time a real change was observed in the picture of the astronomer. Before that time, you pictured an astronomer as an old bearded man with his charts and his photographs, looking through a telescope, in a hemispherical dome, wondering what he would find, and as you stood there as a spectator, you would think, "Well, wonder what he will see out there?" and that sort of picture. What have we now, indeed? We still have the hemispherical dome, we have a Space Science Building and maybe a radio telescope nearby, but the astronomer today is pictured as a young astronaut, sitting on a tube, ready to fly off to the stars; so there is a great difference in the thoughts about the profession of the astronomer of these days.

The first place they thought of visiting was the moon, since it was the closest object. At last, the moon began to come into its own. In the early days of the beginning of telescopes, people were interested in the moon, but when the big telescopes came in, the moon and planets were beneath the dignity of them. The big telescopes all had to be turned to galaxies, to objects that were difficult to see through small telescopes. For a long time nobody paid any attention to the moon, so space astronomy most certainly has brought the moon back into its position.

There was also that old dream about reaching the moon; you felt that you would never attain that. Now we know that is perfectly possible. However, the astronomer most certainly has set a great foundation for the astronauts to go to the moon. Actually, a great deal was known about the moon before the astronauts went there. We knew the distance, we knew something about the dust on the surface, we knew something about the topography, and we knew the great range in temperature from about boiling when the sun was shining on the moon, to close to absolute zero when it was dark. We knew that there was no air on the moon and did not believe that there was much water, although they think now they have found evidence of some water. The astronomers had mapped the moon. In 1878, for example, there was a map showing 32 000 craters.

Thus, the astronauts knew where to go and where to land, but there was one great discovery the astronauts made. I believe, the first was Russia's Lunik III, in 1959, which orbited the moon and photographed the back side. That, most certainly, was a great contribution to astronomy; this was new knowledge about the moon. Who would have dreamed, when I started astronomy 50 years ago, I would ever see any pictures of the back side of the moon! Since the moon rotates and revolves about the earth with the same period, we always see the same face, and just never would have thought that we would see the back of the moon. In the meantime, it has been photographed many times by astronauts, and the craters on the back of it have been named. Up to the time the Russians first photographed the back of the moon, 41 percent of it had never been observed. The 59 percent known to astronomers was because the rotation was not uniform. Since the revolution followed Kepler's second law, we are permitted a look around the edges, plus the fact that its axis is tilted a little, which permits looking over the poles; when it rises we can see a little over the west edge, and when it sets, a little over the east edge. So, a total of 59 percent of the moon had been observed.

Of course, we know the moon is a great place for a rock collector. We have got all those rocks that came back, but at present it is hard to say what will be determined from the study of those rocks about the age of the moon, the evolution of the solar system, the evolution of the moon, and of the earth. I think, one of the big things this trip to the moon has done is that astronomy is not so far removed from people anymore — just the fact that people actually saw the astronauts, they felt they were up there with them through television. Then, of course, their coming back, and that splashdown right on the second, "There they come!" The fact that people could look out and see those astronauts coming home has been a great contribution getting more people more interested in astronomy and particularly in the moon.

I do not believe there is today quite as much opposition to spending the money. It used to be that the taxpayer thought the money was put on the rocket and was actually sent up to the moon, that the money was up there someplace and we would never get it back. If you point out how many people are involved, and the great technology that is used today preparing for these trips then I do not think the opposition is quite as much.

The planets, of course, are always alluring. There is something about those spheres that attracts attention because there is the possibility that there might be life on them, especially on Mars and Venus. Mars, of course, has always been known as the Newspaper Planet. Years ago, when people learned that I was studying astronomy, or that I was an astronomer, they always asked, "What about life on Mars?" That was always the first question, never about life anywhere else — just what about life on Mars. I think that dates back to 1877, when there was one of the favorable oppositions. Every 2 years, Mars lines up with the Earth and the Sun; this is called an opposition. There was one in the summer of 1971, but some of those oppositions are better than others. If you get the perihelion of Mars, that is, when it is closest to the Sun, nearer the time that you have the aphelion of the Earth, we get the very closest approach. The one in the summer of 1971 was a very close one. In 1877, there was one also, and as a consequence there were great preparations in those days for the study of Mars' canali. Schiaparelli, in Italy, observed the canali; he meant to say channels (in Italian, canali means channels). The word was taken to mean artificial waterways and, therefore, there must be smart Martians who were able to make an elaborate irrigation system. You see, Mars has two polar caps, and for a long time they were believed to be ice and snow; now, they are thought to be carbon dioxide, but the proponents of the canal theory would say, when the polar cap is turned toward the Sun in summer it would diminish and then the canals become stronger. During winter, when the polar cap would get larger, the canals were not so prominent, and, therefore, people interpreted the canals as a very elaborate irrigation system for the planet. To have such an elaborate irrigation system, there had to be intelligent Martians. That, of course, attracted attention.

Then there was the excitement about the Mars satellites. The two satellites of Mars were discovered, in 1877, by an American astronomer, Asaph Hall, Sr., of the Naval Observatory. That telescope had just been completed. You could almost interpret those two satellites as artificial satellites sent up by Martians because of the timing of their revolutions. Mars rotates in 24 hours 37 minutes 22.58 seconds; the markings are very prominent, and it has been timed so many times. One of the satellites revolves around Mars in 7 hours 40 minutes, that is, it goes around three times while Mars rotates once — almost like an artifical satellite. The other one goes around in 30 hours 18 minutes, which is just a little over a Martian day — just like we observe our artificial satellites today. This caused people to speculate that they might have been artificial satellites sent up by Martians. A third satellite has now been discovered, which has a period of about 12 hours, right in between those other two. The canals on Mars and these two satellites, of course, have attracted a great deal of attention; thus, people have always been very interested in Mars, about whether or not there might be people living there.

Ground-based astronomy has detected carbon dioxide in the spectrum and some trace of oxygen and water vapor. Mariner IV photographed Mars from 6000 miles (that is as close as it came to the planet). The photographs revealed craters just like those on the moon. I do not think that has ever been suspected before, that Mars has craters similar to the Moon. The craters probably happen to line up, and it is these lines that people have interpreted as canals.

Venus, of course, is another planet that is close by the Earth. In fact, Venus comes closer to Earth than Mars. Venus, when it is the closest, is about 26 million miles distant; Mars is about 35 million miles. When Venus is closest the dark part is turned toward the Earth, therefore, up to the time of space astronomy, you never heard much about Venus because you could not see it. When Mars is closest, the illuminated part is turned toward the Earth. Venus, of course, is an object of study, especially its atmosphere. Carbon dioxide has been discovered, as well as hydrogen fluoride, hydrogen chloride, and others. For years I taught that Venus was most like Earth, and that if there was any life anywhere it would be on Venus. But the radio telescope, the radio astronomers, and also some spacecraft agree fairly well that the temperature on Venus is 800 to 900° F. If that is the case, then the Venusians cannot be like the Earthlings. We could not stand a temperature as high as that.

What about the sun? There are so many problems about the sun for which we need ground-based astronomy, balloons and orbiting solar observatories, plus everything you can think of. The sun does not rotate as a solid, for example. It rotates faster at the equator than at higher latitudes. There is a sunspot cycle, storms on the sun that have a cycle of an average 11 years, and have very far-reaching effects here on the earth. So the study of the sun with both ground-based and spacecraft observatories is very important.

As we go on out to greater distances, it is impossible to think that we will ever have a manned spacecraft or an unmanned spacecraft out to any of the stars, but we, most certainly, can have these orbital observatories. I think there are plans now for a big telescope in 1978, of 120 in. which will show stars 100 times plainer than here on earth. Now, that will change our knowledge in astronomy! It is estimated that with a 200-in. telescope on earth we could see 2 billion light-years out in space; with this new telescope, if it ever gets finished, our range would be 20 billion light-years, and then all these quasars would not be such a mystery. The quasars were first discovered by radio telescope and then, a quasar was picked up as an optical speck by ground-based telescope. Also, the spectral study showed the great red shift, the velocity of regression, that the great galaxies show.

The history of the human race is a continuous struggle from darkness toward light. It serves us, therefore, no purpose to discuss the use of knowledge. Man wants to know and when he ceases to do so, he is no longer man. In man's brief history, the challenge of cosmic space stands unparalleled. Space exploration is here whether the people like it or not, we just cannot get away from it. We have just got to keep on. I want to conclude with this statement: It does not make any difference whether we are talking about the astronomer who had the gnomon — the vertical stick — or the astronomer who will work with the big 120-in. telescope that orbits the earth. If he is a true astronomer he loves the stars too much to be fearful of the night.

Transcribed from tape.