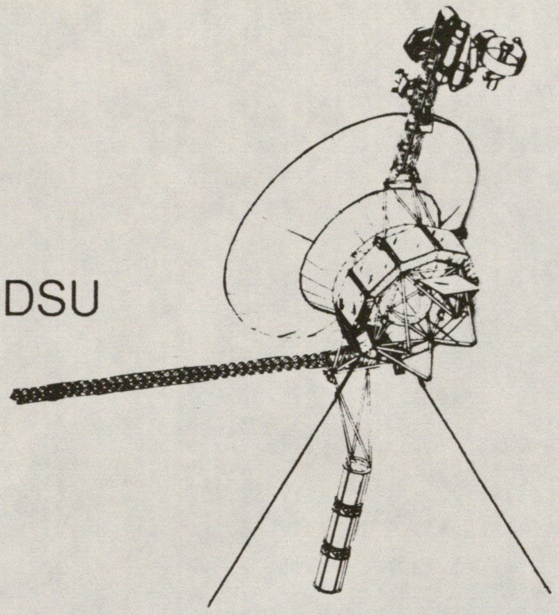
You are cordially invited to the

Annual Meeting

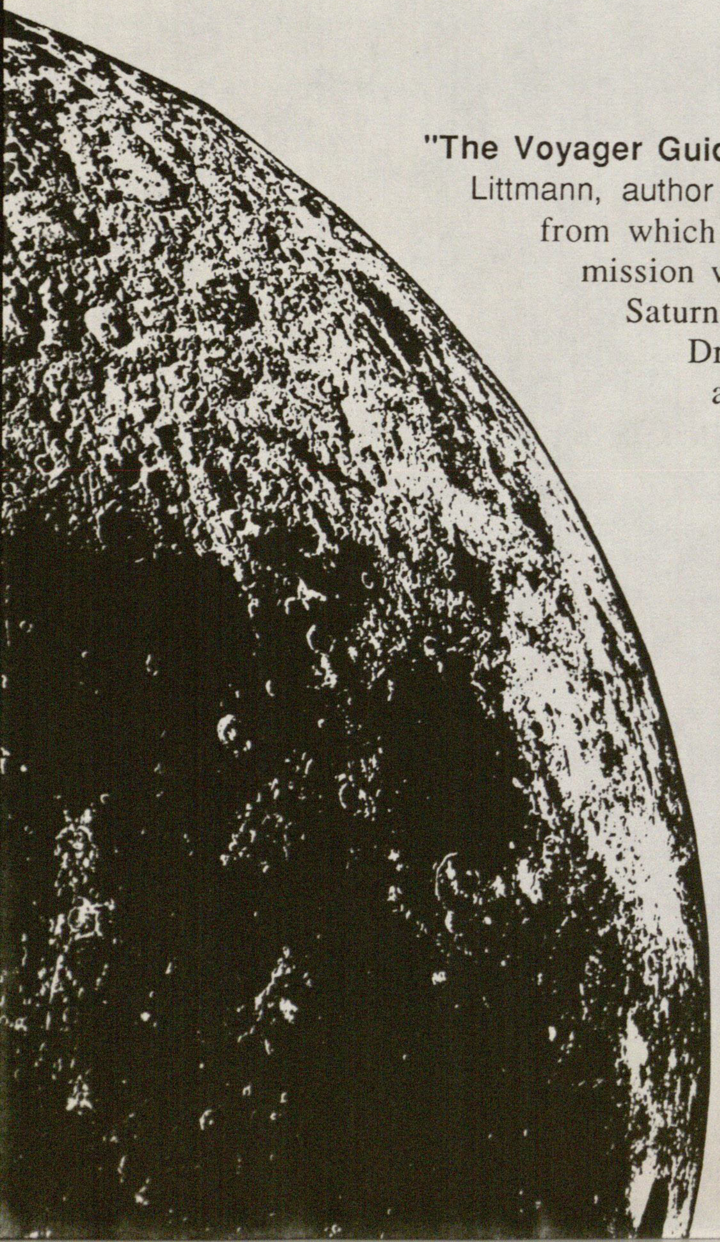
Friends of the Malcolm A. Love Library, SDSU
and the

Picnic in the Patio



Faculty Staff Center
Saturday, June 3, 1989

11:45 Punch in the Patio, Courtesy of the Board
12:30 Luncheon in Dining Room



"The Voyager Guide to Giant Worlds" will be presented by Dr. Mark Littmann, author of *Planets Beyond: Discovering the Outer Solar System*, from which his talk is adapted. NASA's 12-year Voyager mission will be completing its tour of the giants Jupiter, Saturn, and Uranus with a fly-by of Neptune this August. Dr. Littmann's timely and entertaining talk will be accompanied by slides.

An accomplished author, Dr. Littmann is President of Starmaster Corporation, a publisher and distributer of educational materials, with a special interest in astronomy education. Among other positions, for eighteen years he was Director of the Hansen Planetarium in Salt Lake City.

SCORECARD FOR *VOYAGER 2* DISCOVERIES AT NEPTUNE

	Best Information before Voyager 2 Encounter	*Data from Voyager 2 Encounter (fill in)*
Neptune		
Diameter	30,800 miles (49,600 kilometers)	
Mass (Earth=1)	17.2	
Density (water=1)	1.76	
Rotation period	17.0 hours (based on clouds); about 18.0 hours suspected for interior	
Magnetic field	not detectable from Earth; suspected to be similar to Uranus' in strength	
Satellites	2; shepherd moon(s) for ring arcs expected to exist	
Ring arcs	3 reasonably certain; material fills about 20 percent of orbit; ring particles expected to be black	
Distance from center of planet	25,000 to 44,000 miles (41,000 to 71,000 kilometers)	
Distance above cloud tops	10,000 to 29,000 miles (16,000 to 46,000 kilometers)	
Atmospheric composition	hydrogen, helium, methane	
Atmospheric features	methane clouds barely discernible away from equator; slight banding expected but not seen from Earth	
Triton		
Diameter	2,200 miles (3,500 kilometers) (highly uncertain)	
Mass (Earth=1)	0.016	
Density	2 (highly uncertain)	
Rotation period	5.9 days retrograde	
Atmospheric composition	methane, nitrogen	
Atmospheric features	pressure and transparency unknown	
Surface features	none known; methane and water frost detected; possible nitrogen ice and/or liquid; dark reddish color expected due to methane polymerization	
Nereid		
Diameter	200 miles (300 kilometers) (highly uncertain)	
Mass (Earth=1)	negligible	
Density	2 (highly uncertain)	
Rotation period	365.2 days	
Atmosphere	none	
Surface features	none known	

TIMELINE: *VOYAGER 2* AT NEPTUNE

Neptune encounter

Closest approach	9:00 P.M. PDT, August 24, 1989 (4:00 A.M. GMT, August 25, 1989)
Distance	18,133 miles (29,183 kilometers) from center of planet 2,700 miles (4,400 kilometers) above cloud tops 420 miles (680 kilometers) above suspected atmospheric drag dangerous to *Voyager 2*

Triton encounter

Closest encounter	2:14 A.M. PDT, August 25, 1989 (9:14 A.M. GMT, August 25, 1989)
Distance	25,000 miles (40,000 kilometers) from center of Triton 23,900 miles (38,250 kilometers) above surface of Triton

Nereid encounter

Closest approach	5:12 P.M. PDT, August 24, 1989 (12:12 A.M. GMT, August 25, 1989)
Distance	2.9 million miles (4.7 million kilometers)

Dr. Mark Littman
"The Voyager Guide to Giant Worlds"
Annual meeting and luncheon, Friends of the Malcolm A. Love Library, SDSU
June 3, 1989

<u>TAPE I, SIDE A</u>

The first sentences of Dr. Littmann's talk were not recorded. He began by explaining how he came to know of SDSU's Zinner Collection while searching for portraits to include in his book <u>Planets Beyond: Discovering the Outer Solar System</u>, 1988.

<u>Dr. Mark Littman</u>: . . . Royal Observatory, Greenwich . . . Various museums in England, observatories and museums in Germany, and in France. I was still not coming up with the pictures that I most desperately needed if the book was going to tell the story right. The book was going to give the human dimension; you had to be able to see these people and what they were working with. In desperation, that is how I called Owen Gingerich at Harvard. He said, "You're doing it wrong!" (Laughter) "What you do is, you call up San Diego State University and your job will be complete!" I knew of you all--I did, because I lived in Utah for twenty years and [your football team] beat up on the University of Utah! (Laughter)

So, of course, I called. That was the beginning of some of the happiest times in my life because I met Ruth Leerhoff, who couldn't have been nicer and more helpful. That's why she's in the acknowledgements to the book and not everybody that I corresponded with is there. I can't begin to tell you how impressed I am with the collection, with the people who preside over that collection, with the fact that you have this collection and one more thing: As Ruth and as Lou and others were showing me around this collection in the last day and a half--I haven't even scratched the surface yet--as I was looking at it for many hours--they had to throw me out by the end of the day--time after time they would open a book and say, "Look here, this is not just the Zinner Collection, it says 'Friends of the Malcolm A. Love Library'." You all have increased the scope and the value of this collection very significantly. I would come all the way from Baltimore to tell you that. Although there are a lot of people in this town who don't know about your collection, anybody who is interested in early science knows and loves your collection. I'm adding myself in this number as one.

I'm sorry. I've taken up much too much of your time. I had to tell you how important you all are and how much you've meant to me and how much you are going to mean to me in the future because now that I know about you, you'll never get rid of me. I'm like a leech!

Can I ask Lyn Olsson, whose been very helpful, if she would mind passing out some little handouts that Ruth and she have made possible--kind of a score card when Voyager 2 goes by Neptune in twelve more weeks. In the meantime, I'll get the projector ready, tell you a few stories and show you a few slides.

I'm about to tell you the story about Voyager II. It is now almost twelve years into a four and a half billion mile mission that has already carried that spacecraft by three planets and forty-eight of the fifty-four known moons of our solar system of which that very spacecraft itself has discovered ten. It has one planet to go. It will pass by Neptune on August 24 of this year. In doing so, it will have completed a grand tour of all four giant planets in our solar system.

Yet, Voyager 2 is legally deaf, chronically arthritic and just a touch senile! (Laughter) By all odds, this mission should never have happened--at least not in this century and probably not until well into the next century and even then, it could not have been accomplished anywhere near as efficiently. It was made possible by insight, by spotting a rare opportunity, by seizing that opportunity despite many obstacles, by overcoming unbelieveable difficulties which have in the conclusion made Voyager 2 a better spacecraft than when it left home.

The mission continues to revolutionize our knowledge of the outer solar system. Yet, this mission almost didn't happen three times. It owes it's origin and there would probably be no story to tell if it were not for a young man back in 1965 named Gary Flandro. He was doing summer internship at the Jet Propulsion Laboratory, where they put him to work on long-range feasibility studies. In short, nothing terribly practical.

In 1965, he was to look at outer planet missions. Remember, back in 1965, the longest space flight that any country had flown was Mariner 4 which had gone by Mars. That was the limit of how far spacecraft had flown. After all, there were a number of problems in going to outer planets: equipment reliability--would the equipment even last long enough to get there; navigation--could you get anywhere close to the planet so that you could see it better than telescopes on Earth; finally, could you get the pictures and the data from the planet home--communication. Those were the problems.

It took about nine months to reach Mars. Going to Jupiter was being considered at the time and that would take two years. Saturn, that was nine years--couldn't go there! The idea of going to Neptune or Pluto, which was forty years, that was ridiculous. How could you solve this long-time travel problem? That was the core of the problem. How could you make it practical? More speed was needed.

In those days, there were no rockets on the drawing boards that were going to be big enough, fast enough, or powerful enough, and yet inexpensive enough to make such a mission practical. If the size of the rocket couldn't be increased to get greater speed, maybe the size of the spacecraft could be shrunken. There was a limit to how far you could do that and still have the spacecraft take pictures and contribute other information to make the flight worthwhile. It didn't seem like either one of those avenues offered any great hope. Was there some other source of energy?

When Gary Flandro began confronting that problem, that turned out to be the key. What other source of energy might be available to get the spacecraft there? He knew and other space scientists knew that comets are disturbed as they pass by planets, particularly the giant planets. Could you make use of that gravitational perturbation? Yes, back in 1925 a German scientist, named Walter Hohmann, had done some looking into that matter. In Italy, in 1956, Gaetano Arturo Crocco had looked at this problem, but more from the point of view of dropping the spacecraft in towards Venus and then letting it coast on in to Mercury. In other words, gravitational assist used by the inner planets.

Their work had been ignored because with the advent of the spaceage in 1957, reaching one planet was hard enough, much less trying to reach two. Others at the Jet Propulsion Laboratory that summer were looking at inner planet missions that used gravitational assist but there were a lot of misunderstandings about a gravitational assist--allowing a spacecraft to pass by a planet and letting that planet's gravity change the course and the speed of that spacecraft so that it would go on to another planet.

The first misconception was that anybody could see that a spacecraft coming close to the planet would increase its speed, but would it not lose that speed when it started to drift away. There might be a little gain in terms of the speed of passage, but there wouldn't be very much gain in the long run. There was a flaw in that thinking and Gary Flandro spotted it. Shortly thereafter, his superiors noted it as well.

The planet, while it's having the spacecraft catch up with it, is also moving around the sun. When the spacecraft goes by the planet, it actually is draining a little bit of that planet's energy. The spacecraft comes out of that encounter, if it's catching up from behind, with more energy and speed than it had before.

People would say that even if there was some net increase in speed, you have to go all the way to Jupiter, then use Jupiter to get to Saturn--you've gone way out of your way. You end up increasing your time enroute anyway. Gary Flandro was looking into that.

He started with the idea of Jupiter as the key energy contributer. After all, it is the largest of the planets by far. He was looking at Earth to Jupiter with a gravitational assist to Saturn. The Earth-Jupiter-Saturn trajectory. He found that late in the 1970s there would be the positioning of Jupiter that would allow for that kind of gravitational assist.

It was at that moment that he noted something else that no one else had yet seen. In the early 1980s, the planets beyond Saturn, Uranus and Neptune, would be in alignment as well. So, a spacecraft that went by Saturn could go on out to Uranus, use

Uranus for yet another gravitational assist and go on to Neptune. Such a possibility only happens once every one hundred and seventy-five years. It was a rare opportunity. The launch window opened in 1977, only twelve years away and would close within a year or two after that. A very rare opportunity.

He never felt quite so much an exhileration, he said, and then very quickly--within a matter of minutes--depression in realizing that the American space program was at that point still moving fitfully forward, still with no plan for the future. Sound familiar? There's still no grand plan for our future, unfortunately. He doubted that there would be the commitment in America to get the job done. Nevertheless, he reported it and his excitement and the fact that either the opportunity was seized or it could never in our lifetimes, or more than a century and a half, be gathered in again.

There were many naysayers at the Jet Propulsion Laboratory, but his immediate boss, Joe Cutting, thought it was amazing. They called in a Cal Tech professor who immediately pronounced it something to do. The next day after that meeting, the Jet Propulsion Laboratory issued a news release about the discovery of the gravitational assist trajectory and how it could be used to reach the outer planets. That was the origin, of not only what we now call Voyager 1 and Voyager 2, but even of the preceding mission, the Pioneer 11.

There were some people in the community who took umbrage at this. They formed the Pasadena Society for the Preservation of the Orbit of Jupiter. (Laughter) They realized that as the spacecraft passed Jupiter, Jupiter would move inward by a millionth of a millimeter. (Laughter)

Next stop for this very large scale plan was Congress. What was being proposed to Congress was a very ambitious, almost billion dollar mission. There would be two major large spacecraft: one would go to Jupiter, Saturn, Uranus and Neptune; the other would go to Jupiter, Saturn, and Pluto. Pluto didn't fit into that four planet mission. At each stage along the way, the spacecraft would drop a probe into the atmosphere of that giant planet.

In 1971, Congress killed the mission. That was the second time that it almost didn't happen. But, in the summer of 1972, with the wails of scientists in their ears, they appropriated three hundred and sixty million dollars to build two smaller spacecraft, Mariner class spacecraft, like the one that had gone by Mars, for a four year mission that would use a gravity assist at Jupiter to send the two spacecraft on to Saturn. Only Jupiter and Saturn. The grand tour mission conceived by Flandro was dead.

Almost, but not quite, because as the spacecraft were built and as time drew near for them to be launched, the scientists and the engineers took one last fond look at the grand tour. They had four primary objective: Jupiter with its innermost large moon, Io, which had long been a mystery; and Saturn, with its largest moon, Titon, which appeared to have an atmosphere. They wanted those four targets taken care of. Was it possible to do that and still have a grand tour mission?

Well, if you took care of Jupiter and Io, then by passing close to Io, you would get to Saturn too soon to go on a gravitational assist to Uranus. That wouldn't work. If you got to Saturn so that you could be diverted to Titon, passing by Titon would send you in the wrong direction for Uranus. But, if Voyager 1, the first spacecraft to reach Jupiter, gave up a hope for a grand tour, it could go close by Jupiter and Io, close by Saturn and Titon, leaving Voyager 2 in a back up position in case anything went wrong, allowing Voyager 2 to stay in reserve for the Grand Tour. The Grand Tour was just a contingency plan. It was a hope, a dream, a long-shot.

This is what happened on August 20, 1977. Almost twelve years ago now. Voyager 2 left the Earth, and just beyond Earth it deployed the Voyager space probe. There it is with its cameras and other sensing gear and up at the top there's the big white dish for radio communication with the Earth. It's partner, Voyager 1, was actually launched two weeks later, but on a faster trajectory so that it got to Jupiter first. Voyager 1 succeeded very impressively at Jupiter.

This is about what you would see at your Laguna Observatory of Jupiter under very favorable conditions. There's Jupiter with its bands and its great red spot about two or three times the size of the Earth. Voyager 1 changed a lot of our impressions of Jupiter. Now it could be seen to look like this: you could see all of those storms, clouds, and banding in much sharper detail and much greater color. In this picture, you see two of the sixteen known moons of Jupiter. One is right over the face of Jupiter and is reddish in color, Io. Off to the right, you can see Europa, whitish in color. Both of these moons are the same size as the Earth's moon, so you can get some idea of the size of Jupiter.

Off to the left you can see the great red spot measuring in this picture more than sixteen thousand miles across, more than twice the size of Earth. Because of Voyager 1 and 2 we have a much better knowledge of the atmosphere of this largest of worlds in our solar system. It almost looks like a piece of modern art. Very beautiful indeed. The great red spot, a giant hurricane-like storm and the white ovals, also storms, just smaller in size. Winds blowing along at 300-350 miles per hour.

To many people's surprise, the Voyagers discovered that Jupiter has a very faint, dusty ring which you can never see with telescopes from the Earth. Looking back from Voyager 1, you can see the sunlight filtering through that ring. Voyager 1 and 2 got remarkable pictures of the four large moons of Jupiter.

This is the outermost of the large moons: this is Callisto which is absolutely saturated with craters. Not much has happened there in the last four and a half billion years. If a comet or asteroid strikes that moon today, there would be no net increase in the number of craters. The new crater would simply erase older craters.

Here is the largest of all the moons in our solar system which is more than half again the diameter of our earthly moon: this is Ganymede. Ganymede had a surface somewhat different. Yes, there were craters there, but now there were wrinkles on the surface. There were mile high and half mile high grooves and ridges that indicated tectonic motion. The surface of this planet was in turbulent motion in its early days.

Even stranger was a still inner moon: Europa. Here is a picture of that. It looks like a cracked billiard ball. Yet, those cracks were lying within the ground. There's almost no surface relief at all. This is the smoothest of all the worlds in our solar system. It looks like this close up. It's as if the surface is primarily frozen water. The surface has cracked and liquid water has flown to the surface and frozen again. Some people have even suggested that there may be an ocean of liquid water underneath the frozen surface. Arthur C. Clark even suggested that there might be life beneath the frozen surface of this moon.

But, as spectacular as these moons were, most spectacular of the worlds that Voyager 1 and 2 saw was this one: Io, the innermost of the large moons. It is a little larger than our moon. As one scientist said when first looking at this picture, "Well, I've seen better looking pizzas!" (Laughter) As you know, what they discovered was that this is the most geologically active of all worlds in our solar system with a number of active volcanos as both of these spacecraft flew by. In fact, in the upperpart you see one of these volcanos spewing lava, or sulpher primarily, to an altitude of more than one hundred miles.

Voyager 1 passed Jupiter in fine looking form. The Grand Tour for Voyager 2 was still a possibility. Voyager 1 and 2 headed on towards Saturn. This is a picture of Saturn as you would see it with one of your telescopes. A very good telescopic view, but not nearly what Voyager 1 and 2 could see of Saturn. What an improvement and what an amazing world.

A computer enhanced picture of the atmosphere of Saturn showed lots of banding, not quite as distinct as on Jupiter, but winds even higher. Winds exceeding one thousand miles an hour. Storms like those on Jupiter, but not quite as large. Of course, examining the rings of Saturn, it was clear that the rings were actually tens of thousands of ringlets.

Voyager 1 took a good look at Titon. It couldn't see the surface because it was shrouded in an atmosphere primarily of nitrogen. Here was another world at last whose atmosphere was primarily nitrogen. Almost unbelieveably, a nitrogen atmosphere that had greater surface pressure by almost a factor of two than the Earth.

However, it wasn't only Titon that had surprises. Other moons like this one, Midas, showed evidence of a surface that was not just simply beaten by asteroids and comets over the centuries and millenia, but instead it had been active in its own right due to internal, radioactive heating, perhaps because of the gravity of Jupiter and other moons.

Voyager 1 succeeded greatly at Saturn and at Titon. The Grand Tour now loomed large. On August 25, 1981 Voyager 2 cleared Saturn on course and the Grand Tour was on. However this time it was threatened by problems on the spacecraft itself.

Remember that I said that the spacecraft is legally deaf, chronically arthritic, and just a touch senile. Shortly after it was launched from Earth, a computer memory chip failed and the computer lost about three percent of its workable memory. The solution was to work around it. All of the computer was needed, but it was a problem that could be worked around.

The arthritis was another problem indeed. The spacecraft had a scanned platform for its camera and other directional instruments. Basically, as it flew by a target, it would pan to look at that target and would have to acquire the target first. As the spacecraft flew by Saturn, that pointing mechanism seized up and wouldn't run anymore. They eventually got it running again, but they couldn't run it at high speed and they were always very scared when running it at all. If you lost pictures, you could not regain them.

They had a solution to that problem. Instead of moving the scanning platform, they rolled the entire spacecraft. A pretty good trick considering that when the spacecraft went by Uranus, it was going at twenty times the speed of a high-powered rifle bullet; it was going more than 56 thousand miles an hour.

There were other problems because any motion at all aboard the spacecraft causes motion of the spacecraft itself; the action-reaction that Newton called our attention to several centuries ago. For instance, here you have a tape recorder to record the scientific data. The tape recorder starts in order to take in some of that data, say some of the photography, when it starts the spacecraft begins to turn in the opposite direction. When the tape recorder stops, the spacecraft turns back in the opposite direction. They had to develop a way of firing tiny bursts of propellant to counteract that little bit of action and reaction aboard the craft.

They solved these problems. But, the most serious of all the problems was a deafness that the spacecraft had developed. A real potential show-stopper. Seven and a half months before it ever got to Jupiter, there was a power surge aboard the spacecraft and it lost its primary radio and its back-up radio lost almost all of its tuning capability. The radio had been able to scan one hundred thousand-hertz, looking for and locking on to signals.

<u>TAPE I, SIDE B</u>

That was the only radio that was left. How serious was it? Consider what the frequency change is. Here's a spacecraft moving in towards Jupiter constantly increasing speed. As it goes away from Jupiter, it's losing speed. As it uses its instruments, it creates a little bit of heat. As it turns off the instrument, it loses heat. The heat and the Doppler Effect of the speed would change the receiving frequency enough so that it could not receive any information from Earth.

How to cope with that? They solved that problem. They calculated how fast that spacecraft must be going in space between the planet destinations. They compensated for the Doppler Effect and the temperature. They cannot communicate with the spacecraft while it's in the process of doing its encounter because it's gaining and losing speed, using its instruments, generating heat, so much so that they can't keep up with it.

But, when you're dealing with Uranus and Neptune, it doesn't make any difference anyway because Uranus is two and three quarter light hours away. By the time the spacecraft says that it has a problem and by the time you transmit the answer to that problem to the spacecraft, five and a half hours has elapsed. In the case of Neptune, eight and a quarter hours would elapse. By that time it's too late.

What was most amazing of all was that from the Earth, billions of miles away, these problems on board the Voyager had been detected, diagnosed and worked around, causing Voyager to lose none of its experimental capabilities. Not only had they restored Voyager to its original capabilities, but they also enhanced its capabilities. I don't have enough time to tell you about all the things that they did, but quite amazingly, by data compression on the computer program and by firing even tinier bursts from the fuel tanks, by enlarging the communication antennae on Earth, they were able to make the spacecraft even better than it originally was.

Consider what it has to do. From three billion miles away, the distance of Neptune, we receive from that spacecraft one millionth of a billionth of a watt! The spacecraft only transmits twenty-two watts altogether. Compare that to a clear channel radio station which has fifty thousand watts. Yet, we hear it and we get these beautiful pictures from it.

The next mission for Voyager 2 after passing Saturn and after these problems were solved was to reach Uranus. From Earth, this is about the best we had ever seen of Uranus. It's the fuzzy object in the middle with three of its five known moons at that time. Uranus is the size, from Earth, of a golf ball a mile and a half away. No wonder we didn't know much about the features there! Imagine if you took a flashlight at arms length and you pointed it at your face, pressed it once and let your finger up. You have gotten from that flashlight more light energy than Uranus has given Earth since the two hundred years when it was first discovered.

Voyager 2 was able to see Uranus as it had never been seen before. There you see it on the left in what is basically true color, kind of a bluish-green. On the right is the computer enhanced picture. As you can see, it is almost faceless. There is no beautiful banding of clouds as you saw with Jupiter and Saturn. The clouds are hidden beneath smog. We on Earth can appreciate that.

With computer enhancement, in this case, you can see one cloud in about the one o'clock position which is kind of white and strung out. You're looking down on the south pole of Uranus. It was pretty much facing the Earth. This planet pretty much lies on its side as it goes around the Sun.

What did we learn aside from atmospheric composition and magnetic fields and all? Take a look at some of the moons. Five moons were known. Ten new moons were disco vered by Voyager 2. All of them are rather small and dark. Voyager 2 also discovered two more rings to add to the nine rings that had been discovered from the Earth. Nine, very thin and dark rings going around Uranus.

One of the questions that was answered was how are the thin rings kept from spreading out? The answer was pretty well known from when Voyager 1 and 2 went by Saturn and saw a thin ring there. Here you see it very well illustrated. The largest of the thin rings of Uranus is here. The gravity of these two moons on either side of that ring keep the debris in that ring from spreading out. In this way they act as shepherds of that ring, keeping it the way we see it.

The moons themselves offered a number of surprises. None of these moon is more than one thousand miles in diameter. They are frozen worlds--three hundred and fifty degrees below zero. They should just be crater-pocked worlds with nothing else ever having happened to them. That was the theory going in.

That theory was shattered. Not so much by the outer moon, this is Oberan, but when you looked a moon in closer, here you have Titania, now you begin to see not just lots of craters but cracks. This moon had had a period early in its history when fluid, a hotter material, flowed to the surface and reshaped the surface. You didn't see much of that at Umbriel, the darkest of all the moons in the solar system.

You did see some curious features like that crater with ice in it at the top and a crater with a central peak where ice is covering the peak. Much stranger was Ariel. Here you see it with cracks going for thousands of miles. This moon was very heavily changed early in its history. Some of those cracks are up to twenty miles deep. This in a moon that is only seven hundred and forty miles in diameter.

The strangest of all the worlds was Miranda. Miranda had heavily cratered areas, three grooved areas--one on the left, one on the center, and one on the right--and the one in the center was called the "chevron" and we are still not sure what happened. It looks as if early in its history, this moon began to melt and material began to sink toward the core, but before it could completely melt, it froze. It's got part of its most ancient crust mixed with crust that flowed to the surface.

It also has gigantic grooves that virtually go all around this moon. This is a moon only three hundred miles in diameter and yet, to stand at the top of one of those cliffs, you would look twelve miles down to the bottom. It is twelve times the depth of the Grand Canyon.

So, we now look forward, after twelve years of flight, to an encounter by Voyager 2 at Neptune. By the time Voyager was looking back at Uranus to see it like this, it was trying to make that gravitational assist work out just right. The equivalent of reaching Neptune from Uranus is as one engineer said, "Like a golfer sinking a put from a thousand miles away." Yet, it is precisely on course, and we will see Neptune in twelve weeks now. Not like you see it here with its large moon, Triton. Not like this, the very best picture of Neptune that has ever been taken on Earth, but with cloud features. After all, to see Neptune from Earth is like trying to see features on a dime one mile away from you.

Yet, what will we see when we get there? We think we are going to see when we get to Neptune a partial ring system. Before this was discovered just four years ago, it was not thought possible that that could exist. Not a complete ring around the planet, but instead debris just in part of an orbit around the planet. There are several theories for how this is caused and pretty soon we will know the answer.

Here's what the flight trajectory will be: Voyager 2 will come in over the north pole of Neptune, flying 27 hundred miles above the cloud tops, the closest approach that any space probe has ever made to a planet without landing there. Then it will move on down and out of the Neptune system by passing close to Triton, about 25 thousand miles away.

What is it seeking to know? It's seeking to know on these two worlds what the origin of our solor system was. The Earth is greatly changed and the Moon is too from how we were when our solar system began. Neptune may be an overgrown comet. Something made up of trillions of comets. Triton may be even closer to that primordial form. We will have to see what information and clues may be provided as for the first time in human history, on August 24, 1989 Voyager 2 reaches Neptune and for the first time Neptune and Triton will have visitors.

Thank you for sharing this with me and thank you for all of the help that you have given me.