INTERVIEW WITH DR. JOHN KRAUS

AUGUST 20, 2002

Q. This is Robert Wagner. I'm at the home of Dr. John Kraus, who is Professor of Electrical Engineering and Astronomy Emeritus at Ohio State. And we're recording this interview on August 20, 2002. Dr. Kraus, do you want to proceed and give us a little introduction to your work?

A. Yes, I thought about your questions and I would like to say some things that relate to my impressions when I came to Ohio State in 1946. This was just after World War II. The students in those classes were some of the most serious and best students I ever had. It was a stimulating atmosphere. Within a few months of being at Ohio State, I made an invention in the basement of my home, the helical antenna, which soon became in use worldwide, and especially on satellites in space. It's one of the main antennas that are used in space communication. The satellites that are up there and the space station and others use them.

I had always been interested in astronomy and had made some experiments years ago to detect radio waves on the sun unsuccessfully. That was in 1932. Anyhow, the idea of building an array of these helical antennas a couple feet in diameter and ten feet long, putting up this array, 96 of them on the corner of the University farms that Dean Rummell, the Dean of Agriculture, said I could use, I thought was an exciting prospect because it would give Ohio State a radio telescope, one of the first built. And it was very photogenic. It was unlike anything that had been up before and appeared on the covers of many magazines.

Life Magazine, the most read magazine at the time in 1946 and 1947, had a two page spread showing the telescope. And we began to make good observations. But in the course of this, not only did we have to build the antenna for which I got $2,000 funding from the Carolyn Lovejoy Fund for the steel and copper.

Q. That was in the College of Engineering?

A. Engineering, yes. My book Big Ear II describes all of this in more detail. A graduate student, Gabe Skitek and I wound the helixes, put them up, and with help from John Cowan, an electrical engineering professor, we got the structure welded and in place and working. But we needed a small building in which to put the receiving equipment, which was very sensitive. These sensitive receivers and the associated equipment, the recorders, the clocks, all of this required a little building about the size of a two car garage.

Gabe Skitek and I constructed that ourselves in about a week's time. I laid the concrete block and he and I sawed the timbers and put up the roof and shingled it. We got equipment in and got it working. And it was just right for the job and made Ohio State one of the first universities to have a working ratio telescope, making some of the first and best maps of the radio sky.

The interesting fallout from this is that some administrators at the University discovered that a building had been built on University property without their knowledge, and they were most unhappy. Immediately memoranda were sent across the campus that would forbid any such thing in the future. And the question was asked, "How did Kraus do that?" Well, when I requisitioned material, I said it was for a receiver enclosure, which it was. It was a really

appropriate description. And we got the job done. The only cost was for materials. No architect fees and no cost for labor. If I had said it was for a building, it might never have been constructed.

I had a very dear friend in zoology who wanted to have a little shed, just a tiny little thing built for his experimental mice. Well, he went through the usual channels, having it reviewed by committees. And the end result was, he never got permission to build it. He was disappointed, disgusted. He resigned and left the University and we lost a very talented person. This illustrates how administrators can strangle ingenuity and enterprise and an attempt to get something done. We had gotten a building all constructed with minimum cost. My graduate student and I did all the work. So I've always thought of that as showing the pluses and minuses at a university.

I soon became aware of the fact that a university is divided into empires, colleges and departments, where the boundaries are very zealously defended. Budgets particularly. And I bring this up because my work, when we built the radio telescope, was interdisciplinary. We were doing astronomy but the technique was all electronic and new. To astronomers, we just had a lot of black boxes that they didn't understand.

There was cooperation, yes. I gave a course in radio astronomy that had an astronomy number and an electrical engineering number. But the Astronomy Department never contributed any money at all to help with the radio telescope work. And after I retired, I gave the course a couple of years more, but then after

that astronomy never listed it and radio astronomy disappeared from the curriculum.

By contrast, sharp contrast, when the helix array was new and getting publicity, Professor Leo Goldberg of the University of Michigan, who was Chairman of the Astronomy Department, flew down to Columbus and offered me a professorship in astronomy at the University of Michigan, with a condition that I develop a radio astronomy program there. Here the initiative at Michigan was coming from the Astronomy Department. Here at Ohio State, it was coming from Electrical Engineering and didn't fall on very fertile ground. Goldberg made a very enticing offer. I'm an Ann Arbor boy, have three degrees from the University of Michigan, have fond memories of living there. But I had so many irons in the fire at Ohio State, I felt it would be inappropriate to pull out and start something else up elsewhere. So reluctantly, I declined Leo's offer.

There were other universities where the initiative for radio astronomy came from the astronomy department, Illinois, for example, but that was not true at Ohio State. That's one of the differences. I have good friends in astronomy but this was not regarded by them as really an essential part of astronomy. They considered it as just a technique.

Although the 96-helix array was big, I realized that a much, much larger radio telescope was needed. I conceived a very unique design which would provide the biggest collecting aperture per dollar of cost. The new telescope was larger than three football fields. We called it "Big Ear."

All the engineering was done by myself and my students, and the work was done by University students, who learned how to weld and did the work, so that for very low cost we built this telescope, which took many years with funding from the National Science Foundation.

While this was in process, some radio astronomers from France came to look at our design. They saw its merit to get a large telescope per unit cost, and they engaged a French company to build one. It was a "Big Ear" telescope four times as large as our "Big Ear." It was finished and completed before ours was done, being dedicated by the French President Charles DeGaule in 1965. It was also featured on a French postage stamp. The French telescope has recently been upgraded and is one of the world's largest. By contrast, our "Big Ear" which discovered the most distant known objects in the universe, among many other achievements, has been demolished for a golf course.

Q. I saw recently in the paper that an architect from Ohio State said that Big Ear was a marvelous architectural design.

A. Yes, he looked at it as an architectural masterpiece regardless of what it was used for. Very unusual design. In connection with the Big Ear project, I got very strong support from Professor E.E. Dreese, Chairman of Electrical Engineering, and from Dean Gordon Carson of Engineering, Dean Bolz, Dean Green, and others. But as the years went on, the atmosphere changed. Some administrators wanted to dump Big Ear. They didn't understand its mission at all.

Q. What was "Big Ear's" mission?

A. One of the most important things, I've been told by my students, is that it was a fantastic teaching tool. They had hands-on experience. Anybody doing astronomy in a national facility now can't touch anything. So you are really isolated. Here, at Big Ear, the students built the equipment and used it, and learned in that way. One of my students, Christopher Walker, who got his masters degree here with me as his advisor, is now at the Stewart Observatory at the University of Arizona. It's one of the biggest optical facilities in the world. And he is working with me on a new edition of my radio astronomy book. And the initiative to do that came from him. And he regarded his experience here as extremely valuable. When we built the telescope, we wanted to survey the sky and determine where the radio emissions were coming from. They came from radio sources which did not correspond to any visible star at all. So it was a whole new universe. We made catalogs, some of the most extensive ever produced. And we found that doing our observing at twenty-one centimeters, which was shorter than most of the earlier surveys, we found many strong radio sources that weren't in the lower frequency surveys at all. That was a matter of great interest. We called them centimeter wave length enhanced radio sources. We made a catalog of these. Some of the students used Palomar prints to see if the positions for these radio sources corresponded to any optical object. And Myra Gearhart, one of the graduate students, found that our radio source OH471 corresponded to an extremely faint optical object. We included it in a list we published.

Astronomers at the Stewart University in Tucson obtained a spectrum of this object. It required long exposure with their big telescope and they found that the spectrum had been shifted to longer wave lengths, red-shifted an unprecedented amount. The red shift factor was over 3.4. There had been no objects in the sky observed with red shifts more than 2.8 before that. So this made it the most distant known object in the universe. When the Stewart Observatory observers, Peter Strittmatter and Robert Carswell announced their results, it made front page news in the New York Times. Walter Sullivan, the science editor, explained that OH471 is the most distant known object in the universe. Life Magazine featured it calling OH471 "the blaze marking the edge of the universe."

Thus, this student built telescope had jumped all the way to the edge of the universe. It was very exciting. And another one of our sources, OQ172 was soon found by astronomers at Lick Observatory to have an even higher red shift. These red shifts were the largest known for many years. So, our telescope was very successful in that respect, but at the same time, the National Science personnel who earlier had been so positive about our work, cut off our funds.

We had a dilemma. We had this big telescope but we had no funding to continue the survey. However, we did it on our own.

About the same time, Big Ear's Associate Director, Bob Dixon, suggested using a multi-channel receiver to look for a narrow band signals, which would be the type expected from an extra-terrestrial intelligence. Our signals of intelligence are narrow band in contrast to the broad band signals that spread all across the spectrum like thermal radiation. And so that began a search for extra-

terrestrial intelligence or SETI survey which was very inexpensive to operate. And after some years, a record appeared that was startling because it was so strong. Jerry Ehman, who was examining the records, wrote the word "WOW!" on it and it has become known as the "WOW!" signal. It moved with the stars and might have been from an extra-terrestrial intelligent civilization but we can't be sure. Although Big Ear accomplished many other things, the "WOW!" signal takes center stage. Whereas our discovery of the most distant known objects in the universe carries little significance to most people, anything related to extra-terrestrials does.

Q. Is that process still going on? The search for extra-terrestrials?

A. Yes, the SETI institute in California is carrying on the work, as are other observatories independently.

Q. Did you ever have any contact with Alan Hyneke?

A. Oh yes, I knew him. He was a member of the Astronomy Department. When flying saucers were rumored, it needed some scientific person to investigate. Was there anything to it? Alan put a lot of effort into it. I think he had a lot of courage to do it..

Q. And finally he appeared in the film "Strange Encounters of the Third Kind." Remember that film?

A. Yes. He also had a very good astronomy column in the Columbus Dispatch that has not been matched since then.

Q. I worked with him a little, when he was working with the V-2 rocket.

A. Yes?

Q. Reconstructed one in the studio and put it on tape. I did work with him. Who else on the campus, among the scientific minds and various fields, were glad to collaborate with you or were supportive of you? For example, Marion Poole.

A. It's interesting that I knew Marion because I was a research scientist at Michigan after I got my doctorate degree, I worked on the cyclotron there, which was the largest particle accelerator in the world at that time. And Marion Poole used to commute from Columbus, coming up weekends to do observing. So I knew him then. And continued to have contacts with him. I admired him very much. There were people in the Physics Department who were very helpful. And in electrical engineering and elsewhere, and many administrators that I've already mentioned.

Q. Al Garrett.

A. Yes, definitely, Al Garrett was one.

Q. It was a remarkable collection of minds. Of course, that was the period of time when I knew a few people on the research faculty. I was always impressed with the quality of the research that was going on at that time. Probably it's still going on but to me it was extremely impressive.

A. You see, if I hadn't just gone ahead and done some things, we might never have had a radio astronomy program at all. Administrators often don't look at things like the investigator does. They're looking at the dollars and they're looking at other issues. And that was the case with my friend in zoology, who unfortunately didn't just go out and buy some boards and put his shed together in an afternoon.

Q. You were always on the edge of pushing information with different methods. When I was in Sri Lanka, I spent an afternoon with Sir Arthur Clarke, I asked

him, "Where do your ideas come from for your wonderful science fiction books?" He said, "One is a professor at Ohio State by the name of John Kraus. I'm in touch with him and he gives me a lot of ideas." How did you first get in touch with Clarke?

A. Well, I'm having a little problem recalling that. We had correspondence early on. We talked by telephone too. I said, "I have a book I've written called Big Ear and I'd like to send it to you." He said, "Well I've already read it." It had just published.

There was a translation of it in Japanese that sold a lot in Japan. And there was a translation also into Chinese. Clarke sent me some of his books and I've sent him others of mine. And of course he is one of the far out thinkers. His geo stationary orbit was really a marvelous concept. And how three satellites in that orbit could cover the earth. Now in what I like to call "The Clarke Orbit," (the geostationary orbit), there are thousands of satellites beaming down all the time and much of what you see on television come via these satellites.

Q. He was not really a scientist originally.

A. Well, he had been a communication officer in the Royal Air Force, and then for a number of years, he worked for a scientific abstracting service. It was an organization that published reviews of science articles. So he was involved in reading the scientific literature, writing reviews. It's like Science Abstracts at Ohio State but it was a British based organization of a similar type. So he did that for a number of years, which gave him a very good background. And then he fell in love with Sri Lanka and moved over there.

Q. I spent some time with him and he gave me a book that had just come out, I think it was Rendezvous with Rama. And I had been reading your book, let's see, Our Cosmic Universe, which is contemporary and so well written. And the reason I mention that is because, as I was reading it, the way you express things reminded me of Clarke's Rendezvous with Rama. That is to say, you have combined science in an artful literary form, which is what he does with the science fiction. Sometimes it's not so fictional. I have a paragraph from the book. Would you mind just reading it because it's so expressive.

A. Oh, and this has to do with the Kuiper aircraft mission. What do you want me to do?

A. Just read.

Q. This comes from my discussion in Our Cosmic Universe of the Kuiper Airborne Observatory trying to make a rendezvous. To quote from the book, "The sun was setting in the west as the big four engine jet passed over the South Carolina coast at twelve kilometer's altitude. Heading eastward at eight hundred kilometers per hour, it met the edge of the night racing westward at eleven hundred kilometers per hour, and plunged quickly into the realm of darkness. Taking off from California five hours earlier, the jet was following no regular air route travelling to any city or airport. But it did have a mission to fulfill, to rendezvous with a star and a planet."

Q. That's wonderful. It makes me want to hear more about it.

A. Well, there's another story in there about the discovery of cosmic rays, which I wrote. I had to research that very extensively, read a lot of old German

documents. And that is another interesting story with some continuity to it. To quote from Our Cosmic Universe: "The linden and willow lined meadow near Ausig in northern Bohemia had been active since the earliest light of morning. Nearby the river Elba flowed northward to the Erz mountains, whose azure peaks shimmered in the distance against a cloudless sky. Now, a few hours after dawn a huge orange and black balloon towered majestically above the meadow's grassy expanse, the low slanting rays of the sun glinting off its rounded dome. Named the Boehmen (German for Bohemia), it stood twelve stories high. Nudged by an almost imperceptible breeze, the big bag tugged impatiently on its ropes. Members of the Austrian Aeroclub moved with a well-practiced efficiency, making final preparations for its ascension but one could detect a feeling of excitement in the air, for this was no ordinary flight.

It was Wednesday, the 7th of August, 1912, and today the Boehmen with its lifting power of two tons, was to carry Herr Doktor, Victor Hess, and a load with his apparatus on a high altitude flight. Hess, 29 years old, taught physics at an academy of veterinary medicine in Vienna. He was already aboard checking his equipment. The flight meteorologist, Ernst Wolf was also in a rope festooned basket adjusting the barometer.

Inflation was complete and the Aeroclub members disconnected hoses from hydrogen tanks on wagons nearby. Captain Wolfgang Hofforg, the pilot, walked around the outside of the basket inspecting the sand filled ballast bags hanging from its perimeter. Shouting final orders to the ground crew, he swung effortlessly aboard. He was a veteran of many ascensions and had in fact piloted

Dr. Hess on a number of flights during the previous months. But none went as high as he hoped to rise today.

At twelve minutes past six, Captain Hoffer gave the command to cast off and slowly the great rotund Beman rose gracefully and silently into the sky, seeking the source of a strange radiation.

For many years scientists had puzzled over the fact that an electroscope gradually lost its charge, even though it was carefully insulated. Electroscopes had come into wide use after the discovery of radioactivity by Antoine Becquerel of France in 1896. A typical electroscope consists of two leaves of gold foil suspended from an insulated electrode or metal rod in a metal container with glass windows. When given an electric charge, as from a rubber comb rubbed with a flannel cloth, the leaves spring apart due to the repulsion of their like charges. Radiation from radioactive material brought near the electroscope penetrates the container, producing ions or charged particles in the air inside, which discharges the leaves and causes them to drop. What the scientists had noted was that even in the absence of any known radioactive material, the leaves would gradually drop, suggesting some unknown radiation. It was suspected and later confirmed that the radiation came at least in part from weak radioactivity of substances present near the surface of the earth."

Q. That's from Our Cosmic Universe?

A. Yes. To continue, "the flight today was the seventh in a series, Victor Hess had begun in April, 1912. And his aim today was go much higher than he had before. The previous ascensions indicated there was a small decrease in ionization going

from the ground to heights of a few hundred meters due to the radiation from the ground. However, with further increase in height up to 2,000 meters, readings did not seem to change.

The Boehmen was now rising rapidly and catching a 50 kilometer per hour wind from the south, began to follow the Elbe northward over the Bohemian countryside. Soon clouds appeared ahead. They were scattered, puffy, white cumulus clouds, all at the same altitude. The Boehmen climbed through them and now viewed from above they dotted the landscape like balls of cotton, all the way to the horizon. Near Peterswalde, the balloonist crossed into Saxony and smoke floating up lazily from the factories of Dresden appeared off to the west.

An hour after lift off they were at 1,600 meters and during the next two hours they rose to 3,000 meters. The sun climbing in the east warmed the balloon, increasing its lift. So Captain Hoffory could conserve on the amount of sand ballasts he had to release.

At 10:45, they had attained 5,350 meters, their maximum altitude, and Captain Hoffery pulled a valve to release some gas and start their gradual descent. Above them at about 6000 meters there was now a thin, filmy layer of strato-cirrus clouds through which the sun shone brightly."

Q. A lot of beauty comes out of research and scientific knowledge.

A. Yea.

Q. It impresses me.

A. Well, as a result of the work, the higher one rose the stronger the radiation from above became. In his report published later that year in the Physikolisches

Zeitschorft, Victor Hess said, "The results of the observations indicate that rays of very great penetrating power are entering our atmosphere from above." This was the discovery of cosmic rays which bombard the earth and some years later Hess received a Nobel prize for it. The atmosphere provides us a measure of protection but they are a significant health hazard for the crews of high flying jets and the astronauts in the space station.

Q. You once said, "We know less about the universe than Columbus knew about America in 1492." Is that still true?

A. The universe is so big, we'll never know all about it. I mean, we're just a tiny little planet in a solar system in a huge galaxy. And there are billions of galaxies. We are such an imperceptible speck that it's awesome, it's frightening, it's overwhelming.

Q. And what we know is still history long gone. In other words, we're always looking at the past.

A. Well yes, as we go further out, we see the way things were then because the further we go, the longer it takes for that information to come to us. And so it is very hard to grasp the enormity of the universe and how really tiny we are.

Q. And some people are looking for a creative intelligence or intelligent civilization which could be read either way, to be a highly spiritual force or an unknown force we have yet to discover.

A. Well, there's a lot to discover. I won't speculate on this. There is so much that we do not know. Where did intelligence come from in the first place? From the particles and atoms in the universe?

Q. They had an article here on Voyager I and II. The thing that surprised me about that is there's a 23 watt transmitter with a very small message capsule. What are your impressions of Voyager I and II and the message it contained? It's now out beyond the solar system.

A. It was an idea to send on this space vehicle something that encapsulated, so to speak, what our civilization was like, with voices and speeches and things of that type, and music. The chances of this being intercepted and then decoded are very remote but it was a symbolic thing to do. And of course, as Voyager goes further out and the data rate at which you can send information back decreases, that is to say, one compensates for the greater distance by sending things more slowly. But still probably faster than the first transatlantic cable was able to send.

Q. Do you think there will be more great discoveries now with space stations and, of course with the Hubbell Telescope? How far do you think we can go within the next decade or two? Or even in a century? Would you care to speculate?

A. I wouldn't care to speculate, no. It's very difficult. It depends a lot on the attitude of Congress.

Q. There seems to be a strong financial or economic side for whatever happens. Is there money to put into something that will in some way produce something on our earthly sphere that produces things like oil or produces more land or more this or more that. And when you're going into outer space, what is the expectation of return on that? I could see that with the moon launch. And that's certainly without a doubt monumental. But the further out you go, don't the incentives for the search began to fall or decrease if nothing comes out?

A. It depends on one's attitude. Some of these searches may have to go on a long time to produce results. We know nothing about extra terrestrial intelligence. It's a very mysterious realm, in which we're using certain techniques, looking at certain wave lengths and certain bands of wage lengths, assuming that they would use one similar to that that we do. There's always the possibility that an extra terrestrial is using the spectrum so completely that it would appear to us as a thermal source. We would never recognize it. And there are these questions. And now I come to what I feature in my book, Big Ear, serendipity, that maybe the discovery will be made by someone looking for something entirely different. Karl Jansky built an antenna to study radiation from thunder storms and he discovered radio emission from our galaxy. Arnold Penzias and Robert Wilson at Bell Labs had been assigned the job of finding the lowest level of radio emission from the sky which would be a benchmark in connection with antenna design. And as a result of this, they found a minimum temperature of about three degrees Kelvin, which is the temperature of the Big Bang. So Penzias and Wilson discovered the big bang background temperature. Then again, there was Antony Hewish, and Jocelyn Bell, at Cambridge University. They wanted to study fluctuations in radio emissions from radio sources, and Jocelyn Bell, the graduate student, observed on the record strange pulsing signals, which were from a previously unknown object, the pulsars. These spinning radio objects sent out pulses, some of them very slow, once a second, and some up into thousands of times a second. They were all looking for something else when they found this. Well who knows? Somebody who isn't looking at all for extra terrestrial

intelligence, but has the right equipment in the right place doing the right experiment at the right time, and he finds it.

Q. Well we've had a long interview and I hope we didn't tire you out. Is there anything you'd like to add or say about the University, your life there?

A. Well I've enjoyed being here. It's been a place that's given me opportunity. I've had encouragements; I've had discouragements, but by and large it's been a wonderful experience.

I have been at OSU now for 57 years. I have taught electrical engineering and astronomy courses. I have written over a hundred articles, also nine books which have come into wide use and are translated into many different languages. I also invented important new types of antennas that are in use world-wide and in space.

Q. You certainly helped put Ohio State on the map. We thank you Dr. Kraus.

A. You're very welcome, Bob.