INTERVIEW OF DR. RICHARD FISHER
Conducted by Troy Cline

My name is Dick Fisher and I am a - - oh, I think at this point you would call me a high mileage, thin treaded, Astrophysicist. For a while I was involved with solar research, and then with the administration of the NASA program in solar research, and also heliophysical research for about the last ten years. What I am interested in primarily is kind of a straightforward thing. I would like to be able to visualize the processes which modulate the Earth. The Earth is embedded in the sun's atmosphere, as I'm sure that point has been made, and because we are embedded in the sun's atmosphere and magnetic field, it impacts the Earth and it changes things on Earth.

This is a thing that's only been known for perhaps 150 years or so. All of the effects were known before that time with magnetic effects, but to be able to visualize that accurately and to understand the dynamics of it is something that's only been possible since the -- sort of the start of the 20th Century. So those are my interests, and I specialized in building instrumentation when I was younger and then later in research on the solar corona and how it varies with time in its physical properties. I think at the present time it is kind of a golden age for the people who work in the field of heliophysics. We have a number of assets which have just -- are just now beginning to bear real fruit -- and we are on the verge of deploying others.

What I mean by that is we have had a spectacular success, I believe, with the STEREO mission and the Solar Dynamics Observatory, which was the first mission of the Living With a Star Program -- are now in routine operation -- and those data are fused together and you can get a very wide vision. You can see the whole sun, all sides, all the time, 24/7, which was a huge advantage that we never had before.

Over the next few years we'll be looking at the data from the radiation belt storm probes, and then eventually from multi scale, and that will add a kind of an anchor point at the Earth. We can see what happened with the sun and we can see its impact and interaction with the Earth in its own kind of electromagnetic system, and I think that that's going to teach us a lot. We also have another kind of wonderful thing that's happened, which is that there is now a magnetospheric mission at Mercury Messenger, and in a few years we'll be launching one (inaudible) to Mars. And then to top it off, there has been a mission to Jupiter, the Juno Mission, which is an investigation of Jupiter's magnetosphere. So, in the very near future, there will be a new kind of scientist that walks out on the stage, one which is kind of an expert in experimental planetary magnetospheres, whereas we have only had sort of the Earth and a little bit of Mars and Venus to look at before, so it's a really special time for heliophysics.

MR. CLINE: That's exciting to me. That really will -- what you just said should really excite some kids about going into this kind of -- it really should think about being able to work -- not only about talking about Earth, but Jupiter and Mars and the idea of us travelling in those directions one of these days. DR. FISHER: We are pretty fortunate with how things turned out. MR. CLINE: No kidding. Yeah, yeah, we are. Now, there are a couple of questions, one is which -- which you've already actually been touching on a lot of these -- what are some of the key events or turning points in space weather research, and I guess thinking historically? DR. FISHER: For me, the key event was the launch of the Skylab experiments on America's first space station. I had not originally been part of the experiment team, or any of the experiment teams, but in fact had been studying the solar corona via a ground based route.

I would go to eclipses and I'd take whatever measurements we could get during the few minutes of totality, and try to piece these together to study the physical characteristics of the corona. And if you do that, you have a very limited perception of time. You have just those few minutes and it's separated by usually a couple of years. So it's a pretty spotty, stop action, strobe light like way of conducting research. In 1973, the United States of America launched the Apollo telescope mount aboard the Skylab pace Station, and this was an attended, a man attended space station, and so there was a possibility of interacting with the instruments, and in point of fact, the station was damaged in launch and the astronauts actually repaired it and we salvaged the experimentation. It was intended to work for a relatively brief time. I think there were perhaps two or three periods initially envisioned of about 25 to 30 days, however, it operated pretty much continuously after that in both a manned, attended form, or an unattended form, via telemetry, like a regular scientific satellite, for nine months.

And this gave us two things that we never had had before. First of all, we had a continuous record of coronal evolution in the outer corona, because there was the SO52 coronograph was included in that. And during that time we saw some 75 to 80 coronal mass ejections, and these had never been very accurately visualized before, and it became quite clear that the sun emitted great big chunks of mass every once in a while, and obviously since it did that pretty much in all directions, every once in a while the Earth was in its way. And it opened up kind of a direct event oriented line of research if we could just see where those occurred and what their physical characteristics were. The second thing that was just a wonderful thing was that there were two x-ray telescopes on the Skylab -- and they operated with film so you had to wait until the crews landed -- but they gave us a tremendously valuable record of how the corona was evolving with respect to the magnetic fields on the sun, and it led to the discovery of coronal holes as low pressure areas where the solar wind was blowing out of them.

And in those nine months it was quite clear to everyone involved at that time that there was kind of a episodic stream of particles that were emitted from a great big coronal hole, which was called the Great Boot of Italy because it looked sort of like that, and these kept sweeping past the Earth at about every 27 to 28 days which resolved a major mystery in geomagnetism that was identified some 30 to 40 years ago, or prior to that -- and what were the origins -- and they used to be called the mystical end readings because nobody had any idea -- there was nothing to look at on the sun, in the visible light, on the Earth's surface, that you could see.

So, those were the two big things in my life, and a lot of the satellite experimentation from 1974 untilpresent has been based on x-ray and far-UV telescopes. Some were the ones that were film operated - - ofcourse, no one uses film anymore with the advent of CCD devices, or coronagraphs, and the combination is
very powerful.

Now, the second thing I think is very pivotal about it is that we initiated several years ago a multi- spacecraft -- two extra spacecraft -- that are in orbit around the sun, similar to the Earth's orbit, but one is ahead and one is behind -- the two STEREO spacecraft -- and they carry a EUV telescopes, which are sensitive to the high temperature material that's found on the corona, and you can see the coronal holes all the time. You can see how they're evolving, you can see what the relationship is to magnetic fields that are sensed in other ways. And because they are moving in space around the sun -- it takes them eight years to go around the sun -- we now, right at the moment, have a circumstance where they are spread out about every 120 degrees as you clock around the sun. So if you think of yourself as standing on a big watch, the spacecraft are oriented out at sort of 2:00 o'clock and I guess 10:00 o'clock. And, of course, we have the solar (inaudible) observatory in Earth's orbit, so every 120 degrees

there is a sensing station, and these data are now fused together. They can give you a 24/7, all sun, all the time, solar surface, solar corona, and it just -- those have been the big events as far as I'm concerned. Now, prior to this, there were two others that were really terribly important, and they are so important that they're hard to see now, and it's hard for people to remember them.

The first one was actually the discovery of a mass of charged particles, and eventually it was understood that they ringed the Earth. And these are the so-called Van Allen Belts, named after an APL scientist who went to the University of Iowa, named James Van Allen, and it was the very first NASA experiment, and it was the very first heliophysics space experiment, and this was a big surprise to most people. The second pivotal event was a mariner mission that went to Venus, and it operated for a number of months -- I think four or five months -- and at the end of that time there was something that everybody knew that nobody had known before. One of them was that there was a wind coming off of our star. It was a solar wind, and it was structured. And moreover, the magnetic field, away from the Earth's magnetosphere, was about as strong as the Earth's magnetosphere, which meant that it was quite different than the textbook formulation for poloidal magnetic fields.

And I, at least, was a student at the time. I had never heard of such a thing. We had a standard sort of exercise in electromagnetic theory that said that was impossible. So those two things really, at the -- right at the beginning of the 1950 --   So the time period of this change in our outlook was about mid-century, about 1958 to 1965, and that has set the tone for the whole development in the field of heliophysics, and heliophysics is, in fact, the science of space weather. So it's the fundamental founding science behind the kind of operational outlook in space weather. Now a number of years ago, just to comment a little bit further about this, two authors -- one named Hufbauer and the other one named DeVorkin -- looked at history and solar physics, and heliophysics and magnetospheric physics, and came to the conclusion that initially, in the civil side of our society, it had been a military science, that there was a strategic advantage developed during the Second World War for any nation that understood how a radio propagation, navigation, other things of that nature - - communications -- could be modulated by the sun. They could choose -- they couldn't do anything about what the sun was doing, but they could choose times and systems that were optimized. And this is kind of how I entered the field. Initially I was an Air Force scientist. I worked at the Air Force Research Laboratory in Cambridge, Massachusetts, and I think I visited there three times. I was actually based at a solar observatory located near Alamogordo, New Mexico. I was 36 miles from Alamogordo, New Mexico in a National Forest, the Lincoln National Forest, and we had one of the largest sort of national level facilities for solar astronomy that existed at the time. And it still is part of the National Solar Observatory. So from my standpoint, there were reasons that we were involved with the Cold War. For why did we need to know what the -- why do we have to maintain some kind of space situational awareness? And as time has gone on, these reasons have only expanded because the systems that we use are sensitive to electromagnetic interference, and the components in spacecraft and navigation systems have become lower power and lighter weight, so their vulnerabilities have increased. And there are other societal reasons that I think everyone can understand now for which we have an interest in space weather. There is a phenomenon which is shorthand called a GIC for a "ground induced current," and this happens when the sun ejects a great big mass of material, electrons and protons, and their associated magnetic fields, and this rubs past the Earth. And in the east, here, we are sitting on a big block of granite which isn't very conductive. And there are induced currents in the sea and in the ground. The sea is no problem. It's a conductor and it works just fine. And the ground, you can develop a difference in voltage across power lines, and this has been known on occasions -- there are five or six well known occasions since 1900 where power generation and distribution equipment have been damaged by solar events. Now, we have a very large, but somewhat fragile, electrification system for the United States in the power distribution system, and one of the things our society depends on -- and I mean vitally -- is the constant supply of electric power. So, there has been a concern in the last 15 to 20 years that the power grids can be disrupted by solar events, and this has happened on occasion. It's happened in Finland. It happened once in Canada. And these are known as low probability, high impact events, and they're similar to -- in their societal impact, they are similar to hurricanes -- and you can see from the Sandy storm that we've just had, and Katrina, that when you lose power for a period of ten days it's really pretty inconvenient. It's hard to get water. It's hard to get fuel pumped. It gets to be kind of a disruptive thing from the standpoint of providing civil services such as 9-1-1. But if you have a 30 day outage, you simply have to migrate. There isn't any question about it. And that was seen in Katrina. People had to leave the city and go to Houston. I think we'll probably see some of that in Sandy, although they're doing a wonderful job of restoring the power distribution in the Northeast. So, space weather has become a national interest, not just a scientific curiosity, and how we perform space weather is currently kind of a thing which evolved rather than being thought out with national goals and priorities, and I suspect in the future we'll have some development from the standpoint of the government in terms of policy and assignment, roles and responsibilities, and so forth and so on. It's gone beyond just a scientific pursuit for resolution of curiosity.

One of the most important things in my life was the advent of regular observations from space. And in 1963 I took a class at the University of Colorado called Eclipses, and we studied eclipses from the standpoint of the astronomy of them -- this and that -- the logistics and so forth and so on. And eventually, as a class exercise, we built and took our own telescope off to an eclipse to try and see if we could get pictures along the path of totality that could be put back together as a kind of a little movie, and I went to a station near Talkeetna, Alaska - - and this was kind of a woolly place at the time -- you could only get there by train or light aircraft -- and I stayed with some people who were kind of miners, actually -- they were kind of a rough bunch. But it was a great adventure and I liked mountaineering, and it was a very stimulating time. I got a picture of the eclipse. Of the seven stations, only four of them actually took pictures, and I felt very fortunate that I could kind of have a mission accomplished.

This set me on a path of going to every eclipse that I could possibly go to. I was interested not only from my cultural and intellectual activity, but also it was a kind of an adventure in travel. My mother once said, "They have eclipses every place where they don't have either oil or water." And so I went to a lot of different places. Siberia and Africa, and so forth and so on. In 1974, I was along the border of Kenya and Ethiopia with the National Science Foundation Expedition to look at an extremely long eclipse, and I had a little experiment. It was to try and measure some coronal temperatures, and it was kind of a rugged spot. It was near a feature called, at that time, Rudolf, but now I think it's called Lake Turkana, and kind of a wild west site. We got there and it turned out that while we were in route they had launched the Skylab experiment, and we heard by radio that there had been a launch accident and that the station was damaged and they didn't know how badly. And at that point we had one shortwave radio that was receiving the British Broadcasting Service, and the Armed Forces Radio Network, and we could tell that it sounded pretty bad. It sounded like almost a mission lost. We went out that night and looked up, and could see the Skylab along with an enormous cloud of debris that was tumbling and moving around. It was maybe four times the size of the moon, and I thought, oh my goodness gracious, we are just sunk. There's a billion dollars we're not going to get anything out of at all. Well, I finished the eclipse, I got home -- I had been gone for about two months -- and I went back to my family. We were living in the mountains of New Mexico at the time at an observatory there, and a call went out from one of the experimenter groups who had essentially used their personnel so hard that they were worn out. They wanted some people -- some volunteers -- to join up so we could run the experiment. And I was sort of at liberty. I was recovering from being kind of sick in Africa, and I thought a little spot of living in a city would feel pretty good, and so I went to Houston for three weeks, which turned into nine months, and it just changed my life because I abandoned our research by using ground based instrumentation because I felt at the end of the Skylab experiment that we simply couldn't see all the things we needed to see from the ground. And whether we've learned to make up that deficiency or not, I'm not quite sure. We've made enormous progress, but it was a pivotal experience in my life.