INTERVIEW

OF

JOAN FEYNMAN

P R O C E E D I N G S

MS. FEYNMAN: Hello.

MR. CLINE: Hello, Joan. This is Troy Cline. How are you?

MS. FEYNMAN: Okay. Well, pretty good. I'm trying to beat a cold.

MR. CLINE: Oh, is that right?

MS. FEYNMAN: So I didn't go to work. Huh?

MR. CLINE: You're trying --

MS. FEYNMAN: Yeah.

MR. CLINE: -- beat the cold?

MS. FEYNMAN: Yeah, I'm -- I'm coming down with a cold and I'm trying to --

MR. CLINE: Hope not.

MS. FEYNMAN: -- I didn't want to go outside because it'll only get worse. Let me turn off my iPad. Okay?

MR. CLINE: Okay.

MS. FEYNMAN: I'll be right back.

MR. CLINE: No problem.

Can you hear --

UNIDENTIFIED SPEAKER: Uh-huh.

MR. CLINE: -- her?

(Off the record.)

MS. FEYNMAN: Okay.

MR. CLINE: Okay. Welcome back.

MS. FEYNMAN: I'm back. Yeah. Now, do we want --

MR. CLINE: She's --

MS. FEYNMAN: Do we want to do an interview now or what?

(Off the record.)

MR. CLINE: Yeah, we're working -- right now we're working on just the sound. So as you were talking, I was -- we're adjusting the volume. And --

MS. FEYNMAN: Okay.

MR. CLINE: And I think we're just about ready. Yeah, we can absolutely do the interview right now. And usually --

MS. FEYNMAN: Okay.

INTERVIEWER: -- how I open that up is in a minute I'll just ask you to tell us, this is for the audio person later on when he's doing the files, but I usually ask the person to just say who they are and

what they do or most recently have done and basically your field. And then we start with the first questions.

And then I won't speak as much, as I was telling you before, so that they don't have to edit me out. And we'll just start with the primary research interest, what you like about it, and how you're involved in space weather and some of the key events and turning points. And then you can talk about anything --

MS. FEYNMAN: You mean, you want me --

MR. CLINE: -- that sounds interesting.

MS. FEYNMAN: -- to just start talking and you're --

MR. CLINE: Uh-huh.

MS. FEYNMAN: -- not going to ask me anything?

MR. CLINE: I will -- actually, I will pop in here and there as we go through the conversation. I'll --

MS. FEYNMAN: Because --

MR. CLINE: -- make sure we stay on track

with the right questions. And if we do get --

MS. FEYNMAN: Okay. So you --

MR. CLINE: -- into a conversation, that's fine.

MS. FEYNMAN: I think it's a good idea to you -- for you to ask me questions and I'll answer them because --

MR. CLINE: Okay.

MS. FEYNMAN: You know, one by one, because I don't see -- you know, I don't have a talk --

MR. CLINE: Uh-huh.

MS. FEYNMAN: -- ready to -- if -- to go on for a few minutes. So it's --

MR. CLINE: Okay.

MS. FEYNMAN: -- not the way I normally work. So --

MR. CLINE: Okay.

MS. FEYNMAN: -- if you're going to ask me who I am and --

MR. CLINE: Uh-huh.

MS. FEYNMAN: -- what I do, please ask me that, then you can edit it out.

MR. CLINE: Okay. That's fine. That will be fine. And if I do ask a question, if it makes sense during the conversation, right after I ask the question, you can just restate the question as you talk.

Like, if I say, you know, what is your primary area of research; you say, well, actually my primary area of research is, you know, and you just.

That way it's easier to edit me out if we need to. Sometimes they keep my voice in, just depending on what I say. I never know what I'll be saying either until the interview starts.

MS. FEYNMAN: Okay. This is slow to work with, but I'll do my best.

MR. CLINE: Oh, you'll be just fine. And actually, the way we're talking right now is exactly the way to do it. And if there's --

MS. FEYNMAN: Okay.

MR. CLINE: -- any part that doesn't make sense and you're like, oh, scratch that, let's -- let me start that over, just say that and the --

MS. FEYNMAN: Yeah, okay.

MR. CLINE: -- editor will know to do that.
MS. FEYNMAN: Interrupt me and tell me, you know, if I go off but please --
MR. CLINE: Okay.
MS. FEYNMAN: -- lead me along, because --
MR. CLINE: I sure will.
MS. FEYNMAN: -- otherwise, I will be babbling.
MR. CLINE: That's no problem. We'll take --
MS. FEYNMAN: Yeah.
MR. CLINE: -- care of that.
MS. FEYNMAN: Okay.
MR. CLINE: Well, we're -- I'm really -- we're real excited that you agreed to do this. And it's -- I'm looking forward to talking with you right now about space weather and -- and your influence and what you've -- your part in the space weather research that's been going on over the years.

EXAMINATION

BY MR. CLINE:

Q And why don't we start this interview, Joan,

by just -- why don't you tell us who you are and a little bit about what you do with space weather.

A Okay. My name is Joan Feynman. I work at the Jet Propulsion Lab at this time. And space weather is something I do from time to time.

But the solar terrestrial relationship is what I do all the time. Space weather is a subset of those because it consists of the sun doing something to the solar wind that does something to the earth. And it becomes space weather when it's dangerous to something else, like people or power plants.

Q So in large, the greater picture of what you've studied over the years, really has to do with the effects of the sun on the entire solar system. Is that correct?

A Well, it's really effects of the sun on the earth

--

Q Okay.

A -- mostly and on the interplanetary medium between the sun and the earth. And it's not just effects of the sun. It's also understanding the sun

itself. There are lots of problem with the sun; for instance, how does it get its solar cycle and why is the solar wind the way it is, and so on. And so I cover all of those problems.

Some years ago, when I first came to JPL, which must be like 30 years now, I was in a group where my boss asked me to -- to make a model for the -- the environment that the Magellan satellite would be -- could be expecting as it flew.

And I looked at what had been done, and I thought the person who had done it had done a very good start at devising a method but that there were certain things that needed improvement, so I improved them.

One of the things was that it had been considered that each solar energy particle event was independent of another. And if you looked at the data, that wasn't true. They came in groups.

And if you do a statistical analysis, which is what I was doing, you have to take account that there are groups, not just individual ones.

And that was my major contribution to that

for quite a while. There are still arguments about what are the groups. I think it's known but not everybody agrees.

Q And when you say "groups," can you explain to us a little bit more of what you mean --

A Yeah.

Q -- when you say that.

A Uh-huh. Yeah. When there's -- the way -- the most important thing in space weather, I would say, is that there are events when in the solar wind there are high energy particles accelerated by disturbances in the solar wind.

These disturbances are due to phenomena related to solar flares. A big glob of the solar corona comes flying out at enormous velocities like 1,000 kilometers per second.

And solar wind, which is a -- which is totally ionized, that is, it's a bunch of protons and electrons and some helium doubly -- with charged helium, so on, it acts like a fluid which was a big surprise to the early people. They couldn't see how it acted like a fluid.

What it does is -- and the reason is unknown but not for this -- anyway, the -- this big blob, which is called a "coronal mass ejection," goes through the solar wind and like a boat going through an ocean it causes the shock -- a shock.

And this shock manages to accelerate particles in the solar wind to very high energies. And those particles come into the earth and can do all sorts of damage to spacecraft, also spacecraft in space.

And the whole coronal mass ejections cause great geomagnetic storms. And there are big currents in certain parts of the atmosphere. And those currents cause currents in the flow in the power plants in their, you know anyway, And the result of that can be (inaudible).

Q Uh-huh.

A You know, like if you have a big surge of current on the -- on your wire at home, you're liable to blow up the toaster.

Well, here, there's a big surge of current in the ionosphere, you blow out the power plants. And

it's very expensive and very annoying.

And so that's one of the things people, if you knew one of these very fast coronal mass ejections was coming, then you could do something to shut down the power plant for a couple of hours and then put it back up again.

Q So --

A But.

Q Uh-huh.

A So this is of great importance to power plant people and causes lots of money being lost.

Q Now, you mentioned Magellan, the Magellan spacecraft. Can you tell us a little bit about what that spacecraft was and the instrument aboard the spacecraft that

--

A Of course.

Q -- that was connected to the work you did.

A No, I can't. Several reasons I can't do that.

Q Okay.

A One is my -- the only question I was asked

was what was the space environment that spacecraft had to be able to operate in. And that does not include -- - I mean, I knew where it was going, I don't remember anymore -- but that does not include the particular instruments. It only includes what kind of particles. They will have to be designed so they're not clobbered --

Q Uh-huh.

A -- by the particles as they're expected. So I don't have to know about the details of the project that Magellan was on.

If you want to know, you can look it up.

Q Oh, sure.

A Actually.

Q And then --

A Yeah.

Q But what you found was very interesting. And it was because of your research that you found out that these particles operated in groups, if I'm understanding properly, and that it --

A Yes, right, and so that the expectation, if you got one you got several, was high. And that made

a difference in the predictions as to what you may get. That is, we knew there were -- in the time we flew about ten big events, big coronal mass ejections.

It makes a big difference in predicting whether those ten came in three groups of three and one separate or was -- which would make -- you'd have to predict four groups or ten separate groups. The statistics are all together different.

And the -- that's -- and those models, the models that the spacecraft designed to -- that is to say, I calculate the probability that you couldn't get an event with so -- and so many high energy particles of such -- in such a -- well, the -- the flux --

Q Uh-huh.

A -- of the particles. And then the designers of the spacecraft have to take that information and say, okay, we have to design our spacecraft and the instruments on it so that it can stand that much radiation without collapsing. And that's what the space environments needs.

Q Well, so up until that --

A Okay.

Q -- point, they weren't -- the spacecraft --
A No.
Q -- really weren't prepared for that?
A No. What happened was that the model that was invented had an error in it. And I corrected the error and the error gave different results for the space environment in the original prediction method.
Q Well, that's significant.
A And they were important different events.
In fact, when Magellan went up, suddenly it -- I got a telephone call from the chief scientist saying, my God, we've had all these sudden events on the sun. He said could it kill us. I said, no, you designed for it. And he was very much relieved.
Q I'll bet. I'll bet. Even today, can you imagine people not paying attention to that --
A Well --
Q -- research.
A Huh?
Q I mean, even today, can you imagine if they -- if anyone sent spacecraft up without that type of protection or preparation, it wouldn't last that long,

I would imagine.

A Well, it would be a waste of money, because, I mean, you have to make certain decisions about how to protect the spacecraft. And if you make decisions that are way out of reality --

Q Uh-huh.

A -- it -- you waste money because you spent too much time or too much money protecting it or it wastes time because you haven't spent -- given it enough protection and it gets clobbered.

So it's -- and -- in spacecraft design and so on you have to worry about the possibilities that things get broken or that things don't work. And it's money either way, so it's --

Q That's right.

A -- a -- it's a give and take on that project.

Q And it's also vital to human exploration. I can imagine if we have humans exploring or living in space and even in those days, I mean, we're -- I guess this is --

A Well, the human stuff is very important. I

mean, if you want to fly to Mars or something, you have to know what the environment is.

And if you've got a human being in there, then you have to decide what probability you want that he will not be hurt, he or she will not be hurt by the high energy particles (inaudible).

And my job was to predict the probabilities. And the -- there are new models that have been developed since mine, but they were -- all the models were based on the same general principles.

And one of the problems is there's a lot of question about the description of if you make something -- if you want to know how many events are going to have fluencies or fluxes above a certain amount, it very much depends on -- when you do it, it very much depends on what you know about coronal mass ejections.

And so besides doing this space weather part, I also do things like study what you know about coronal mass ejections. And the sun has a solar cycle, which every 11 years the sun gets more spots and then it starts out for three or four years in the

sun increasing the number of sunspots. You know about sunspots?

Q Yes, and the sunspot cycle, uh-huh.

A Yeah, and then for seven years it decreases the number of sunspots. And the number of events that you expect depends partly on the sunspot number.

So it would be nice to be able to predict the sunspot number. And it takes, say, ten, 15, 20 years to decide you're going to make a spacecraft, to design the spacecraft, to get it all ready, and to launch it. Okay.

Q Uh-huh.

A So you have to know what the sunspot cycle is going to be like 20, 30 years from now. And we don't know how to do that. And we don't know how to make those predictions because we don't understand the solar dynamo.

Q Uh-huh.

A Which is the dynamo is emulsions which cause the sun to have the magnetic field that it does and the sunspots that it does.

And so one of the things I do is study the

solar cycle and the solar dynamo. And during the last ten years, the sun has been doing something very unexpected, that is to say, it has been much, much calmer than was generally expected.

Q Huh.

A In my opinion, that's because it's another cycle of the amplitude of the sunspot cycle which is about 90 to 100 years.

And so what I'm doing at the moment is seriously looking into that finding whatever I can find out about this 80 to 90, 90 to 100 year cycle, which I call the "Centennial Gleissberg Cycle," and what's its cause on the sun and what's its effect on earth.

Now, there's a lot of evidence that during periods at the minimum of at least 88 or a hundred year cycle, Centennial Gleissberg cycle, there's a cooling effect. It's from ultraviolet radiation is apparently -- we don't really know, but there's some evidence that it changes, that it interacts with the earth's atmosphere. This is not agreed to by everybody but there's evidence for it.

Q Uh-huh.

A That the changes in the solar output interact with the earth's atmosphere to change the climate.

Q Ah.

A So that when the sun is at the minimum of the Centennial Gleissberg Cycle, it's a little cooler on earth than it would otherwise be.

So my guess, because at this point only a guess, is that one reason that the earth isn't hotter than it is is because the sun has been cooling it relatively. That is to say, heating from the sun has been relatively small 2010 -- 20 -- yes.

Q Uh-huh.

A 2007 to 10 and -- but I don't know how much smaller. And I don't even know if that's true. But you asked me what I'm working on, so I am working to find out if that's true.

Q Wow. So --

A So that's my present --

Q -- that's amazing.

A -- present. And if it is true, it would

mean that the warming due to the carbon dioxide, which I think people now believe in since it's true and we've known it's true for 15 years or so, but anyway, it would mean that the cooling from the carbon dioxide is partially canceled by this -- I mean, the heating from the carbon dioxide is partially canceled by the cooling from the sun.

So that we are probably underestimating the cooling that will happen in 15 years if you just say, okay, it's going to continue whatever it's doing now.

Q Uh-huh.

A So it's important. I think that the most important problem in the earth for all societies in the earth world today society that we are paying no attention, essentially no attention to the global warming which is going to clobber us. And --

Q And -- that's right. And the impact that the sun is having on that.

A The impact that the sun is having is minor.

Q Huh.

A But it is in the direction of currently making the carbon dioxide high warming or looks

smaller. If you think it's all due to carbon dioxide, then you think that the warming of the earth is less important than it really is.

Q Oh, I see.

A Because the -- yeah. So that what the effect of the sun on the earth in this Centennial Gleissberg Cycle is still not agreed to by everyone.

And the question you're asking me, what I'm working on, I've got to be working on something that's not agreed to by everybody. If it's agreed to, you don't work on it anymore if you're a scientist.

Q That's right. And that's exciting --

A Yeah.

Q -- to hear you talking about this, because there are many, many young scientists and people who'd like to go into science that will be hearing this. And this is really --

A Uh-huh.

Q -- an area I think that many people would find interesting to explore.

A Well, look there, earth science is a wonderful thing because when we know something, one of

the side effects is that we realize there's something else we don't understand. Like -- and then you go on from there.

So there are always new subjects in science. And for young people it's a good idea to work, if they're interested, on the subject that they find interesting or delightful and that's new. Because it's easier when it's new.

What happens is all the easy things get done at the beginning and then it gets harder and harder to make new contributions and they're less and less important.

So rather than looking at what's, you know, a 15-year-old kid, boy or girl, who looks and sees what's interesting now may find it, by the time they're ready to get their Ph.D, something else is more exciting and that's where they ought to be studying.

But you got to study something that really excites you. Otherwise, you know, it's a matter of personality, what you like to do. But science is something you have to do because you like to do it.

Otherwise, it doesn't work.

Q Uh-huh. It's all about passion.

A So, yeah, you know, scientists are supposed to be such dispassionate people. We're not at all. We're very passionate people.

Q Uh-huh.

A We spend long hours working on things. We're only paid for part of the time, more or less. I mean, you don't leave the problem when you come home from work. You work on it in your sleep. You know, it's not a job like selling shoes where you may want to forget about it when you come home and think of something else.

Q Uh-huh.

A It's a passion.

Q It's a passion.

A For all of us.

Q It's a lifestyle.

A Huh?

Q Yeah, it sounds like science for people who are passionate about it and really pursue it, it becomes an entire lifestyle and a way of being.

A Well, yes. And if you're not passionate about it, you shouldn't try it because --

Q Uh-huh.

A -- it's very -- it's difficult. You have to do a lot of learning and a lot of thinking. And if you don't have a passion for it, you're not going to make any nice -- you know, you're not going to enjoy it. There's no point in going into it if you're not passionate about it. And I've always been passionate about it.

The reason I was interested in all of this was because, you know, all of this geomagnetic activity and solar influence on the earth, one of the things that it produces is aurora. It's very beautiful.

And when I was a kid, not a terrible lot was known about them except that they came from -- something from the sun caused them.

And when I was about four years old, my brother got permission from my mom -- it was nighttime and I was in bed asleep -- my brother got permission from my mom to wake me up and take me to see the

aurora which was happening on Long Island at that time.

And he walked me to a nearby golf course, and I looked up and there were lights turning bluish green -- though they may not have been green but there were lights flashing in the sky and it was very beautiful. And I got hooked. So that's what I've been studying the rest of my life.

Q Well, that's amazing.

A Things to do with those aurora. Huh?

Q I love those stories of what it was that actually ignited the interest or the passion to pursue a particular career.

Some people have talked about stories of seeing the aurora. Others have talked about looking up and seeing a comet or shooting stars or the moon and it just totally ignited this entire path in their life from that point on.

A Yeah. Well, of course, all my family was very interested in science -- my father, my brother. My mother was interested in the beauty of nature.

Q Uh-huh.

A But, you know, there I was a little kid and my brother got permission to break all of the rules so that he could show me the aurora. So my mother and father were behind this also. So it was very exciting for a little kid. And it's been fun.

Q It's been fun.

A That's why I'm still working at this insanely a long time.

Q And still making -- and still exploring new territory. That's what's -- that's really awesome. That's amazing.

A Yeah. Well, you know, I still -- quite awhile back I thought I might retire, so I tried it for two weeks. And I decided I didn't like it, so I came back.

Q Well, my dad's a minister, and I can totally understand that that certain people --

A Yeah.

Q -- in certain careers that are passionate about their careers, they --

A That's right.

Q -- never stop.

A You never stop unless somebody forces to you stop but -- and they can't really, because you can always do it at home especially now with the computers where all the data is available and so on.

So it's been great fun for my life. And I started at a time when it was not considered reasonable for women to do this, but now it is.

And so I think, you know, anybody who finds something, you know, in science or somewhere else that interests them, should choose to do it, you know.

Q That's right.

A I was told it was impossible. It turned out that was wrong.

Q Wow, what a --

A Thank goodness.

Q -- different time.

A Yes. Yes. Yes. That's right. Women didn't make a living when I was a child. And women weren't supposed to be mathematicians and scientists. There was a prejudice against it.

But it doesn't make any difference. You just do it anyway. You don't have to get permission

from the entire world to decide what you're going to do.

Q They will eventually catch up.

A Oh, yeah. But I, you know, just think passion takes you a long way.

Q It sure does. And you know in the interviews that we've been conducting for Space Weather Living History, it seems that many of the scientists and people being interviewed always come back to that word, that that is really --

A Passion.

Q Passion, that that really is the torch --

A Yes.

Q -- that kept them involved.

A That is. That is. That is the torch for scientists. And it always strikes me as strange that laymen think we're very serious, very, you know, unpassionate people.

Q Uh-huh.

A We're not. We're not. So you want more information?

Q I -- this has been already, believe it or

not, we've been talking for 33 minutes.

A Oh, my. That's a long time.

Q Yeah, these interviews go very well especially when people start talking about what it is that they're excited about and what they do. It just happens. And it's such a pleasure --

A Yeah.

Q -- on my end to be able to hear that and to listen to it.

A Yeah.

Q I think it's a very unique experience for me as well.

A Yeah, well, I'm glad you enjoy it. And I hope people really warm up to the idea that science is not a chore, it's a pleasure.

Q Well, we'll probably take that statement and make that one of the main statements in your interview that you just said. I'll make sure --

A Okay.

Q Yeah, that would be wonderful.

A Okay.

Q Yeah.

A Okay. Fine.
Q Well, thank you so much.
A Okay.
Q And do you have anything else that you think you would like to add or are you good with --
A No. I think my -- yeah, my main dream has been really to get this preserved.
Q And it was very good.
A My main idea is that you should find something you're passionate about and do it whether people tell you can or not. And that it's -- that's the message, not the particular thing that you're passionate about, that'll be part of your life somehow.
Q Wow.
A Yeah.
Q Well, thank you --
A Okay.
Q -- so much, Joan, for your time.
And what we'll do from this point on is, Carolyn and Barbara Thompson will take a look -- they'll listen to the sound, they'll have it

transcribed, and then they will go through and edit out the parts that they know that we don't need or that my voice or whatever it is that they edit out. And then they'll send that final transcript to you and you can take a look --

A Okay, great.

Q -- at the actual transcript and give input to it. So if there are parts that you'd rather be moved around or changed, that's no problem.

A Fine. Fine.

Q And then we'll put it up online on Sun-Earth Day and in the Space Weather Living History Project at some point. And we'll let you know when that happens, so.

A Okay, fine.

Q Well, thank you so much.

A It's been nice talking to you.

Q I'm glad we finally were able to --

A Beautiful --

Q -- make it happen.

A -- really. Okay.

Q All right. You have a wonderful day.

A Bye.

Q Good-bye.

A You, too.

(Whereupon, the interview of JOAN FEYNMAN, was concluded.)

CERTIFICATE OF TRANSCIBER

I, JANET M. RICE, a Transcriber for the State of Oregon, do hereby certify that I transcribed the audio tapes(s) of the proceedings had upon the hearing of this case, previously captioned herein, that I thereafter had reduced by typewriting the foregoing transcript; and that the foregoing transcript, consisting of Pages 1 to 34 both inclusive, constitutes a true, and accurate record of the proceedings had upon the hearing of said cause, and of the whole thereof.

WITNESS my hand as Transcriber this 27th day of August, 2013.

_____
JANET M. RICE
Transcriber

