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Paul Feldman
Interviewed By
John Frame
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Johns Hopkins University
Oral History Collection

Interviewee: Paul Feldman

Interviewer: John Frame

Subject: Life of Paul Feldman

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JF: My name is John Frame. I'm an undergrad at Hopkins, a double major in Math and Econ, and I'm taking a course with Dr. David DeVorkin to interview a prominent researcher on his field and see his perspective in the changes in the field of astronomy in the last 35 years. So Professor Paul Feldman, what got you interested in astronomy?

PF: It's a relatively long story, but I can make it short. As a child growing up in New York, I was a member of the Junior Astronomy Club, which is at the Hayden Planetarium. I remember my father had to drag me into Manhattan to attend the meetings, but I learned to make star charts and go to their observing sessions in New York. It wasn't too much in the way of great observatories. But I actually lost that interest and was a physics major as an undergraduate and as a graduate student. I got my PhD in physics.

But what happened is my PhD was in 1964 and my thesis advisor, Robert Novick, had gotten very interested in space following Sputnik and the build-up of NASA and the ability to fly physics based experiments on sounding rockets and satellites. Satellites were still way in the future, and he convinced me to take a postdoctoral position in Washington at the Naval Research Laboratory with Herbert Friedman, who was one of the pioneers in flying the German rockets, the V2s from White Sands, New Mexico and built up a laboratory and institute in Washington. So I was there for three years and went into the field.

JF: So it was later in your life. It wasn't a childhood ambition to become an astronomer.

PF: No, it wasn't a childhood ambition.

JF: Did you have any prior research experience with the sounding rockets, or was that your first [experience]? I know a lot of people do grunt work in the labs before. What you did sounds like a major endeavor.

PF: Well, I didn't do the sounding rockets until I went to the Naval Research Laboratory. I did laboratory experiments in my PhD thesis.

JF: What was the dissertation on?

PF: It was on metastable alkali atoms, which has nothing to do with astronomy. It has a lot to do with physics.

JF: Do you have a specific research interest specialty?

PF: No, because I said I was interested in what you could do from space, and the group that I worked with in Washington was doing infrared astronomy, which was in its infancy and technically it didn't really mature for another 20 years with the IRAS [Infrared Astronomical] Satellite and then with a number of things most recently in the Spitzer Observatory.

But when I finished my postdoc, or when I was doing my postdoc and looking for positions, Hopkins was hiring, and they had a group working in ultraviolet astronomy. And that seemed to appeal to me because a lot of the processes that occur in the ultraviolet are very much related to the atomic physics that I worked on before.

JF: Can you elaborate on that a little bit?

PF: I'll give you a very simple example. When I worked in the laboratory, my degree was electron excitation of alkali atoms. Part of what I did, which was a little bit outside the thesis, was to just put all sorts of other things into the chamber, and so I was exciting oxygen, nitrogen and various other things that I could get my hands on and see what came out. I wasn't measuring spectra, I was measuring particles that were produced by atoms that were excited as they struck a metal plate, and it would produce a signal.

JF: I definitely heard of the electron excitation.

PF: This is a process which I was familiar with, and photo electron excitation in the earth's atmosphere was one of the things I worked on when I came to Hopkins. Because at that time, we were on it so we did the earth's atmosphere, and it was pretty simple. You didn't have to point very accurately. It was in the '70s that NASA developed the sounding rocket capability to do fine pointing astronomical objects in a small affordable package.

And then just recently, I'm working on the Rosetta Mission, a mission that's flying along with the comet, and I've done a lot of comet spectroscopy where what we observe is very unusual compared to what you observe with Hubble and in fact it's doing a lot of electron excitation, so I've come full circle.

JF: Was the math different back then? Before computers, was it all done by hand for the sounding rockets, when you were calculating trajectory, etcetera?

PF: Well, I don't know what you mean by "before computers."

JF: I mean, before modern [computers], because I when I talk to all my friends who do computer [work], they do some sort of quantitative work, but they did applied math. They say they haven't touched pen and paper since school. So I'm curious, was it different?

PF: For analysis, as a graduate student I had to calculate matrix elements for atomic transmissions. And across the street from Columbia was the Goddard Institute for Space Studies, and they were funded pretty lavishly at the time. You probably heard of them because they were very big on climate change. But they had a state-of-the-art IBM 709 or a 704, and we could use their computer. They would let us come over, and we would drag boxes of cards. Have you ever seen computer key punch cards?

JF: Yes. definitely.

PF: So then we'd drag boxes of cards, and we would stick it into their computer, and then all we were doing is simple things like matrix multiplication. But it was much faster on a computer than trying to do it by hand. When I went to the Naval Research Laboratory, they also had a Control Data Corporation computer. I can't remember the model number, but the person I worked with was really into computing, so I learned assembly language.

I didn't quite learn machine code, but I learned assembly language and did simple things like calculate trajectories and positions, doing transformations between coordinate systems. It came pretty quickly, and it evolved to the point where we have the equivalent of a supercomputer sitting on your desk.

JF: Could you tell me a little bit about your UVX experiment aboard the shuttle Columbia in the '80s?

PF: Not only an ultraviolet experiment. It was actually a hodgepodge. Professor Richard Henry was behind it. NASA had this idea that they could put cheap experiments on a space shuttle. And the answer was that you couldn't put cheap experiments on a space shuttle because as long as there were men-in-space concerns, the hazardous components, gases, and things like that, you had to go through a certain degree of rigor in testing and specifications.

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But the idea was that the gas can was a little cylinder, maybe 30 inches around, and we put in some old spectrometers that we had. And the idea was to look at the sky with a large field of view so that you don't see a field of stars, but you see what's behind the stars. The thing that came out of it was a measurement of this diffuse light. This is the dust in the solar system. I wasn't the prime mover behind it so it wasn't one of my favorite projects.

JF: What was your favorite?

PF: Well I guess my favorite thing was some of the sounding rocket flights that we did for comets.

JF: Okay, definitely.

PF: Those were pioneering in a way. There was some difficulty because the comet was moving, and the pointing systems were based on fixed stars. So if it moves one day, you have to tell the rocket pointing mechanism, ACS's attitude control system, where the comet was going to be. Now, in the sounding rockets, we have joysticks so we can move things around, move the whole thing around, and we can steer it with jets.

So if we fail to launch on one day because of wind or weather or something like that, you have to get in there and completely reprogram the ACS because the comet would reenter the part of the sky, and so it was pretty awful working with morning launches. You observe the comet before the sun rose so you were launching at 4:30 in the morning. It was quite exciting actually.

JF: Have you read the book “Picturing the Cosmos” by Elizabeth Kessler?

PF: No.

JF: It reminded me of astronomers working late at night, coming out in the morning – because they're in an observatory so they see a sprawling view, and they're drinking coffee in the morning. Has that changed? Do you still get that?

PF: I've never been a real astronomer. I've never gone to an observatory. I've been to observatories, but I've never done any major work in an observatory. Well, that's not completely true. My daughter reminded me that when NASA put up the first facility instrument, the International Ultraviolet Explorer. The control center was in Goddard and it was in geostationary orbit so observed 24 hours a day.

It was shared between the U.S. and Europe. So we had 16 hours, they had 8 hours, and they were 8-hour shifts. And being that I and my colleagues were really close to Goddard, we always got Christmas and Thanksgiving. Depending on where the satellite was in orbit, we would sometimes get a shift that ran from 8:00 in the evening to 4:00 in the morning. And then you had to drive back on the Baltimore Washington Parkway at 5:00 in the morning.

JF: That's not too nostalgic [laughs].

PF: It was good. So they have this little control panel. Well, the iPhone could do more than those panels, but they had them on display at the Udvar-Hazy branch of the National Air and Space Museum near Dulles Airport. So [my daughter] sent me a photograph of it. She remembers when I used to come home early in the morning after an all-nighter.

JF: That brought back memories. So were you around through the implementation of CCDs?

PF: Not on Hubble. It was done on the Wide Field Planetary Camera. I was involved on a team that was developing a camera for a mission that never happened. It was called Comet Rendezvous Asteroid Flyby [CRAF]. It was a NASA mission. It's sort of a strange story because NASA, having these big missions following Voyager and Galileo, having big planetary missions, decided they could build one spacecraft that could do multiple missions. So they designed a spacecraft to be used for both a comet mission and a Saturn mission.

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And then they found that, whereas they originally thought they could build two spacecraft for the price of one, they can only build one spacecraft for the price of one, so they canceled CRAF and flew Cassini, which has been very successful at Saturn. So as a member of one of the science teams for CRAF, we developed a camera. I wasn't really involved in the instrumentation, but CCDs were in their infancy,] so we were dealing with the development and procurement of CCDs from various inventors. And that was back in the late '80s, early '90s.

At the same time, they were doing the same thing for Hubble and those generations. We also tried flying CCDs in a sounding rocket early on. They had to be cooled. I can't remember if we were successful or not. I think we probably weren't, but I don't remember.

JF: Sounds like a triviality.

PF: I think in the mid '90s we tried a CCD-based ultraviolet detector. We ended up using position sensitive detectors of different kinds, ultimately based on microchannel plates. But the CCD always had a problem that if you're working the ultraviolet and you convert the UV photons into visible photons for the CCD, you're still not blocking all the visible photons that can go ahead indirectly and swap the signals in the UV photons. So they were never very useful for the ultraviolet, but they're great for visible imaging. Every instrument uses them now.

JF: It's become the standard. You joined the committee on the Hubble in 1992. I wasn't sure of the position.

PF: Committee?

JF: It said on your Hopkins profile you were on the Observatory Committee for the Hubble from 1992 to 1995?

PF: I was on the Users Committee.

JF: Can I hear about the details of your job?

PF: I don't remember very much. I think we had meetings and presentations. Oh, I know why I was on the committee. When Hubble was developed, one of the PIs of the instruments, Jack Brandt, who was at Goddard, developed the Goddard High Resolution Spectrograph; his team did, anyway. He was interested in Halley's Comet. Hubble was supposed to be launched in '85 or '86, and that was when Halley's Comet was visible.

So they run the specification that Hubble should be able to track moving targets in the sky up to the limit in which Halley's Comet would be, which was something like two hundred milliarcseconds per second. It was a relatively low rate, but these objects, the planets, they move. They're not fixed. So when we started making observations of planets with Hubble, we found that they didn't have the software implemented to track them properly. They would have to use some guide stars. They would have to point it at the planet, and after a certain amount of time, they have to go back to the guide stars and change the tracking.

There was some problem, so in fact, my role on that committee was simply to advocate for a proper moving target capability, which they have now. But it's not so trivial when you're trying to maintain pointing to several milliarcseconds, to be able to do that. Mainly it was a lot of presentations on the status of the observatory, and then of course that was close to the first repair mission. So that was very important.

JF: Were you around for the flawed mirror?

PF: Yes.

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Bill Fastie was one of the telescope scientists, and he died in 2001. He blamed himself for not discovering the flaw in the telescope because the outside committees were kept away from the details of the instrumentation. Even though he was an expert in optics and that's why he was appointed as a telescope scientist. They actually made him too nervous. And then two contractors from Perkin-Elmer in Connecticut, was the prime contractor. I think Kodak in Rochester was the second contractor, and they were building a backup mirror. The error was made at Perkin-Elmer. They inspected it, and the inspection was what was flawed. When they inspected it they decided to go ahead with the primary and leave the second mirror unfinished. In other words, it's not polished to final smooth, and it turns out the second mirror was done correctly.

PF: The first one was the flawed one, and that's an interesting story. Holland Ford was one of the PIs on the instrument to correct the spherical aberration. They built in a set of mirrors that they would put in the telescope, some of the instruments called COSTAR, which would correct for the spherical aberration, and then feed the instruments that were in there.

None of the old instruments are there anymore, but the new instruments all have the correction built in. That was pretty hairy. I was in a scientific meeting in 1990 and I went to the launch that was canceled. Then I didn't go back for the second attempt when they did launch it.

The shuttle always had problems with launches. There was a meeting of COSPAR (Committee on Space Research) in the Hague in June and I remember someone showing up and saying they just discovered the flaw with the mirror, and there was a great stunned silence in the room.

JF: You said this was 1990?

PF: In April of 1990. That's a wild ride right there when you send something up and [it] takes a while–

JF: To get data. But I'm sure it's still within the same year, it's got to be disheartening for a little bit.

PF: It didn't affect the spectrograph as much as the images.

JF: What was wrong with the images when they came back? How was it was evident that they were flawed?

PF: They were blurry. It was very clear where the problem was, and then they figured out a way to [repair it].

JF: So you said they put the device in front of the mirror.

PF: They put it behind the mirror.

JF: To correct it, right?

PF: Well, you've got the primary mirror, you've got a secondary out front, then the light comes through, and then it gets spread into the different instruments. Then you put something into correct the output.

JF: Would it have been too costly or too difficult to make a new mirror? I don't know how it works at all.

PF: No. You'd have to bring it back.

JF: You still have to service that in space. All right. And you have to open it up I'm sure.

PF: Oh yeah.

JF: Lose a screw out of it – that'd be bad. Could you speak about the Hubble's role in changing the way we view space and the way the public views space? Did it affect the funding of projects?

PF: Well, the funding of Hubble itself was very controversial for a long time because it was so expensive. It's like this JWST is. – It had lots of overruns because the technology you're trying to implement is new and relatively risk-prone.

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So Hubble has been a great thing for PR, for NASA. But even after it was prepared and successfully operated, there were certain members of Congress who said, "Well, we've gotten great data. Let's shut it down now, and we do not have to fund it anymore." It's been a struggle, but it's been a very good enterprise. Have you seen any of the exhibits across the street?

JF: No. I've seen the building.

PF: The lobby. Just in the lobby.

JF: Did they get the data from the Hubble there, out of curiosity?

PF: Yeah. Well, they don't get it directly. They get it from Goddard, but they process it there and they distribute it to people like me from over there. And when you're doing planetary or cometary observations and you have moving targets, you work with someone over there to schedule it so that it's in a timeline when you can see those targets and track them. Some of the things we try to do with the satellites of Jupiter is to see a satellite going into or coming out of eclipse behind planet, and the timing on that is very, very, very tricky. You don't know where the spacecraft is relative to where the planet and satellite is.

JF: Are there any main goals in the field of astronomy? This might be a poor comparison, but I know in physics they have the Higgs boson. It seemed like a goal for the industry, so to speak.

PF: Well, there were key projects for the Hubble when it started, and there are key projects now for the JWST when it gets launched. But, for instance, the measuring of the Hubble constant – how fast the universe is expanding – and the discovery of dark energy wasn't anticipated. It came from careful measurement using Hubble to measure the distances of supernovae. So you always have any ideas that you want. For instance, what JWST wants to do is look back at the time when the first galaxies were formed after inflation following the Big Bang. But you always find things that you don't expect and that's the beauty of science.