

Capital Reporting Company  
Interview of Don Fairfield

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INTERVIEW  
OF  
DON FAIRFIELD

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1 P R O C E E D I N G S

2 MR. CLINE: All right. There we go. Okay.  
3 If you could just tell us again your name and a little  
4 bit about who you are and then we'll start with the  
5 first question.

6 MR. FAIRFIELD: Uh-huh. Yeah, I'm Don  
7 Fairfield. And I've been working in the field of  
8 magnetospheric physics for many years. I was sort of  
9 in on the beginning of it.

10 I know when I was taking my first physics  
11 course in college in 1957, Sputnik was launched. And  
12 when I graduated from college, I had -- I was offered  
13 an assistantship at Penn State. And I went to Penn  
14 State and -- to work in the ionosphere research lab  
15 there. And this was 1960.

16 And the next year, they offered me the  
17 opportunity to work with Jim Dungey who was a  
18 consultant at Penn State but -- and he would come  
19 visit a couple of times a year. And I accepted their  
20 invitation to do this. And he was my thesis advisor  
21 for my five years at Penn State.

22 In 1961 he published, which I think most

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1 people would -- will admit was probably the -- maybe  
2 the most important paper in space sciences. And for  
3 my Master's thesis at Penn State, he had me looking at  
4 high latitude magnetograms that are from the IGY,  
5 because he had an idea of how the currents might be  
6 driven by the solar wind.

7           And after completing that Master's thesis,  
8 he gave me a problem for my Ph.D thesis, which in  
9 retrospect, I think was maybe the best thesis project  
10 anybody ever had.

11           His idea was that the magnetosphere was  
12 controlled by the interplanetary magnetic field and it  
13 would operate differently depending on whether the  
14 interplanetary field was northward or whether it was  
15 southward. And because when it was southward, then  
16 the currents would be driven and the magnetosphere  
17 aurora would be produced and it was a very significant  
18 theory.

19           And his idea was that I could look at the  
20 magnetic field data. And at that time the first  
21 satellite to orbit the earth and make measurements  
22 outside of the magnetosphere was Explorer 12. And he

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1 arranged for me to go to the University of New  
2 Hampshire and work with Larry Cahill who was the  
3 experimenter on the magnetic field experiment.

4           And I went to New Hampshire for the summer  
5 of 1964 and looked at this data. It was an  
6 interesting experience. When I arrived there, the  
7 halls were completely filled with bookshelves of  
8 printout of his data because before this time he had  
9 worked with satellite data where you have maybe just a  
10 few minutes of data on one rocket flight. And now he  
11 suddenly had day after day month after month of  
12 satellite data and his experiment measured the  
13 magnetic field three times every second.

14           So he was overwhelmed with this data. And  
15 he had some students with mechanical calculators  
16 computing averages of this three-second data and --  
17 while some other people were working trying to get the  
18 data onto modern, at that time, computer.

19           Anyway, that was a very profitable summer.  
20 And indeed, I -- the magnetograms that I was using to  
21 detect the magnetic field activity was clearly  
22 enhanced when the interplanetary field was southward.

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1 And it -- I remember thinking, is research always this  
2 easy. And because it did just seem very, very  
3 apparent that his ideas were correct.

4           After finishing my degree at Penn State, I  
5 accepted a postdoctoral position at NASA Goddard  
6 working with Norman Ness. And Norman then had the  
7 best solar wind data of anybody at that time with his  
8 data from the interplanetary monitoring platform.

9           So my first goal was to try to provide a  
10 statistical support for the -- my earlier work. And  
11 to do that, I needed a measure of the magnetic fact --  
12 of round magnetic activity which was better than the  
13 three-hour KP averages.

14           And at that time Davies and Secura --  
15 Sugiura had published a paper defining what they  
16 called the "AE," or auroral electrojet, Index. And  
17 this was just what I needed to -- for statistical  
18 work.

19           And they -- so I worked with the data center  
20 at Goddard and started computing this AE Index on a  
21 regular basis. And then I went on to compare it with  
22 the larger data set from M spacecraft. And indeed,

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1 that did confirm the association with southward field  
2 and magnetic activity.

3           And that work I then published in a  
4 proceedings of the Kosovar meeting I think in 1967,  
5 and I think that was the least-referenced paper I ever  
6 published because this is a rather obscure journal. I  
7 never bothered to publish it in a real journal. This  
8 was a -- just the proceedings of a meeting.

9           Q     I think one of the questions that we had  
10 were also -- which you've already started touching on  
11 some of them -- were, what were some of the key events  
12 or turning points in space weather research that you  
13 were involved in. And again, if you can --

14          A     (Inaudible.)

15          Q     That's right. And just kind of maybe repeat  
16 that a little bit what the question is and then just  
17 you can move into this really awesome looking list,  
18 and I think that will be awesome.

19          A     Yeah. Back in these early days when  
20 spacecraft were being launched quite frequently, it  
21 was really very exciting because every spacecraft went  
22 to a different region and found new things.

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1           And so it was not like the situation is  
2 today where you make incremental advances, but you  
3 were discovering really new and unexpected things at  
4 that point.

5           When I first came to Goddard, Norman Ness  
6 sort of turned over the analysis of the M-2 spacecraft  
7 to me. And this spacecraft was actually called a  
8 failure by NASA headquarters because the apogee was  
9 only about 16 earth radii; whereas, they had meant for  
10 it to go out about twice as far where it would survey  
11 or -- survey the solar wind and it's magnetic field.

12           But in fact, 16 earth radii was an excellent  
13 orbit for studying the magnetosphere and -- for it  
14 took many, many years before there was another  
15 satellite in that very important region.

16           The nice thing about the M satellites was  
17 that they go out to typically 30 earth radii. They  
18 covered all regions of the magnetosphere. So I felt  
19 very, very fortunate in being able to work in all  
20 these different regions where the spacecraft  
21 traversed.

22           One of the early things I did was to map out

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1 the positions of the magnetopause and the bow shock.  
2 Explorer 12 had really mapped the magnetosphere pretty  
3 well. It went out to 13 earth radii. But that wasn't  
4 far enough out to see the bow shock. So a lot of the  
5 early work on -- you know, was done at the bow shock.

6           And I went through and determined the  
7 various crossings on each orbit and published a paper  
8 which really delineated the position of the bow shock  
9 and the magnetopause, which was of considerable  
10 interest to people who would follow because it's  
11 important to know where these basic structures were  
12 located.

13           I also used the early magnetic field M-2  
14 data to study the configuration of the magnetic field  
15 and particularly how the solar wind compressed the  
16 data on the day-side and then extended the data on the  
17 night-side. Because it was just before that time that  
18 Norman Ness with his, you know, one data had  
19 discovered the -- discovered the magnetotail.

20                           (Whereupon, there was a brief break in  
21                           the recording.)

22           MR. CLINE: No, that's fine. Okay. We'll

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1 continue with -- with where you were just a second  
2 ago.

3 UNIDENTIFIED SPEAKER: The day-side/night-  
4 side of the magnetotail.

5 BY MR. CLINE:

6 Q Okay.

7 A Of course, the configuration of the  
8 magnetosphere is important because that controls where  
9 the particles go. So this was of considerable  
10 interest.

11 At that time, the conventional wisdom was  
12 that nothing would propagate outward from the bow  
13 shock and -- well, at least any -- no magnetic field  
14 waves could propagate outward from the bow shock  
15 because the wave propagation speed was less than the  
16 incoming solar wind speed.

17 But in looking at the data, it was clear  
18 that there were waves upstream of the bow shock. And  
19 this was a surprise that I was able to use IMPs data  
20 to show that the location of these waves upstream from  
21 the bow shock depended on what the interplanetary  
22 direction was.

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1           It was on one side of the magnetosphere when  
2 the magnetic field was directed one direction and on  
3 the other side if the magnetosphere were directed  
4 another direction. And this, in fact, was really the  
5 first determination of the foreshock as it was later  
6 called which has been much studied in later years.

7           And it became, of course, the question was,  
8 how do these waves exist upstream when they're not --  
9 don't have high enough velocities to propagate  
10 upstream.

11           And I remember going over to the University  
12 of Maryland and talking to Derek Tidman. And it was  
13 his suggestion that it was particles moving upstream  
14 from the bow shock which would generate these waves in  
15 the upstream region.

16           And this is something that I think has held  
17 up over the years and much -- very much more data has  
18 been done on the foreshock since then.

19           When I was in graduate school, there was --  
20 the field of plasma physics was only just beginning.  
21 I -- at Penn State they didn't teach a course in  
22 plasma physics because the field was so new. So I

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1 felt very fortunate over the years in learning my  
2 plasma physics by seeing it in action, you might say.  
3 Because, of course, this whole interaction of the  
4 solar wind with the magnetosphere is all plasma  
5 physics.

6 I remember at one point I -- when we had  
7 IMPs 1 and 2 flying at the same time, I was able to  
8 see features in the interplanetary magnetic field,  
9 first at the spacecraft further upstream and then at  
10 the spacecraft nearer to the earth.

11 And this was clear evidence of how the  
12 magnetic field is convected with the solar wind. And  
13 this was a -- I think a pretty well accepted idea at  
14 that point, but I don't think anybody had ever  
15 observed it. So it was interesting in being able to  
16 see something that the -- as predicted by the theory.

17 I remember in another case, I was doing some  
18 early work on the earth's bow shock, and I was able to  
19 determine that there were waves standing on the bow  
20 shock itself. And this was a phenomenon that was on  
21 the cover of an early book on plasma physics and shock  
22 physics. So it was very interesting to see something

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1 in real life that had been predicted by theory.

2           Since the magnetic field controls all  
3 particle motion, it was of interest to have a model of  
4 the field which was representative of the distortions  
5 of the magnetic field and the fact that the field was  
6 no longer a dipole field but was distorted by the  
7 solar wind.

8           So at some point, I collected data from a  
9 number of IMPs satellites in the magnetosphere. And  
10 then I worked with Gilbert Mead at Goddard, and we  
11 came up with the first quantitative model of the  
12 distorted magnetic field by fitting the data to  
13 magnetic field -- well, by using -- we used Gill  
14 Mead's experience in modeling fields with the data to  
15 -- to create this realistic model of the magnetic  
16 field.

17           And, of course, subsequently, many people  
18 went on to produce more sophisticated models, but that  
19 was useful as a start.

20           One of my most interesting experiences, I  
21 would say, was in work with the polar rain. The polar  
22 rain was known to be low energy electrons

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1 precipitating over the polar cap. And it had been  
2 observed that they precipitated over one polar cap and  
3 -- but not over the other, but then sometimes they  
4 would reverse and it was the other polar -- other --  
5 well, say -- start that again.

6 Q Okay.

7 A It was observed that sometimes they would  
8 precipitate over the north polar cap but not the south  
9 polar cap, but sometimes that would reverse and they  
10 would appear to the southern hemisphere and not the  
11 northern hemisphere. And it was also not so clear  
12 where these particles came from.

13 But in working with Jack Scudder at Goddard,  
14 we used his knowledge of the solar wind to realize  
15 that the electrons in the solar wind are aligned with  
16 the magnetic field, at least a portion of the  
17 distribution is aligned with the magnetic field,  
18 follows the magnetic field lines.

19 And we realized that the -- it was these  
20 electrons which would follow magnetic field lines  
21 which connected to the magnetotail, and they would  
22 precipitate over one polar cap; whereas, the other

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1 polar cap would be going out into distant space.

2           But which polar cap connected back to the  
3 sun was dependent on the reconnection at the  
4 magnetopause. And when the magnetic field reversed  
5 and whether it -- when the magnetic field was pointing  
6 outward from the sun, it would connect to one lobe of  
7 the tail. And if it were pointing in the opposite  
8 direction, it would point to the other lobe of the  
9 tail. And that was why the polar rain reversed  
10 hemispheres.

11           In later years, I did further work on the  
12 foreshock. I realized that many of the perturbations  
13 in the upstream region were magnetic field  
14 compressions. And this is realized, that many of the  
15 perturbations in the upstream region were density  
16 compressions. And this was different than what is  
17 seen in the unperturbed solar wind.

18           So it was evidence that something was  
19 happening in the foreshock and then these density  
20 perturbations would be convected through the bow shock  
21 and impinge on the magnetosphere and create  
22 compressions of the magnetosphere. And this was

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1 apparent in the data and was a new phenomenon at that  
2 time.

3 Subsequently, much further work has been  
4 done on the foreshock and how it affects the earth.  
5 But this was one of the early evidences for it.

6 At a later time, I again used IMP data to  
7 notice that there were very significant waves on the  
8 magnetopause surface.

9 And I worked with Antonius Otto with the  
10 University of Alaska, and we realized that these were  
11 -- were Kelvin Helmholtz waves. Kelvin Helmholtz  
12 instability had been well known, but it had not been  
13 seen on the magnetopause until this time.

14 But with Antonius's theoretical expertise  
15 and the IMPs data, we were able to demonstrate that  
16 this was occurring at the magnetopause.

17 (Whereupon, the interview of DON  
18 FAIRFIELD was concluded.)

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