THE SOLAR WIND STRUCTURES ASSOCIATED WITH COSMIC RAY DECREASES AND PARTICLE ACCELERATION IN 1978-1982

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Abstract

A study has been made of the time histories of particles in the energy range 1 MeV to 1 GeV at times of all >3% cosmic ray decreases in the years 1978 to 1982. Essentially all 59 of the decreases commenced at or before the passages of interplanetary shocks, the majority of which accelerated energetic particles. We use the intensity-time profiles of the energetic particles to separate the cosmic ray decreases into four classes which we subsequently associate with four types of solar wind structures. Decreases in class 1 (15 events) and class 2 (26 events) can be associated with shocks which are driven by energetic coronal mass ejections. For class 1 events the ejecta is detected at 1 AU whereas this is not the case for class 2 events. The shock must therefore play a dominant role in producing the depression of cosmic rays in class 2 events. In all class 1 and class 2 events (which comprise 69% of the total) the departure time of the ejection from the sun (and hence the location) can be determined from the rapid onset of energetic particles several days before the shock passage at Earth. The class 1 events originate from within 50° of central meridian. Class 3 events (10 decreases) can be attributed to less energetic ejections which are directed towards the Earth. In these events the ejecta is more important than the shock in causing a depression in the cosmic ray intensity. The remaining events (14% of the total) can be attributed to co-rotating streams which have ejecta material embedded in them.

1. INTRODUCTION

Since the earliest observations (Forbush, 1938) it has been recognized that transient decreases in the cosmic ray intensity occur at the times of sudden commencement geomagnetic storms (SCs). Lockwood (1960) showed that decreases with a rapid onset, Forbush decreases (FDs), generally commence within 3 hours of an SC. Lockwood (1960) also pointed out that most large FDs (magnitudes > 5%) are associated with polar cap absorption events, indicating the presence of high fluxes of protons in the energy range 5-20 MeV. It is now widely accepted that SCs and cosmic ray decreases are caused by interplanetary (IP) shocks and that IP shocks (both transient and co-rotating) accelerate particles, and yet particle acceleration has not been included in attempts to understand the nature and causes of Forbush decreases.

The mechanisms responsible for short term cosmic ray decreases are also responsible for the long term modulation i.e diffusion, convection, adiabatic deceleration and drift. What is not known is the relative contributions of these mechanisms both in general and in specific events. We intend to address this question in two papers. In this paper, the solar wind structure (shock, ejecta, co-rotating stream or combination of these) responsible for every cosmic ray decrease in a specific time period (1978 - 1982) is inferred by examining intensity-time profiles of the cosmic rays and the associated lower energy (<25 MeV) particle enhancements. The particle enhancements associated with the different solar wind structures have unique signatures allowing them to be

distinguished. With the structures determined it is then possible to identify the predominant mechanism responsible for cosmic ray depressions associated with particular types of structures. For example, drift in smooth, high magnetic fields will dominate in depressions caused by ejecta as discussed in a related study (Cane, submitted to J. Geophys. Res., 1992) where this effect is quantified. In a subsequent paper the relative importance of other mechanisms (including scattering in turbulent fields, and convection) in producing cosmic ray depressions will be quantified using the solar wind plasma and field data. This work (in progress) confirms the associations made in the present paper between cosmic ray decreases and specific types of solar wind structures.

Along with providing a complete list of decreases and their causes, in a 5 year period around solar maximum, we also reconfirm some statistics of cosmic ray decreases obtained in earlier research.

2. DATA ANALYSIS

This analysis uses data from the GSFC experiment on IMP 8 (McGuire et al., 1986). In addition to differential proton intensities, data from the plastic scintillator anticoincidence guard (G) on the medium energy telescope are used. These provide an integral rate for ions with energies greater than about 60 MeV/nuc. The time histories of IMP 8 ~1 MeV to ~100 MeV proton intensities and G rate were examined during periods of short term (<20 day duration) cosmic ray decreases >3% recorded by the

University of Tasmania Mt. Wellington neutron monitor in 1978 - 1982. Our list of decreases is slightly different from that of Lockwood (1990). Several of the events listed by Lockwood have been divided into multiple events resulting in 10 additional events. Since we included all decreases >3% regardless of their intensity-time profiles, one event on our list (September 15, 1979) was probably excluded from the Lockwood list on the basis of its slow onset and long duration and another event (November 30, 1982) because of the large diurnal variation. Six events on the Lockwood list were too small to be included in the present study. The resulting number of decreases (see Table 1) in the 5 year period was 59. Note that the onset times of the decreases are given to the nearest 3 hour interval. These onset times are only estimates as many decreases do not commence rapidly.

Reports in Solar Geophysical Data of sudden commencement geomagnetic storms (SCs) and lists of shocks detected by near-earth spacecraft (e.g IMP-8, Borrini et al., 1982) have been used to provide the arrival times of the interplanetary (IP) shocks associated with the decreases. In the majority of cases a shock arrived before the depression commenced but for 4 events the ordering was reversed. The time difference between shock arrival and the start of the depression is given in Table 1 and a histogram is shown in figure 1. It was found that 73% (43/59) of the neutron monitor decreases began within 6 hours of the passage of a relatively strong shock. The September 1979 decrease (and possibly the November 30, 1980 decrease), with no shock occurring

within days of its start, may be explained by the presence of a large IP shock moving off the east limb of the Sun (Cane, 1985) because an energetic shock can affect the cosmic ray intensity at Earth, even when the shock itself is not detected (Lockwood, 1971).

The percentage decreases seen by the Mt. Wellington neutron monitor and the IMP 8 G rate are also listed in Table 1. For 25 events the IMP 8 G rate included a particle enhancement, which we attribute to shock acceleration, during some or all of the decrease. In these events the decrease is given as a '-1'. Events listed with a '-2' are those in which there was some other solar event during the decrease. For the other events the IMP 8 decrease was approximately a factor of 2 greater than the neutron monitor decrease.

The events have been divided into 4 classes based on the cosmic ray and IMP 8 proton intensity-time profiles. An example from each class is shown in Figures 2-5. The percentage decreases at Mt. Wellington and in the IMP 8 G rate are shown along with proton intensities in two energy ranges (0.9-1 MeV and 9-23 MeV). The IMP 8 and neutron monitor data are 30 min. and 1 hr averages respectively. The neutron monitor data are pressure corrected. Vertical lines indicate shock passages.

Class 1 events (an example of which is shown in Figure 2) are those in which the G rate and the neutron monitor show a minimum intensity at about the same time and an intense energetic particle enhancement is seen. For most events the enhancement extends above 60 MeV and appears in the G rate but does not extend much beyond

the commencement of the cosmic ray decrease. The low energy particles (<~20 MeV) peak near shock passage and show an abrupt decrease a few hours later. Class 2 events (Figure 3) are associated with intense >60 MeV ion enhancements seen in the G rate. The G rate stays high beyond the commencement of the cosmic ray decrease, sometimes never showing a decrease as is the case for the event illustrated in Figure 3. For class 2 events the low energy intensities do not exhibit an abrupt fall during the decay following shock passage.

Class 3 and class 4 events (Figures 4 and 5 respectively) are associated with proton enhancements which do not extend above 60 MeV and hence are not seen in the G rate. Consequently the G rate and neutron monitor intensities decrease and reach minimum together. For class 3 events the associated particle enhancement peaks at shock passage at all energies at which it is seen and the intensities drop abruptly during the subsequent decay. These events are similar to class 1 but less energetic. Class 4 cosmic ray decreases are long lived and generally do not have a rapid onset. They also exhibit more structure than the events in the other classes.

Class 1 (15 events) and class 2 (26 events) make up 69% of the total and all can be associated with a specific solar event. The particle events associated with class 1 and class 2 cosmic ray decreases are very energetic. In fact they comprise the majority of all 'solar energetic particle' events observed in the period 1978-1982. The solar source regions of these particle events have

been published previously by a number of authors (e.g. Cliver et al., 1989). The presence of associated energetic particles makes possible the determination of the source locations on the Sun for these cosmic ray decreases. The particle enhancement starts at the same time at all energies at about the time of the associated solar Hα event. The longitudes are listed in Table 1.

It is not possible to assign specific source regions for class 3 and 4 decreases because the associated particle enhancements do not have well defined start times and the low energies commence before the higher energies. However there is one exception. The event of November 30, 1980 may have been associated with a relatively energetic IP shock, and associated particle event, originating near the east limb of the Sun, which was not detected at Earth but was detected remotely via the radio emission that it generated (Cane, 1985).

3. DISCUSSION

We first consider the size of the neutron monitor decrease as a function of the longitude of the source region for class 1 (open circles) and class 2 (filled circles) events (Figure 6). It can be seen that the events tend to originate in different longitude regimes with class 1 restricted to within 50° of central meridian and the class 2 originating from outside of 20° of central meridian. The distribution of events in figure 6 is similar to those that have been presented previously (e.g. Barnden, 1972a). In particular there are more decreases from eastern regions than

western regions (in our sample 30 vs. 11) and the largest events originate near central meridian. However, by using the source locations based on energetic particles we believe the associations in our distribution are more reliable. We do not find precise agreement with the results of Barnden's study (which included all Forbush decreases >3% for the years 1966-1972) since we find 2 decreases from regions beyond W60° (Barnden found none) and 2 decreases greater than 7% from E90° (Barnden's largest was 5%).

In a companion paper Barnden (1972b) presented a model for the number density distribution of cosmic ray particles during Forbush decreases based on the large scale structure (proposed originally by Hundhausen [1972]) of interplanetary shocks and their drivers, and on the dependence of a number of characteristics of Forbush decreases on source longitude. The essential features of this model are the presence of ejecta plasma, magnetically isolated from the ambient solar wind, which drives the shock, and the draping of solar wind field lines around the western side of the ejecta. This latter feature means that following passage of a shock originating in eastern regions, the Earth becomes connected to the nose of the shock where it is strongest. This model has also been used to explain the large scale characteristics of energetic particle events invoking IP shock acceleration as the principal source of particles (Cane, Reames and von Rosenvinge, 1988). It was noted that a sharp drop in particle intensity occurred for central meridian events when the ejecta was intercepted. A similar conclusion was reached by Barnden (1972b). Thus the difference

between our class 1 and class 2 cosmic ray decreases is whether following shock passage the ejecta is intercepted (class 1) or whether the observer continues to be magnetically connected to the shock (class 2).

There has been some recent discussion about the relative roles of the ejecta and the shock in producing cosmic ray decreases (e.g. Sanderson et al., 1990). The existence of decreases in which the ejecta are not intercepted (i.e. class 2) argues that ejecta alone are not responsible for decreases and that shocks must play a role. The close temporal correspondence of the increase in the G rate and the decrease in the neutron monitor for the events like the one illustrated in figure 3 (this event originated on the east limb and other events from the limbs behave similarly) shows the close relationship between the acceleration of low energy particles and the exclusion of high energy particles. Both are presumed to arise from scattering in the turbulent fields in the vicinity of the shock.

The time profiles of the class 3 events suggest that they are similar to the class 1 events but less energetic (based on the absence of particles above 60 MeV). Most have been previously considered in the paper on cosmic ray decreases and magnetic clouds (Cane, submitted J.Geophys. Res.,1992). In these events the ejecta is more important than the shock in producing the cosmic ray decrease. These ejecta are attributed to mass ejections which do not drive strong, extensive shocks and which are detected because they are aimed directly at the Earth. This proposal is supported

by some earlier work relating particle enhancements, shocks and coronal mass ejections (Cane, von Rosenvinge and McGuire, 1990). Particle enhancements associated with shocks but not showing a prompt onset at all energies were related to slow coronal mass ejections.

The class 4 events are similar to the so-called 'recurrent Fds' discussed by e.g Lockwood (1971) in that they are of long duration and have more symmetrical time profiles. Recurrent events have been associated with co-rotating high speed streams which are prominent at solar minimum and often include low energy particle enhancements peaking within the stream (Richardson et al., 1992 and references therein). However during class 4 events further shocks were detected i.e. in addition to the one usually associated with the onset, consistent with the complex structure of streams around solar maximum. The secondary shocks were associated with further decreases with rapid onsets like class 3 decreases and suggest the presence of ejecta embedded in the streams.

Finally in Figure 7 we shown the distribution of the event sizes and source regions as a function of time. In this figure class 1 and 2 are combined since from a solar point of view they are the same ie. they can be attributed to energetic coronal mass ejections. The implication from Figure 7 is that near solar maximum there were few very energetic coronal mass ejections (a point that has been noted previously e.g. Cane and Stone, 1982). At this time the dominant source of short term modulation of the cosmic ray intensity was a number of co-rotating streams with

embedded ejecta.

ACKNOWLEDGEMENTS

HVC was supported at GSFC by a contract with Universities Space Research Association and at the University of Tasmania by a grant from the Australian Research Council. The work of IGR is supported by NASA grant NGR 21-002-316.

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FIGURE LEGENDS

Figure 1. Distribution of the time delay between shock passage and the start of the cosmic ray decrease for the 55 events associated with shocks at Earth.

Figure 2. Energetic particle observations recorded at the time of a cosmic ray decrease in November 1978. From top to bottom: (a) proton intensities (particles/(cm^2 s sr MeV)$^{-1}$ in the energy ranges 0.9-1 and 9-23 MeV, (b) and (c) the Mt Wellington neutron monitor and IMP 8 G count rates expressed as a percentage of the pre-event level. The vertical line indicates the time of shock passage. The event shown in Figure 2 is an example of a class 1 event. The G rate shows an enhancement before the shock passage but the rate drops at about the same time as the neutron monitor rate. The low energy particle enhancement shows an abrupt drop shortly after the shock passage.

Figure 3. The format is the same as in Figure 2. For this class 2 event the intensities stay high for a long time even extending to the range to which the G rate is responsive. The particle enhancement shows a uniform decay without an abrupt fall off.

Figure 4. An example of a class 3 event, which is typified by no enhancement in the G rate and a rapid decrease seen simultaneously in the G rate and the neutron monitor rate.

Figure 5. An example of a Class 4 event which is typified by being gradual in both the onset and recovery. The second more abrupt decrease late on November 11, 1979 looks like a class 3 event.

Figure 6. Size distribution of cosmic ray decreases as a function of source region on the Sun. Filled and open circles represent class 2 and class 1 events respectively.

Figure 7. The variation of sizes and types of cosmic ray decreases during 1978 to 1982. Filled circles represent classes 1 and 2, open circles class 3 and asterisks class 4. The arrow indicates the time of sunspot maximum.

TABLE 1. Cosmic Ray Decreases 1978 - 1982

Event Number	Date	Onset Time, UT	Shock-Onset hrs	Decrease % MTW	Decrease % IMP8	Class	Source Longitude
			1978				
1	Jan. 3	18	3	5	15	1	E06
2	Jan. 25	21	5	5	10	4	...
3	Feb. 15	00	2	17	-1	1	W20
4	Mar. 8	15	0	8	21	2	E20
5	Apr. 10	12	-1	6	17	1	W11
6	Apr. 18	06	6	5	-1	2	...
7	Apr. 30	09	-1	15	-1	2	E38
8	June 2	12	3	7	14	1	W43
9	June 25	12	4	5	-2	1	E16
10	July 13	09	5	8	-1	2	E45
11	Sept. 29	06	3	9	14	3	...
12	Nov. 12	03	2	5	12	1	E01
13	Dec. 19	00	20	6	11	4	...
			1979				
14	Feb. 18	09	6	7	-1	2	E59
15	Apr. 5	06	4	7	15	1	W14
16	Apr. 25	03	3	7	11	1	E10
17	June 6	21	2	6	-1	2	E14
18	July 7	06	10	8	-1	2	E36
19	Aug. 19	09	-21	9	-1	2	E90
20	Sept. 15	09	...	10	-1	2	E90
21	Oct. 6	18	7	6	14	4	...
22	Nov. 9	06	4	7	14	4	...
			1980				
23	Feb. 6	12	9	7	-2	4	...
24	Apr. 2	21	...	7	18	4	...
25	June 7	15	16	7	19	4	...
26	June 24	06	3	5	11	1	E14
27	July 25	15	4	5	12	1	E17
28	Nov. 25	03	4	4	7	2	W20
29	Nov. 30	00	...	4	10	2	E63?
30	Dec. 19	09	4	6	12	3	W20
			1981				
31	Jan. 29	12	5	7	14	4	...
33	Mar. 01	09	1	5	10	3	...
34	Mar. 05	09	3	4	10	3	...
34	Apr. 3	09	5	6	-1	2	W52
35	May 11	03	5	4	-1	2	E42
36	May 18	03	4	8	-1	1	E14
37	July 25	21	16	8	18	3	...
38	Aug. 10	06	2	5	-1	2	E25
39	Oct. 11	06	15	5	-1	2	E83
40	Oct. 14	00	1	8	-1	2	E31
41	Oct. 20	18	...	4	-2	3	...
42	Nov. 11	15	2	8	-2	1	E17
43	Dec. 29	15	10	6	10	1	E16

1982

44	Jan.	31	06	5	8	-1	2	E13
45	Feb.	12	00	9	6	14	3	...
46	Mar.	1	12	0	7	12	3	...
47	Apr.	24	18	-2	4	9	3	...
48	June	9	09	9	6	-1	2	E25
49	June	12	18	3	4	-1	2	...
50	July	11	15	5	6	-1	2	E76
51	July	13	18	2	19	-1	2	E36
52	Aug.	7	00	5	4	13	3	...
53	Sept.	6	03	4	9	18	1	E33
54	Sept.	21	09	5	8	25	1	E06
55	Nov.	24	09	0	7	-1	2	W36
56	Nov.	30	15	3	6	-1	2	W87
57	Dec.	10	09	2	6	-1	2	W86
58	Dec.	17	12	4	5	-1	2	E24
59	Dec.	27	12	5	5	-1	2	E45

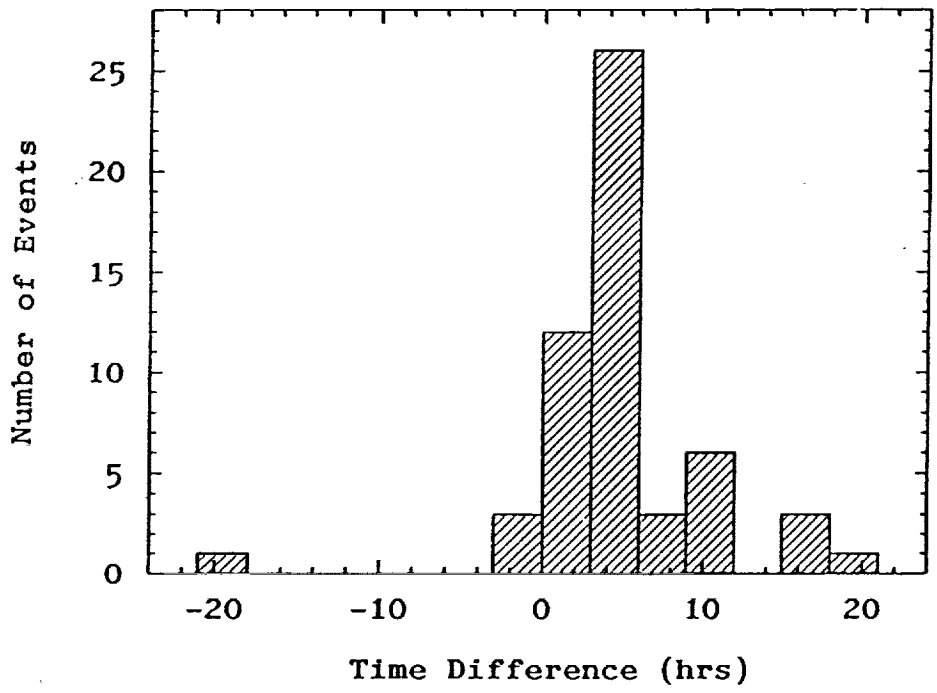
Number of Events
25
20
15
10
5
0
-20
-10
0
10
20
Time Difference (hrs)

FIGURE 1

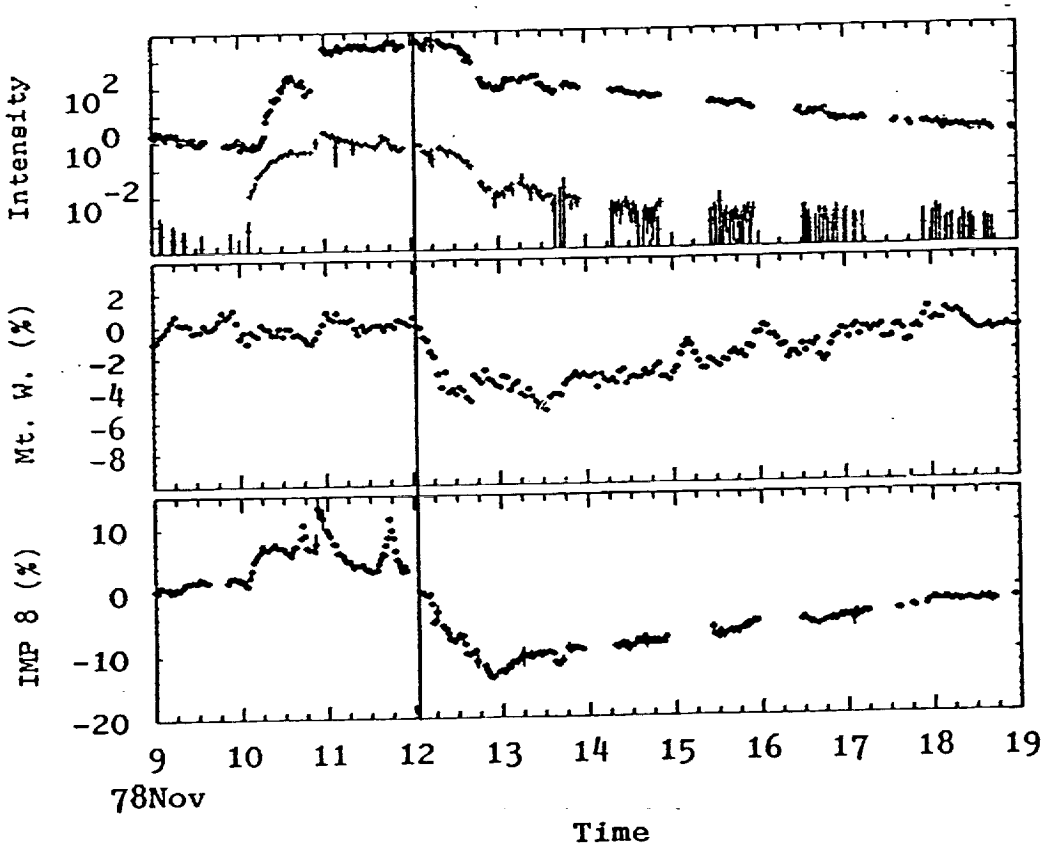
Intensity
10^2
10^0
10^{-2}
Mt. W. (%)
2
0
-2
-4
-6
-8
IMP 8 (%)
10
0
-10
-20
9
10
11
12
13
14
15
16
17
18
19
78Nov
Time

FIGURE 2

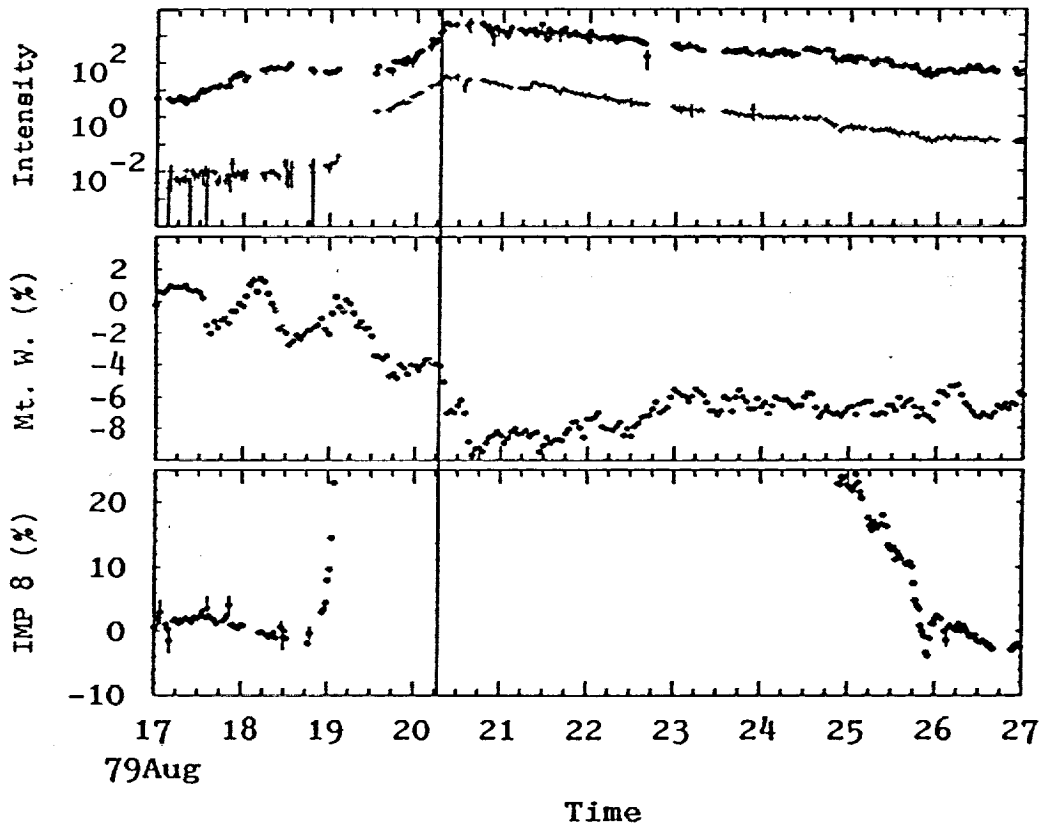
Intensity
10^2
10^0
10^{-2}
Mt. W. (%)
2
0
-2
-4
-6
-8
IMP 8 (%)
20
10
0
-10
17
18
19
20
21
22
23
24
25
26
27
79Aug
Time

FIGURE 3

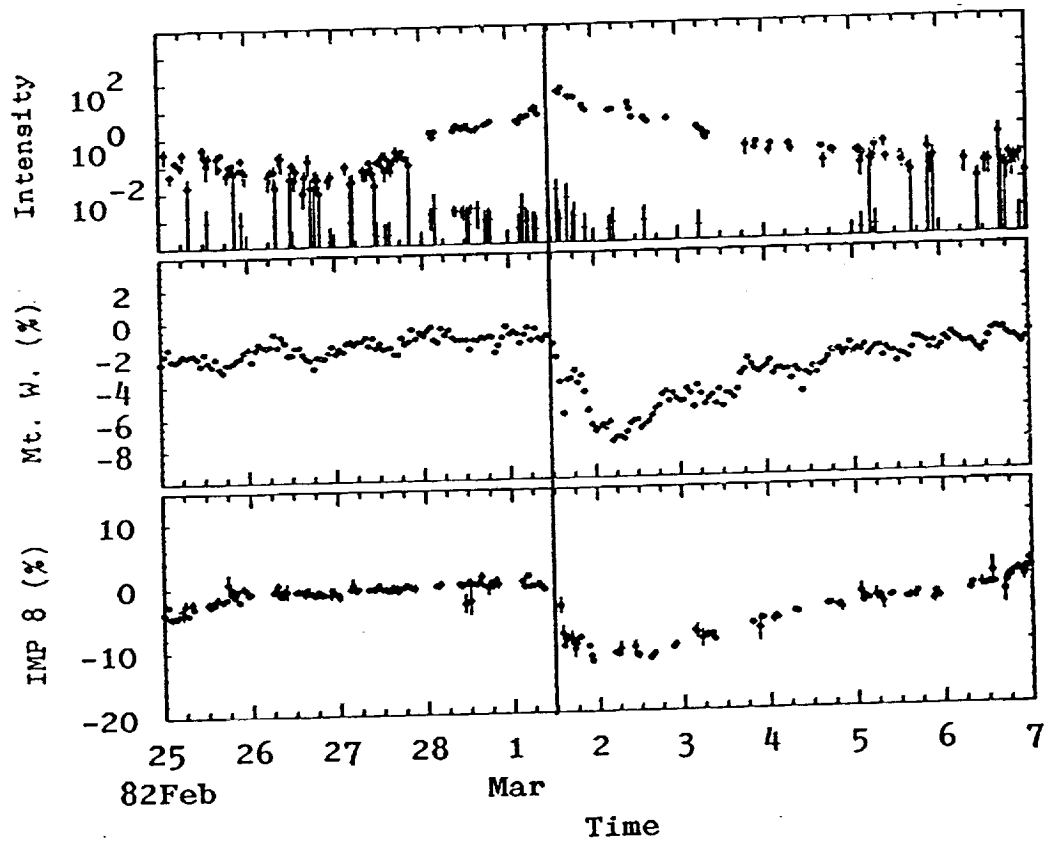
Intensity
10^2
10^0
10^{-2}
Mt. W. (%)
2
0
-2
-4
-6
-8
IMP 8 (%)
10
0
-10
-20
25
26
27
28
1
2
3
4
5
6
7
82Feb
Mar
Time

FIGURE 4

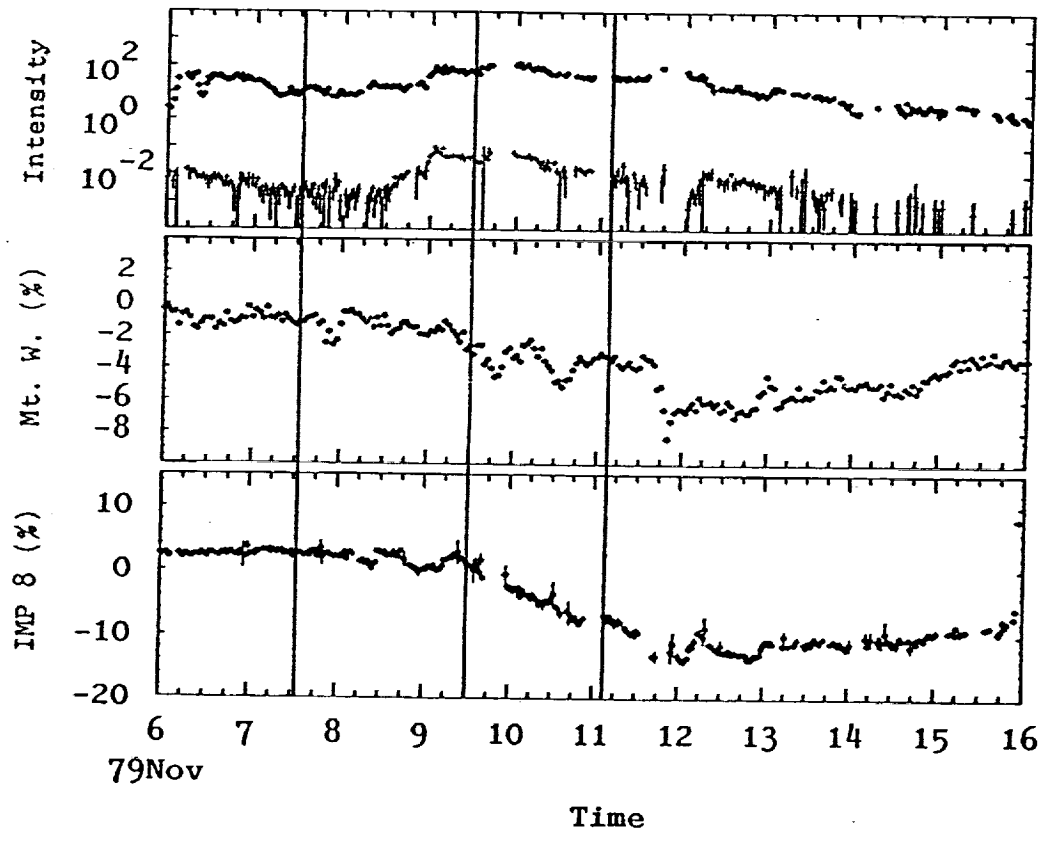
Intensity
10^2
10^0
10^{-2}
Mt. W. (%)
2
0
-2
-4
-6
-8
IMP 8 (%)
10
0
-10
-20
6
7
8
9
10
11
12
13
14
15
16
79Nov
Time

FIGURE 5

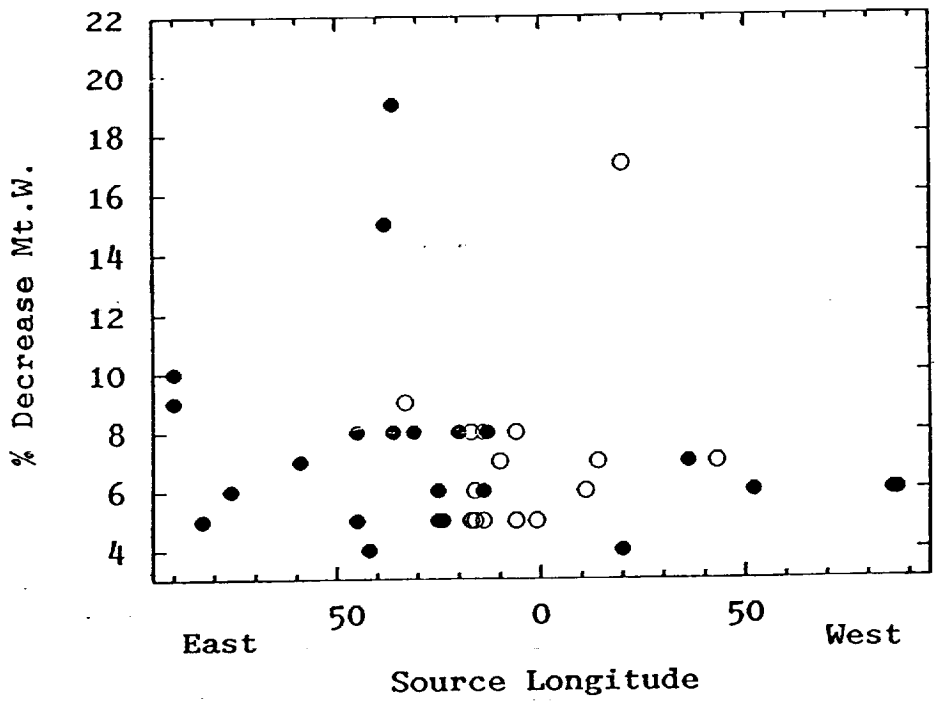
22
20
18
16
14
12
10
8
6
4
% Decrease Mt.W.
50
0
50
East
West
Source Longitude

FIGURE 6

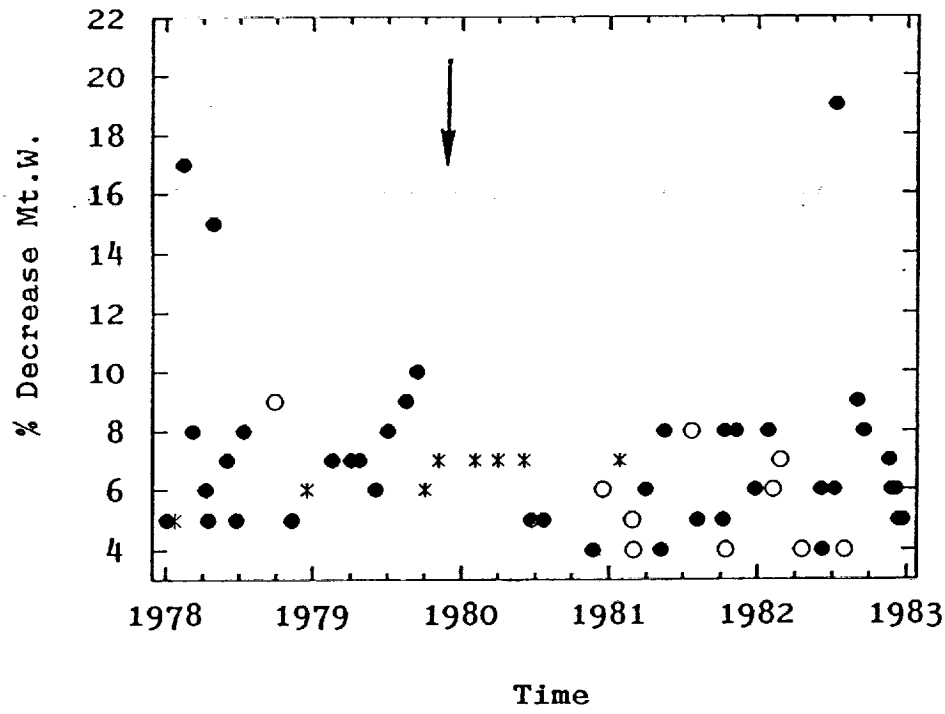
% Decrease Mt.W.
22
20
18
16
14
12
10
8
6
4
1978
1979
1980
1981
1982
1983
Time

FIGURE 7

660-035

Quarterly Technical Report for 1 July to 31 September 1992

Brenda L. Dingus
Task No. 660-035

I am continuing to develop the drift chamber tracking detector for AGATE. The construction of the 8 - 1/2 by 2 square meter frames has been completed. Four frames have three layers of 2 meter long wires, and the other four frames have only one layer of 1/2 meter long wires. The frames will be placed in a vacuum chamber that we have had built, and amplifiers and discriminators will be installed for each anode wire. The electronics is being tested on the 1/2 by 1/2 square meter frames. An alternative driver for the signals is being considered since the driver causes oscillations on the ground that are then being amplified. We have not yet been able to detect tracks from the 1/2 by 1/2 meter stack of drift chambers due to excessive noise.

The AGATE anticoincidence dome is a composed of several very large pieces of plastic scintillator. The baseline readout system uses over 200 photomultiplier tubes. I have recently reviewed a proposal by RMD, Inc. to develop avalanche photodiodes to replace the photomultiplier tubes on the anticoincidence dome. Avalanche photodiodes require less power, are light weight, small, and more stable than photomultiplier tubes.

The results of some of my analysis of EGRET data were presented at the Washington University Compton Observatory Symposium. Godfreid Kanbach gave a paper about the solar flares observed by EGRET during June 1991, and Ping Kwok showed a poster about two gamma-ray bursts which were within the EGRET field of view. I was also a coauthor on several other EGRET talks which were presented. The papers for the symposium will appear in an AIP volume and will be submitted by the end of October.

I have begun writing a paper for Ap. J. on three high galactic latitude sources seen by EGRET which have positions consistent with flat spectrum, radio loud, active galactic nuclei. The 3 sources are 0454-463, 0202+149, and 1606+106. I have examined the data for evidence of time variability and am working on the energy spectrum for each object. The number of gamma-rays observed in all 3 cases is small, so the estimate of the statistical significance is especially relevant. After finishing this paper, I plan to search the EGRET data for evidence of sources which have been detected at energies above EGRET's threshold.

I have also submitted two abstracts for a meeting entitled "Astroparticle Physics and Novel Gamma-Ray Telescopes" which will be held in April 1993 in Orlando, Florida. The abstract titles are "The Advanced Gamma-ray Astronomy Telescope Experiment, AGATE" and "Detectability of Monoenergetic, GeV, Gamma-Rays based on Preliminary EGRET Measurement of the Diffuse Gamma-Ray Spectrum".

The following paper was accepted for publication.

"Observations of the Large Magellanic Cloud in High Energy Gamma Rays", P. Sreekumar, D.L. Bertsch, B.L. Dingus, C.E. Fichtel, R.C. Hartman, S.D. Hunter, G. Kanbach, D.A. Kniffen, Y.C. Lin, J.R. Mattox, H.A. Mayer-Hasselwander, P.F. Michelson, C. von Montigny, P.L. Nolan, K. Pinkau, E.J. Schneid, D.J. Thompson, accepted by Ap. J. Letters.

The following papers were submitted for publication.

"Detection of High Energy Gamma Rays for Quasar PKS0528+134 by the EGRET Telescope on the Compton Gamma Ray Observatory", S.D. Hunter, D.L. Bertsch, B.L. Dingus, C.E. Fichtel, R.C. Hartman, G. Kanbach, D.A. Kniffen, P.W. Kwok, Y.C. Lin, J.R. Mattox, H.A. Mayer-Hasselwander, P.F. Michelson, C. von Montigny, H.I. Nel, P.L. Nolan, K. Pinkau, H. Rothermel, E.J. Schneid, M. Sommer, P. Sreekumar, D.J. Thompson, submitted to Ap. J.

"The EGRET Detection of OVV Quasar 1633+382", J.R. Mattox, D.L. Bertsch, J. Chiang, B.L. Dingus, C.E. Fichtel, R.C. Hartman, S.D. Hunter, G. Kanbach, D.A. Kniffen, P.W. Kwok, Y.C. Lin, H.A. Mayer-Hasselwander, P.F. Michelson, C. von Montigny, P.L. Nolan, K. Pinkau, E.J. Schneid, P. Sreekumar, D.J. Thompson, submitted to Ap. J. Letters

Brenda L Dingus 10/23/92

HAMPDEN-SYDNEY COLLEGE
Founded 1776

DEPARTMENT OF PHYSICS

October 2, 1992

Dr. Donald A. Kniffen
P.O. Box 862
Hampden-Sydney, VA 23943-0862

University Space Research Association
Visiting Scientist Program
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

Subject: Technical Activity Report

This report accompanies a consulting voucher for services provided under NAS5-30442 in Supporting the High Energy Gamma-Ray Telescope (EGRET) on the Compton Gamma-Ray Observatory, and a travel reimbursement request for a trip to the Goddard Space Flight Center to complete the subject activity. This report covers activities for the month of September 1992.

Activities during this reporting period involved attendance at the EGRET Team meeting held at the Goddard Space Flight Center on September 22-24 and preparations for this meeting on September 21, 1992. The principle activity of this meeting was the preparation of papers for submission in the near future involving Phase I results from the EGRET experiment. The consultant was also responsible for obtaining correction factors for calibration sensitivity values which have been updated using in-flight data.

Sincerely,

Donald A. Kniffen

HAMPDEN-SYDNEY, VIRGINIA 23943 • (804)223-6183 • FAX (804) 223-6374

September 3, 1992

Dr. Donald A. Kniffen
P.O. Box 862
Hampden-Sydney, VA 23943-0862

University Space Research Association
Visiting Scientist Program
NASA Goddard Space Flight Center
Greenbelt, Maryland 20771

Subject: Technical Activity Report

This report accompanies a consulting voucher for services provided under NAS5-30442 in Supporting the High Energy Gamma-Ray Telescope (EGRET) on the *Compton* Gamma-Ray Observatory. This report covers activities for the month of August 1992.

Activities during this reporting period involved work accomplished at the Hampden-Sydney College, working remotely via a NASA Internet link. The activities fell into three major categories: (1) scientific data analysis, (2) performance monitoring of the EGRET instrument, and (3) review of the EGRET Guest Investigator involvement in Phase II and Phase III of the *Compton* Observatory Guest Investigator Program.

The data analysis work included development of a correction factor for correcting for an improper exposure in the lowest energies of the EGRET instrument. Upon completion of this work final work will be completed on the time variability in the gamma-ray emission from the source 3C279 discovered by EGRET as a gamma-ray emitter, and the manuscript submitted for publication. This will be followed by papers on EGRET observations of pulsars for the Compton Observatory workshop in St. Louis and a paper on gamma-ray emission from the globular cluster 47-Tucanae.

The performance monitoring included the continued supervision of a Hampden-Sydney College student to analyze the housekeeping data from the EGRET instrument. Analysis is done remotely from Hampden-Sydney College, by networking to the computers at the Goddard Space Flight Center.

The analysis of the Guest Investigator involvement consisted of a review of the Guest Investigator proposals to look for

possible conflicts or duplication between the proposed work of the Guest Investigator and work being accomplished by the EGRET team.

Sincerely,

Donald A. Kniffen

Donald A. Kniffen

660-038

To: Denise Dunn
From: Dr. M. Corcoran
Task No: 660-038
Subj: 3rd Quarter Technical report, 1 Jul 1992 – 30 Sep 1992
Date: 23 Oct 1992

ARCHIVE-SPECIFIC TASKS:

My duties as archive scientist involved the development of the ROSAT public archive in anticipation of its opening in October, and development of the new ROSAT Rationalized FITS file format which will be used to distribute/archive data processed by the new software system. My 3rd quarter activities in these areas are described below.

1) Public archive:

a) The data flow pipeline from the USRSDPC to the NSSDC has been implemented and successfully tested. The USRSDPC has successfully sent data to the NDADS staging area, and the NSSDC has successfully copied this data to optical disk. Automatic retrieval of the test data using ARMS was completed successfully .

b) The mecahnism by which users can browse the list of distributed ROSAT data sets via use of the Mission Information and Planning System (MIPS) has been implemented. Use of MIPS to request ROSAT public data sets has also been tested successfully.

c) The mechanism by which users can browse the list of distributed ROSAT data sets using BROWSE has been implemented and successfully tested.

d) I've placed lists of public data in an anonymous FTP area for downloading by archive users.

e) I've assisted Peter Damon in writing the "public contents" file which needs to be generated for each data set before the data set can be archived by the NSSDC. Software is now in place to generate this file automatically.

f) I've written a draft of the ROSAT Public Archive User's Manual which will appear as an article in both the ROSAT and HEASARC newsletters.

g) I participated in discussions concerning the overall structure of the archive with representatives of the USRSDPC and MPE in September.

2) Rationalized FITS development:

a) Development of the rationalized FITS files (which will define the format in which data processed by the new processing software will be distributed and archive) is nearing completion. I have now provided file specifications for each of the 4 types of files (BASIC, ANCILLARY, CALIBRATION and DERIVED) associated with HRI and PSPC data.

b) Dave Bouler has written software to generate each of the 4 files for each ROSAT instrument. I am presently engaged in testing these files. Some minor problems have been identified and fixed.

C-2

c) I've re-structured the DERIVED file for both the HRI and PSPC by splitting the file into a number of separate components. Modification of the gatherer routine by Dave Bouler is set to begin.

USER SUPPORT ACTIVITIES

1) I provided GOF support to the following guest observers in the 3rd quarter

Gayle Rawley
Tim Heckman
Lee Armus
V. Tsikoudi
Wayne Waldron
Qingde Wang
Raymond White
Richard Pisarski
Dennis Cioffi

2) I provided archive support to

Richard Thompson
Stephen Unwin
Peter Meszaros
James Rose
George Pavlov
Michael Garcia
Qingde Wang
Jonghee Rho

in the third quarter.

2) Programming:
Below is a list of IDL programs written or updated in the 3rd quarter:

```
coverlay.pro - overlays contour map on image
stretcher.pro - stretches image to specified dimension
dft.pro - performs discrete fourier transform on time-sorted data
ring.pro - draws ring at specified location in contoured image
jd.pro - calculates julian date
get_list.pro - modified to read directly from FITS file
mkatable.pro - outputs spectral table model in XSPEC "atable" format
```

SCIENCE ACTIVITIES:

1) I presented a poster of a recent ROSAT observation of the Wolf-Rayet binary V444 Cygni at the COSPAR symposium "Recent Results in X-ray and EUV Astronomy" at the World Space Congress in Washington DC (28 Aug – 5 Sep 1992)

2) I am participating in a collaboration with J. Siah and E. Guinan at Villanova to observe the star HD229041 (which is possibly X-ray bright) with the Automated Photometric Telescope on Mt. Hopkins. Preliminary results suggest the presence of possibly periodic variability.

3) I've completed a draft of analysis of the X-ray spectrum of Zeta Pup obtained with BBXRT.

PLANNED 4th QUARTER ACTIVITIES

1) Supervise opening of ROSAT public archive.

2) oversee development/testing of gatherer programs to produce rationalized FITS formatted files

3) write up results of ROSAT observations of V444 Cyg.

4) Attend "Back to the Galaxy Meeting" at U Md in October.

5) Present poster describing the format of the ROSAT Rationalized files at the ADASS conference in Boston in November.

6) Discuss ROSAT public archive at ROSAT Workshop in Boston in November.

7) Publish paper on BBXRT spectrum of Zeta Pup, and complete analysis of BBXRT spectra of Zeta Ori and EZ CMa.

660-040

Technical Reports for July 1 through September 30, 1992

Hisamitsu Awaki
Code 666
TASK NUMBER : 660-040

In previous period, I tried to figure out the property of the X-ray telescope (hereafter XRT) using the a ray tracing program, and obtained nature of the XRT. In this period; we illuminated the XRT with a parallel X-ray beam at White Sands, New Mexico, and have evaluated the characteristics of the XRT.

First, we prepared the experiment, in particular, I took charge of the preparation of the flow counter monitoring the intensity of X-ray beam. The flow counter was delivered from Japan, and I adjusted it with Dr. Tsunemi who is assistant professor at Osaka University.

We carried out the experiment with MIT and NIST from August 15 through to October 10, and I joined it in twice, from August 15 through to August 22, and September 9 through to September 23. During first two weeks, we set up equipment, and the XRT was calibrated using a monochrometer and an X-ray CCD detector from the beginning of September.

Now, we are analyzing data taken at White Sands. I am interested in the effective area around gold edge. I compared them from the results of a ray tracing, and try to reproduce the data, adjusting the optical constant in the ray tracing.

In addition, I present my paper entitled "Ginga observations of Seyfert Galaxies" at COSPAR Symposium in Washington D.C. in stead of Prof. Koyama. This is a summary of Ginga observation for Seyfert 2 galaxies. We found that in general the observational results are consistent with the prediction of unified Seyfert model proposed by Antonucci and Miller.

In next period, I will evaluate the image quality of the XRT, and would like to investigate how to reproduce real data. Using simulation-data, I would like to study the image restoration technique.

660-041

Universities Space Research Association
Foriegn Travel Report - 17 September, 1992

Gregory Pike
NASA/GSFC
Code 666
301-286-3565

During the period September 14-17, 1992 I attended the Astronomy from Large Databases II conference in Strasbourg/Haganeau, France. The conference was designed to allow scientists with large databases to present results and demonstrate the capabilites of their algorithms.

The ALD-II conference alowed me the opportunity to perform a number of tasks. First, I presented the latest results from the IUEAGN database, including our recent BL Lacertae continuum survey and PKS 2155-304 micro- variability study. The database project itself received general exposure to the scientific community. Finally, I was able to update myself on the latest products available to database designers and how these systems have been implemented in other projects such as NED and SIMBAD.

In addition to database design, ALD-II focussed on specific data sets, including *ROSAT*. This was especially informative since I will be developing a database of *ROSAT* spectra in the coming months.

UNIVERSITIES SPACE RESEARCH ASSOCIATION
VISITING SCIENTIST PROGRAM
QUARTERLY TECHNICAL REPORT
JULY 15, 1992 - AUGUST 14, 1992
RUPALI CHANDAR

Since arriving here at the end of October 1991 my main programatic responsibility has been to finish cleaning of the CMA database and produce a catalogue of point sources detected by the 3 - lexan filter of EXOSAT. We have discovered numerous problems with the database and the preliminary catalogue that was created from it. Most of these have been fixed now and we are ready to recreate the database and see what problems still remain to be corrected. All the images included in the preliminary catalogue have been assigned a classification and put into the appropriate sample. There are a total of six classifications:

1. POINT SOURCES - good sources which will go in the catalogue and have correct count rates and position.
2. PSF problem sources - point sources that were detected far out in the detector and have incorrect count rate and position
3. GOOD SOURCES THAT ARE EXTENDED such as supernova remnants, clusters, etc
4. MARGINAL entries - there are 420 of these out of 3956 total entries. These are images where a detection is made, but there is no definite source in the region. These will probably be added on as an appendix to the point source catalogue
5. SPURIOUS detections. These include images that put in unreal sources due to detector problems, such as grating or a pixel stripe, and extra detections of extended emission from a large nearby source
6. CALIBRATION PROBLEMS - this includes the CYGNUSX-2 field (raster scan) and the HZ43 field where the position of the source was not updated, resulting in several entries for a single source.

These different entries will receive classification numbers ranging from 0 to 6 which will make recreation of a cleaned catalogue easier.

The time since July 15th has also been spent writing down exactly what has been done to the database and the catalogue. The above samples have been written down in text files, and we have begun to write a paper of the steps taken to locate the problems and the correction measures applied afterwards. We do plan to continue to work to finish up the catalogue of point sources. Also being continued is work on the images from the aluminum paralene filter.

660-042

Technical Report

Robert J. Nemiroff

1 July 1992 to 31 September 1992

The third quarter of 1992 was one of writing papers, supervising graduate work, and carrying out research. Recearch topics I participated in included investigation of gravitational effects near neutron stars and black holes, investigation of potential cosmological effects on gamma-ray bursts (GRBs), and searching for possible echoes in GRBs caused by gravitational lensing.

I continued to research how gravitational lens effects distort the appearance of a high gravity environment, such as near a neutron star or black hole. I have now completed a paper on this subject and submitted it to the American Journal of Physics. I also continued to research what visible effects a neutron star would show if it had an ultracompact equation of state. I have been collaborating with Peter Becker and Kent Wood, both of the Naval Research Laboratory on this subject. We have submitted a paper on this subject to The Astrophysical Journal. This paper has been accepted.

I continued a research project of which I was a co-investigator in a Phase 2 *Compton* Gamma Ray Observatory proposal - searching for direct lens echoes in gamma-ray burst data. I spent more time deciding which mathematical tools would best show this and coding these tools onto a VAX computer in FORTRAN and IDL. This research is not yet complete, however some preliminary results are in. All GRBs within 20 degrees of each other that triggered on the *Compton* Gamma Ray Observatory satellite before 21 July 1992 were compared for gravitational lens echoes. No lensing echoes have yet been found, although comparisons are ongoing. Preliminary indications are that a non-detection of echoes inside the first 49 GRB time profiles significantly constrains the type and abundance of dark matter in the universe. Specifically, the non-detection translates into a probablility that compact dark matter with mass between 10^6 and 10^7 solar masses cannot have an abundace of closure density. Research in this area in ongoing and results are being written up into papers.

I continued to help supervise the graduate work of Thulsi Wickramasinghe from the University of Pennsylvania. He has visited NASA/GSFC five times now, twice in this quarter. We continue to discuss how gravitational lensing could be seen in gamma-ray burst data. We also continue to investigate what cosmological redshift distribution is implied by the number counts of gamma-ray bursts of different brightnesses. Thulsi continues to excel in research in this area.

During the fourth quarter of 1992, I plan to continue to fulfill the research objectives outlined in the description of the position that I was hired to fill. This will include studying more about GRBs, gravitational effects detectable in the universe, and detectable gravitational effects on GRBs.

Quarterly Technical Report
(1 July - 30 September 1992)

Name: Wan Chen
Position: Research Associate
Task Number: 5000-643
Date: 25 October 1992

Travel : 10-12 September 1992, Convention center, D.C., COSPAR meeting.

Wrok accomplished: An Interpretation of the Narrow Positron Annihilation Feature from X-ray Nova Muscae 1991, Wan Chen, Neil Gehrels, and F.H. Cheng, submited to ApJ, Letters, in 14 August 1992, and the revised version in response to the referee's report in 25 September 1992.

Work in progress and planned:

(1) Modeling the secondary maximas in the X-ray and UV light curves of X-ray novae A0620-00, GS2000-25, Nova Muscae 1991, and GRO J0422-32. Data show that in these black hole candidates, the normal light curve, an exponential decay of time scale of about 30 days, has always a second maximum around 50-80 days after the outburst. We are trying to model such brightening by increased mass overflow from the secondary due to X-ray heating of the inner Lagrangian point in the late stage of the decay phase when the accretion disk becomes optically thin. This work is in collaboration with Dr. Mario Livio in Space Telescope Science Institute.

(2) Companion in the Galactic center hard X-ray source 1E1740.7-2942. It has been great difficulty in trying to find the optical counterpart of this source. The IR search in the Galactic center region has always failed to reveal any point source in the radio position or X-ray error circle. We use the reported I-, K-, and L-band upper limits to place a severe limit in the luminosity and spectral type of the possible companion on the HR diagram. The companion has to be a late type dwardf or subgiant. But the X-ray light curve has shown some long-term variability. We are investigating the possibility that binary accretion from a late type dwarf companion to produce such long-term variabilities. A possible explanation is the magnetic solar-cycle type of variability from such stars.

(3) Instabilities in Bondi-Hoyle type of accretion systems. The long-term variability from the Einstein source 1E1740.7-2942 may also be due to the instabilities in the Bondi-Hoyle accretion if the source is accreting directly from the surrounding molecular cloud. Such an instability may be the result of the X-ray heating of the cloud material near the source. The heating creates a cavity and so turns off the accretion. Low accretion will cause the X-ray radiation drop and the accretion can then restart. We are carrying out theoretical calculations to see if this can work.

(4) A trip is planned to go to Toulouse, France, to work with SIGMA team on the Nova Muscae black hole mass, 1E1740.7-2942 light curve, GRO J0422-32 possible positron annihilation line data.

(5) Model the broadband spectrum from stellar balck hole accretion disk system X-ray Nova Muscae 1991 and Cen X-4.

(6) Publish my thesis results.

660-044

USRA Technical Report (3rd Quarter, 1992)

Helmut Seifert (Task Number: 660-044)

Task Description:

I have been leading the Transient Gamma-Ray Spectrometer (TGRS) data analysis and Ground Support Equipment software development, and am responsible for writing the software requirements/specifications and documentation. I am furthermore designing and testing the algorithms which are being used by the software. Similar work is done by me also for the KONUS instrument. I am taking an active part in the laboratory testing of the TGRS analog/digital flight electronics and software. I am responsible for formulating and conducting all the instrument tests and calibrations during the integration and calibration phase of TGRS.

Activities:

In July, August, and the first two weeks of September 1992 I was working in the laboratory on the characterization and calibration of the TGRS detector and electronics. For these activities TGRS was in flight configuration, complete with our recently delivered Ge detector (in Al module), front-end, and analog/digital electronics. The detector performs well and we obtain about 4 keV (@1 MeV) resolution.

From 14–16 September 1992 I lead the team which delivered the TGRS electronics to GE Astro in Princeton, NJ. We successfully performed the Bench Acceptance Test and also verified the performance of the GE flight harnesses.

In the time of 17–30 September 1992 I calibrated the detector efficiency using the engineering analog and digital electronics, and in the week of 5–9 October I supervised work on the TGRS Operational Test Fixture (OTF). We installed a fixture which can hold a radioactive calibration source for future use.

From 14–17 October 1992 I attended the Compton Gamma-Ray Observatory Symposium in St. Louis, MO, where I presented a poster paper on the TGRS instrument. During the same time the detector was cooled down again to cryogenic temperatures.

In the week of 19–23 October 1992 more efficiency calibrations were performed in the laboratory. At the same time, I made preparations for various work to be done on the flight radiative cooler after 26 October 1992.

In parallel to all the aforementioned activities, I could complete two software requirements and specifications documents for TGRS and KONUS. The TGRS document deals with software which will generate count time-histories for various data-types. The KONUS document deals with the software which will read/decode the raw telemetry data, extract/sort the data by type, and manage them in a data base.

In the next few weeks there will be more data analysis software development, and on or about 18 November 1992 I will again lead a team which will deliver the TGRS detector/cooler assembly to GE Astro in Princeton, NJ. In the following months I will participate in the various environmental tests at GE.

666-046
(666-030)

James Lochner
LHEA Office for Guest Investigator Programs
Code 668.0
(Activity 5000-646)

3rd Quarter Report, 1992

From 1 July through 30 September 1992, Dr. Lochner spent considerable effort on the Guest Observer Facility (GOF) for the X-ray Timing Explorer (XTE). The GOF is part of the Science Operations Center (SOC) managed at Goddard by the X-ray Astrophysics Group (Code 666.0). Having defined the XTE GOF requirements in the previous quarter, Dr. Lochner spent the third quarter collaborating with other SOC members on the development of the SOC software architecture, the construction of a software build plan, and preparing for presentations at the SOC Preliminary Design Review on Sept. 3 - 4.

The software being developed in the SOC for science operations and analysis utilizes an object oriented architecture. Of the many software subsystems being designed, Dr. Lochner has concentrated on the Data Analysis, Calibration and Proposal subsystems. The goal is to achieve completeness in meeting the requirements and allow flexibility as knowledge of the instruments and new analysis techniques develops. During this time, strawman designs were put in place so that a common framework could be developed. By doing this, the design team recognized those subsystems which would entail greater complexity than originally thought. The goal for the next quarter is to put in place realistic designs.

Dr. Lochner also headed up the effort to construct a development plan for the SOC software. Dividing the software into subsystems, each subsystem undergoes a staged development up to and beyond the XTE launch in Aug 1996. This staging puts the fundamental architecture into place early, and successively enhances the capabilities. This approach insures that the software necessary to support operations is in place long before launch.

Considerable effort was spent preparing for the SOC Preliminary Design Review (PDR) on Sept 3 - 4. The month of August was spent participating in reviews and dry runs to prepare for the presentation. At the PDR, Dr. Lochner presented the SOC's design of the Analysis and Calibration software architecture, and of the software build plan. It is anticipated that in the next quarter, Dr. Lochner will formulate appropriate responses to the concerns of the PDR review team.

Dr. Lochner also organized and presided over two of the software interface meetings between the SOC and the instrument teams from MIT, UCSD and GSFC. During the third quarter, these meetings were held at Goddard July 13, Aug 13 - 14, and Sept. 24, with Dr. Lochner presiding

over the latter two. These meetings, which are held regularly, provide opportunities for the SOC and instrument teams to discuss software interfaces and shared responsibilities which must be further delineated. In particular, the meetings during this quarter were important in laying out the framework of the software design, and describing the areas in which the instruments teams are expected to contribute to the software design. We have also discussed common issues such as selection of a data base management system, base class libraries, software development standards and quality assurance standards. Dr. Lochner will continue organizing these meetings into the next quarter.

In other areas, Dr. Lochner has continued to be available to Dr. Laura Whitlock to provide assistance in the HEASARC All Sky Monitor effort. He has continued to share his own plans and ideas which he had developed for the *Vela 5B* and *Ariel 5* data before shifting his effort to XTE. He and Dr. Whitlock wrote an article for the HEASARC journal *Legacy* describing these data and their availability through the HEASARC.

With Dr. Whitlock, Dr. Lochner also continued the investigation of long term trends in galactic X-ray sources using the *Vela 5B* data. They examined the data for the sources in the Small Magellenic Cloud, finding transient events in a HEAO-1 A1 source. They also initiated an investigation into a suspected systematic trend in the *Vela* data due to the satellite's 300 day precessional period. They also continued the routine investigation the Vela data for previous outbursts of new transients sources identified in the Circulars of the International Astronomical Union.

Finally, this third quarter saw publication of Dr. Lochner's work with Dr. Alan Smale on a Vela 5B study of long term variability in low mass x-ray binaries (Ap.J. **395**, 582)

Report of activity for the period July - September 1992 – Ivan HUBENY

During this period, I have worked on extending newly developed numerical techniques for calculating very sophisticated model atmospheres of hot stars. Together with Dr. T.Lanz (NRC fellow), we have calculated many non-LTE model stellar atmospheres including effect of tens of thousands spectral lines (the so-called non-LTE line blanketing), using our previously developed concept of non-LTE opacity distribution functions. First results have been presented on the IAU Colloquium No. 138 in Trieste, and several papers are in preparation and are expected to be submitted soon.

I have worked with Dr. D. Mihalas on a third edition of the textbook "Stellar Atmospheres". We have prepared a detailed outline of a completely changed book, taking into account all recent developments.

I have also worked at the NCAR with Drs. B. Lites and P. Judge on radiative transfer with partial frequency redistribution.

I have collaborated with researchers from Space Telescope Science Institute and Johns Hopkins University on model atmospheres for white dwarfs in some cataclysmic binary systems.

Trips accomplished:

1) July 4 - 11, Trieste, Italy - IAU Colloquium No. 138 "Peculiar versus Normal Phenomena in A-type and Related Stars"; presenting two invited papers there.

2) July 24 - August 24, Boulder, CO (HAO NCAR and JILA); collaborating with Dr. D. Mihalas on writing a third edition of the book "Stellar Atmospheres", and collaboration with Drs. B. Lites and P. Judge on radiative transfer with partial frequency redistribution.

Papers published:

1) Hubeny, I., Lanz, T., 1992, "Accelerated Complete Linearization Method for Calculating non-LTE Model Stellar Atmospheres", *Astron. Astrophys.* 262, 501.

Papers submitted:

1) Hubeny, I., Lanz, T., 1992, "Modeling A-type Atmospheres: NLTE Models", in *Peculiar versus Normal Phenomena in A-type and Related Stars*, Ed. by F. Castelli, M.M. Dworetski, and R. Faraggiana, (in press).

2) Lanz, T., Hubeny, I., 1992, "Spectral Diagnostics of Chromospheres and Winds in A-type Stars", in *Peculiar versus Normal Phenomena in A-type and Related Stars*, Ed. by F. Castelli, M.M. Dworetski, and R. Faraggiana, (in press).

My plans for the next three months include

i) I will continue the work on NLTE line blanketed model atmospheres, in collaboration with Dr. T. Lanz. We expect to submit at least one, and hopefully two, papers to *Astronomy and Astrophysics*. Some results will also be presented at the AAS meeting in Phoenix.

ii) I will continue my work in theoretical analysis of hot stars, in collaboration with Drs. Sally Heap and Bruce Altner from the GHRS group in Goddard. In particular, the work will continue on interpreting the HST/GHRS spectra of the hot subdwraf BD+75 325; the first results will be presented at the AAS meeting in Phoenix.

iii) I will continue to work with researchers from Space Telescope Science Institute (groups of Drs. K.Long and K. Horne) on model atmospheres for solar–composition white dwarfs which are found in some cataclysmic variable systems, observed by Hopkins Ultraviolet Telescope and Hubble Space Telescope. Some results will be presented at the AAS meeting in Phoenix.

iv) I will continue to work with Dr. M. Plavec (UCLA) on models of accretion disks and helium–rich stellar atmospheres.

My travel plans include:

i) December 7 - 17, University of California, Los Angeles: collaboration with Dr. M. Plavec on theoretical modeling of spectra of accretion disks in the Algol and W Serpentis classes of close binary systems, and on helium-rich model stellar atmosphers.

JAMES BIGGS

QUARTERLY TECHNICAL REPORT

1 July 1992 - 1 September 1992

Hubble Space Telescope High Speed Photometer (HSP) activities have dominated my time in the past quarter. I have been heavily involved in the analysis of Crab pulsar data acquired with the HSP in October 1991 and January

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1992 (see 1/1/92 - 3/31/92 and 4/1/92 - 6/30/92 quarterly reports). One of my main activities was assisting Dr J. F. Dolan (NASA/GSFC) in the analysis and writing up of these observations for publication. The results of our study have been submitted and accepted for publication in the Astrophysical Journal.

Other HSP activities included analysis, on the NCCS CONVEX mini-supercomputer, of approximately 23 million samples of broad-band UV SN1987A data. These data have undergone Fourier analysis, and so far no significant sinusoidal or pulsar-like signal from the proposed remnant pulsar has been found. These observations are far more sensitive than any from the ground, and the upper limit is approximately 31st magnitude. Similar analysis of data collected over 4 months from the eclipsing dwarf nova Z Cha only found periodicities associated with the length of the individual observations, and the time interval between observations. Observations from the high-mass X-ray binary Cyg X-1 were searched for signals from matter infalling onto its proposed black hole. No signals were found, other than that associated with data corruption. The Space Telescope Science Institute (STScI) was notified about this problem. Also, in this quarter I assisted Dr Dolan in the extraction and reduction of polarization calibration observations.

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ROSAT data acquired for two old, but rapidly rotating, pulsars was analysed at the ROSAT data analysis facility at NASA/GSFC. No signals were detected from the pulsars, but useful constraints on their emission were obtained. Other sources, however, were found in the observations, and work is proceding in order to find more information on them.

In the middle of July 1992, I travelled to the NRAO 140 foot radio telescope at Green Bank, WV, for an observing session in a collaborative project with Dr C. Salter (NRAO) and Dr R. Foster (NRL) in which we are monitoring HI absorption in radio spectra. The observations were a success. So far, we have reduced all the data acquired and have produced absorption spectra for our selection of pulsars of similar, or higher quality, than those

published in the literature. We have also finished a draft of a proposal to observe the HI absorption spectrum of nearby pulsars with the 140 foot telescope at Green Bank.

A paper entitled "PSR 1718-19: A long-period pulsar in an eclipsing binary system" on which I was a co-author with Drs A. Lyne, P. Harrison and M.

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#1 10-SEP-1992 12:20:47.68 NEWMAIL
Bailes (University of Manchester) was submitted to Nature. Also, my paper entitled "Analysis of Radio Pulsar Statistics" was published in the August 10, 1992 edition of the Astrophysical Journal. Work on a paper with Drs M. Bailes and A. Lyne (University of Manchester) concerning two radio pulsars I discovered at my previous job is nearing completion.

The Directors Discretionary Proposal (submitted last quarter) to use the HSP to find pulses from the Geminga pulsar was accepted and awarded 1.5 hours observing time by the STScI. Other proposals submitted to STScI on which I was PI were: "A search for optical pulses from globular cluster radio pulsars" with Dr J. Dolan (NASA/GSFC) and Dr W. vanCitters (NSF), and "Phase-resolved UV spectrophotometry of the eclipsing pulsar PSR 1957+20" with Dr S. Shore (CSC). Also, I am a co-I with Drs A Michalitsianos and J. Dolan (NASA/GSFC), and Dr M. Perez (CSC) on a proposal entitled "HSP observations of MWC 560".

James Biggs 10 September 1992

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QUARTERLY REPORT: JULY 1 TO SEPTEMBER 30, 1992 68D - 011

This quarter, I have been working on documentation for the COBE project. The documents include the Cosmology Data Analysis Center (CDAC) Orientation Handbook, the COBE Guest Investigator System (CGIS) User's Guide, and the Guest Investigator (GI) Handbook. Most of my time has been spent on the CGIS User's Guide. This document is meant to be a tutorial for the CGIS interface, UIDL, and UIMAGE. I was first responsible for writing the section on UIMAGE, the COBE menu-driven software. To do this, I became very familiar with UIMAGE, its capabilities, problems, and areas which may be improved. I report the problems that I find with the new system so that they can be addressed. We are now in the final stages of completing the User's Guide so it can be presented at the October SWG meeting. Once this version is finalized, we will put it on-line so users can access it via the CGIS software. This will involve converting the text and graphics files from WordPerfect to ASCII and then implementing the document into the interface. When the CDAC Handbook is completed, it too will be converted to ASCII and put on-line for access through the CGIS software.

During this quarter, I was also involved in some of the CGIS interface development. I aided in the software conversion from JAM to IDL; this involved changing the menus and text screen files and finally conducting an interface "shakedown" to see that everything was properly installed.

A draft of the Guest Investigator Handbook was partially completed. This will be the visiting scientist's guide to the surrounding area and a brief overview of the CDAC facility.

My non-local travel included travelling to Pittsburgh in order to relocate.

CELINE GRODEN
NASA/GSFC CODE 6853
CDAC
COMMERCE CENTER II

Universities Space Research Association
Visiting Scientists Program
Technical Report for Third Quarter 1992

Employee Name: Alan Kogut Activity: 5000-821

My major effort for the period July 1 -- September 30, 1992 has been analysis of data from the Differential Microwave Radiometers (DMR) experiment aboard the Cosmic Background Explorer (COBE). Sky maps produced from the first year of data show significant structure in the microwave sky at levels consistent with predictions based on structure formation through gravitational collapse. I am a co-author on 3 papers in The Astrophysical Journal describing these results and first author on a fourth paper describing the analysis of systematic artifacts in the first-year maps.

I have continued efforts to quantify the anisotropy in the first-year maps, concentrating on limits to isolated point sources. The number density of such point sources can limit non-Gaussian contributions to the microwave anisotropy, providing a test of various theories predicting anisotropy at roughly the level found in the maps. I am also the first author on a paper describing in detail the DMR observations of the dipole anisotropy and implications for large-scale velocity flows in the Universe.

DMR has continued to take data; there are now nearly three years of data "in the can". The increased sensitivity provided by multiple years requires a more sophisticated understanding of weak instrumental effects in the data stream, while the increase in the size of the data set requires a faster system to make maps in timely fashion. I have assumed a leading role in preparing a new software analysis system to create new sky maps from the 2- and 3- year data set. A major emphasis is the instrument calibration. I have analyzed the multi-year data set for evidence of drifts in the existing calibration and will incorporate the results into a new set of calibration algorithms.

I have continued investigations of the spectrum of the microwave background. I attended the Second School for Astrofundamental Physics in Sicily to present an invited talk reviewing the current status of CMB spectral measurements, including COBE-FIRAS and recent ground-based measurements from the South Pole. I gave a similar talk to the cosmology seminar at Goddard Space Flight Center. I am Principal Investigator on a proposed Small Explorer satellite designed to measure the CMB spectrum to 0.1% precision and the large-scale anisotropy to DT/T ~ 10^-6.

During the next quarter, I plan to complete analysis and implementation of the multi-year DMR calibration. I will submit a paper on the DMR determination of the dipole anisotropy to The Astrophysical Journal, and will continue to investigate point sources and non-Gaussian structure in the one-year DMR maps.

Alan Kogut

October 26 1992

Quarterly Report for A.J. Banday, Activity: 5000-821, July 1 - September 30 1992.

Most of my time for the last 3 months has been devoted exclusively to providing support for the COBE space project.

In particular, I have completed my analysis of the eclipse effect and found that a promising means of correction is to use a linear combination of 2 spacecraft housekeeping signals (one corresponding to temperature variations, one to voltage variations during the spacecraft orbit) to remove an apparent baseline variation in the observed differential temperature measurements. This correction applied to the 31 GHz radiometers removes the spurious magnetic coefficients found in the absence of correction to about 70/to be within the month-to-month variations seen in the other channels, and thus the correction may be usable. I continue to monitor the effect, and when time is available try alternative methods of correction.

I have carried a comprehensive comparison between the COBE DMR results and the RELICT1 satellite in the light of their recent claim of detection of cosmic anisotropy in their 37 GHz map after a reanalysis. Having treated the DMR maps in exactly the same fashion as the RELICT1 map, I can confirm that there is no cosmologically significant structure in the COBE maps at the level claimed by the Russian group. This work is intended to be published, and I am currently working on the manuscript.

I have continued to study the effect of incomplete sky coverage and noise on the systematic fitting of quadrupoles to the DMR maps. This may be extended to higher order multipoles in order to check fits to power spectra. This is still in progress.

I have begun to assist Dr Gary Hinshaw in correlating the DMR maps with extragalactic source catalogs at both radio (5 GHz and 1400 MHz) and infra-red frequencies (IRAS point source catalog at 100 microns). It seems that there is little evidence for correlation between the DMR maps and the radio catalogs, which allows a limit to be placed on the contribution of known extragalactic radio sources. Work continues with the IRAS correlation. I have also begun to consider updating the theoretically expected contribution from unresolved discrete radio and IR sources using new deep source counts. I do not expect the limits to change significantly, and the contribution to the DMR maps should be a the 1 - 2 μK level.

As my newest DMR project, I have begun to look at the systematic effects which may be present in the maps due to on-board magnetic effects from the spacecraft torquer-bars (used for attitude control). This will be one of my major projects for the next few months.

I continue to collaborate with Dr Bob Nichol of Northwestern University, IL in investigating the Edinburgh/Durham Southern Galaxy and Cluster Catalog.

680-028/680-029

MAIL>
#2 26-OCT-1992 18:00:09.11 NEWMAIL
From: SMTP%"dc@cobi.gsfc.nasa.gov"
To: usra@nssdca
CC:
Subj: Third quarter progress report

Date: Mon, 26 Oct 92 17:58:40 -0500
From: dc@cobi.gsfc.nasa.gov (Dave Cottingham)
Message-Id: <9210262258.AA13941@cobi.gsfc.nasa.gov>
To: usra@nssdca
Subject: Third quarter progress report
Cc: dc@cobi.gsfc.nasa.gov

USRA Progress Report
Third Quarter 1992

David Cottingham

Progress this quarter:

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The FIRAS calibration pipeline has produced numerous new versions of the calibration dataset and I attempted to repeat my earlier analysis on these new datasets. These attempts turned up a variety of defects in the datasets, which led the pipeline maintainers to fix a number of bugs in their software. All of the datasets produced during this quarter proved defective in one way or another. (Since the end of the quarter the pipeline has produced a dataset which appears to be bug-free and we are progressing toward a new set of model solutions.) In addition, Fixsen found and corrected an error in the calculation of the sigmas in the old calibration dataset; in rerunning the fit to the instrument model I found that the reduced chi-squared on this data ranges from 2 to 8, where we previously believed it to be in the range 1 to 4. Thus we find that the previous good fit to this data was an illusion. The badness of fit seems to be due to inadequacies in the bolometer model, which will not affect the calibrated sky signals.

I began extending earlier work by E. Cheng on characterizing the non-linearity of the DIRBE detectors by examining the results of a pre-flight test of the internal reference source (IRS). I have

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repeated this work with newly refined measurements of the channel bandpasses. I have attempted to include the effect of the fused quartz filter which is in front of the IRS, which was ignored in the

earlier work. The data on this filter is unfortunately rather sparse. This work is continuing.

We completed a preliminary analysis of the data from the first flight of the far-IR balloon borne telescope. We have analyzed about 7% of our data and can already place competitive limits on anisotropy in the cosmic microwave background. In this effort I performed the Monte-Carlo statistical analysis for placing bounds on rms fluctuations under various hypotheses about the correlation function of the anisotropy.

Work planned for next quarter:

We are finishing up several papers on the calibration of the FIRAS and on the spectrum of the CBR and dipole anisotropy for submission in January. I am directing the effort to validate these results.

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The development of the FIRAS calibration method will continue. Hopefully we will produce a validated set of calibrated sky maps this quarter.

The analysis of the non-linearity of the DIRBE detectors will be completed next quarter. I will re-analyze the IRS runs under various assumptions about the passband of the Suprasil filter, and, if it seems warranted, will take new measurements of the filter. I will also repeat this analysis with some in-flight IRS data to check that the results are consistent with the pre-flight data.

At present we are planning a new flight of the far-IR balloon borne telescope in the spring of next year. Work will continue on refurbishing this instrument. We hope to complete the analysis of the data from the first flight and begin preparation of a paper on the results.

68D-029

RESEARCH ACTIVITIES

(July 1 - September 30, 1992)

Takeshi Namioka

(Task No. 680029)

In the last quarter I derived analytic formulas needed for the design of a deformed ellipsoidal grating. These formulas are capable of minimizing aberration coefficients in the light path function over a given wavelength range. The formulas thus derived are applicable to most design purposes, but they lack the capability of balancing aberrations which is essential to the design of highly sophisticated spectroscopic grating instruments. In order to overcome this shortcoming, I have developed a rigorous third-order aberration theory of the deformed ellipsoidal grating with variable spacing and curved grooves. The thory is based on the exact ray-tracing theory and gives analytical expressions for spectral images formed on a flat or a cylindrical image plane. With the help of a merit function developed for the deformed ellipsoidal grating, the present aberration theory enables one to balance the aberrations as a whole, yielding the truely optimized ruling or holographic recording parameters.

In view of practical difficulties in polishing and testing a deformed ellipsoidal blank to the required accuracy, I have started to investigate the possibility of achieving the required resolution without using deformed ellipsoidal blanks. One approach to the solution is the use of an ellipsoidal holographic grating produced by means of aspheric wavefront recording. The effort, therefore, has been directed toward derivation of an analytic expression for the groove pattern recorded with two aspheric waves generated by reflection of two spherical waves from respective spherical mirrors. The aim of this study is to obtain rigorous fourth-order expressions for the aspheric wavefront recording geometry in the framework of the third-order aberration theory, and such analytic expressions are of pressing need for the phase B study of the FUSE spectrographs.

The work planned for the next quarter includes (1) numerical examinations of the validity of the newly derived analytical formulas of spot diagrams and rms spread of the spots (merit function for grating designs) with reference to those computed by means of rigorous ray tracing, (2) theoretical studies on the aspheric wavefront recording geometry of holographic gratings, and (3) preparation of papers for possible publications.

690-001

USRA Quarterly Technical Report: S. Ghosh
Task Number: 690001
period: 1 July 1992 - 30 September 1992

Sanjoy Ghosh has continued studying the properties of magnetohydrodynamic (MHD) turbulence with applications to the solar wind. During this period, S. Ghosh completed a paper on the parametric instabilities of a large amplitude circularly polarized Alfven wave and submitted the manuscript to a scientific journal. A subsequent paper on the nonlinear phase of these instabilities is under preparation.

In other research, a manuscript on the evolution of magnetic helicity in compressible magnetohydrodynamics with a mean magnetic field was completed and submitted for review by Ghosh. This paper is expected to appear in an AGU Monograph on a recent Chapman Conference on micro- and meso-scale turbulence in space plasmas.

Ghosh participated in the submittal of two proposals. The NASA Space Physics Theory Program proposal under M.L. Goldstein (Code 692) will study the role of turbulence in heliospheric plasmas. This is a renewal of Ghosh's current source of funding. Ghosh is also the consultant for a NASA Small Business Innovative Research proposal by L.W. Klein (ARC). This proposal is for developing three-dimensional, compressible, spectral algorithms for simulating fluid dynamics.

Ghosh's non-local travel during this period include several (bi-weekly) trips to the Bartol Research Institute (Univ. of Delaware, Newark, DE 19716) where he continues his scientific collaboration with Prof. W.H. Matthaeus. In addition, Ghosh attended the Gordon Research Conference on Solar-Terrestrial Modeling (13-17 July, Plymouth State College, Plymouth, NH).

690-007

TECHNICAL ACTIVITY REPORT

Bertram Donn

Contract NAS5-30442,

Task 690-007For the Period March 1 - August 31, 1992

This task provides consulting support to the Astrochemistry Branch, Code 691 for research on cometary ices and interstellar grains. In collaboration with Dr. Reggie Hudson, I critically examined the paper by A. Bar-Nun and associates entitled "Gas Release from Comets" published in Icarus. It was pointed out that those authors did not properly take account of all the parameters associated with their experiments and therefore their conclusions were not justified. This also appeared in Icarus. Discussions were held on the experiments by Moore and Hudson on irradiation of crystalline and amorphous water ice films. Irradiation produced temperature dependent cycling between the two phases. The results have implications for interstellar ice grains and cometary ices.

690-011

QUATERLY TASK REPORT July 1 - September 30, 1992

V. Papitashvili Task 690-011A Contract NAS5-30442

1. The 1992 STEP Symposium

During July and August the preparatory work continued for the 1992 STEP Symposium. Computer equipmnet for demonstrations during Symposium has been rented, Program Guide has been updated, a lot of organizational work has been done. The Symposium held at August 24-28, 1992, as it was planned. Before Symposium the SCOSTEP General Meeting and STEP SC Meeting took place. During the Symposium about 300 papers have been presented, about 250 people attended the Meeting. A number of demonstrations of communication facilities (on-line data systems, educational software, CD-ROM technology, etc.) was presented, including a direct "dialog-mode" communication with RUSCO via GOLDIS system maintained by WDC-B2 in Moscow. Separate report has been created by Dr. M. Teague with description of all activity for the 1992 STEP Symposium.

2. STEP International Newsletters.

Two Newsletters (## 7 and 8) have been generated, printed and mailed in the reporting period. Due to some problems with publication of STEP NL the # 8 has been printed on 20 pages and distribution has been postponed until end of September. Eight articles have been initiated and/or substantially rewritten or translated by the Coordinator and Visiting Scientist. One article has been solicited form Russia, five articles have been written by american scientists, one came from Japan. Newsnotes covered a considerable part of the STEP activity around the World. RUSCO Bulletin Board has been included in the GOLDIS system in the former Soviet Geophysical Commettee and regular communications (including "on-line dialog mode") have been pursued between USSCO and RUSCO.

Articles from the leaders of different STEP projects have been solicited during the STEP Symposium and trip of Visiting Scientist. The latter attended the AGU Chapman Conference on VLF/ULF in Williamsburg, VA (Sep 17, 1992) and presented a talk about the current state of STEP Program.

3. Project 6.4

Visiting Scientist has been invited also (and partially supported from IAGA) to attend the INTERMAGNET Executive Council and Operatin Committee Meeting in Paris, France (Sep 26 - Oct 1, 1992). In this Meeting the proposal from US STEP Coordinator has been intensively discussed to establish a joint effort with the creation of the INTERMAGNET and STEP Project 6.4 CD-ROMs with worldwide 1-minute geomagnetic data base. The objective of STEP Project 6.4 is to establish an on-line database of ground-based magnetometers in order to provide the STEP Community with a global view of the Earth's magnetic field variations. The invited paper has been presented on the STEP Symposium with identification approximately 100 sites around the World which will accomplish this objective. Part of those sites is located in Russia and FSU states. Four magnetic observatories from Russia (Tixie Bay, Cape Wellen, Dixon, and Ashkhabad) have been digitized by the 1-minute resolution during 1992 in IZMIRAN. Part of these data have been delivered to USSCO, software development has been discussed by the project team.

4. Other Activity

Visiting Scientist received a confirmation from international scientific journals (Journal of Geomagnetism and Geoelectricity, Journal of Planetary and Atmospheric Physics, and Geophical Journal International) that 3 papers of him have been accepted for publising in 1992. Two other papers have been accepted for publishing in the Proceedings of Solar-Terrestrial Prediction Workshop. Four papers (invited, solicited and two contributed) have been presented on the STEP Symposium, and will be published in the Proceedings. Visiting Scientist, together with US STEP Coordinator, took a resposibility for editorial work with the STEP Symposum Proceedings for the next few months.

5. Future Plans

A major task for last quarter of 1992 will be a preparation of the STEP Symposium Proceedings (COSPAR Colloquia Series). About 15 papers have been received in the begining of October, the deadline is October 31. Papers will be forwarded to the Session Chairmen for review, and all volume should be ready for publication at the end of January 1993.

STEP International Newsletter # 9 is under preparation in October. Solicitation of articles will be continued for the following issues.

The process of data collection for the Project 6.4 begins, some data are available in USSCO, software development is in a progress.

Scientfic papers for the STEP Symposium Proceedings should be written on the base of presented reports.

10/18-92

690-91L

QUARTERLY REPORT

Observations on the emission from Na and K in the exosphere of Mercury obtained in December 1990 during a period of intense solar activity have been reduced. The Na and K emissions do not show a strong spatial correlation. The Na emission shows frequent concentrations towards the polar regions and is time variable. The peak of the potassium emission tends to be fixed from day to day during this period. A simple explanation for this phenomenon is that the surface expression of the relatively incompatible element K is more variable than that of Na. A preliminary report of this work will be given at the Munich meeting of the Division of Planetary Science in October and a publication is being prepared.

There are two broad classes of explanation for the apparent concentrations of Na and K. External ones and internal ones. External ones include photon stimulated desorption and sputtering while internal processes might include diffusion and porous flows (the regolith and megaregolith are highly fractured structures). Both photon simulated desorption and diffusion have been considered this year (see publication list). The conclusion of this work to this point is that diffusion is likely not a major source process for Na and K in the atmosphere of Mercury unless the temperatures at shallow depths are much larger than presently supposed, that the crust of Mercury must be more sodic than previously thought (more like that of the Earth), and that a very likely explanation for the loci of K concentrations is simply that the composition of the crust of Mercury may show regional variations.

Tom Morgan

690-014

Quarterly Report: 1 July - 30 September 1992

Susan Hoban
Code 693
301-286-3840 hoban@lep693.gsfc.nasa.gov

Task 5000-914

Science:
I have continued a project of reduction and analysis of infrared images of Mars and Venus obtained last year with D. Gezari's (Code 685) 5-18 micron array camera. This work is done in collaboration with M. Mumma, F. Espenak (Code 693), D. Gezari and F. Varosi (Code 685). Preliminary results of this work were presented at the annual meeting of the Division of Planetary Sciences, held in Munich, Germany, Oct 12 - 16, 1992.

My work on the reduction and analysis of narrowband CCD images of comet P/Brorsen-Metcalf continues, in collaboration with M. A'Hearn at the University of Maryland. We are investigating the variations in spatial structure of the OH and CN comae of this comet. We submitted an abstract for the Annual Division of Planetary Sciences meeting on this subject; however, due to illness, I was unable to travel to the meeting to present this paper.

Proposals:
I submitted two observing proposals this quarter: 1) I submitted a proposal with M.J. Mumma(NASA/GSFC) and J. Davies (UKIRT) for long-term status for target-of-opportunity observations with the UKIRT to study organic molecules in comets using infrared spectroscopy. Comets come randomly, so such status is needed to have a procedure in place for when a comet does appear. 2) I submitted a proposal with M.J. Mumma and D.C. Reuter (NASA/GSFC) to make infrared spectroscopic measurements of Young Stellar Objects with the IRTF.

Service:
Education:
E. Roettger (USRA), D.C. Reuter (NASA/GSFC) and I were awarded a small education grant from NASA's Planetary Atmosphere's Program to produce an Astronomy Sourcebook to assist teachers in locating educational resources on astronomy in the Baltimore-Washington Area. We are currently compiling the sourcebook and contacting schools in the area.

Proposals:
I am serving on the Hubble Space Telescope Planetary Science review panel. I am currently in the process of reviewing the proposals.

Programmatic:
I serve as the IRAF (Image Reduction and Analysis Facility) Systems Manager in our branch. I assist individuals who need help using the IRAF package.

Plans for the upcoming quarter:
I plan to continue my work on Mars and on P/Brorsen-Metcalf, continue production of the Sourcebook with Roettger and Reuter, and complete the HST proposal review (scheduled for early November).

690-214

MAIL>
#6 26-OCT-1992 09:17:56.04 NEWMAIL
From: LEPVX2::YSEER "E. Roettger 301-286-1528, code 693, T2-rm1"
To: NSSDCA::USRA
CC: YSEER
Subj: report

Technical Report, 1 July 1992 - 30 September 1992
Elizabeth Roettger, GSFC code 693
Activity 5000-914 lepvax::yseer
Task number 690-014A Employee number R00903
Badge number G-115360 Phone number 286-1528

I am reducing a survey spectrum of comet Halley taken from the KAO. This spectrum shows 15 to 20 emission lines of water. I previously developed programs to look for laboratory-detected lines of water, evaluate the intensity, and test for statistical significance. I am learning (and documenting) how to use an available program and computer system to model the EarthUs atmospheric transmission. I am modifying my programs to test, statistically, the results of varying model parameters to match a lunar spectrum, and will apply the answers to the Halley

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spectrum. The line fluxes thus obtained should permit analysis of the excitation state of the water molecules. I expect this to be an iterative process, with more details added each time. The programs can then be used on other spectra from the same observing program. I submitted an abstract of this work for the AAS/DPS meeting in October.

A target-of-opportunity proposal to observe comet Shoemaker-Levy using the CSHELL instrument on the IRTF was granted time; we developed the means for optimizing the search for water emission lines, observed the comet July 21-23, and began reducing the data.

For the 30% of my time earmarked for work with NASA/HQ, I continued coordinating two projects with JPL: the JPL summer school and a related International Conference. I have worked on the announcements and programs, participant lists, invited speakers/lecturers and letters of invitation, protocol, and coordination between JPL and HQ. I organized the
Education Research Program reviews (supplemental to Planetary Astronomy/Planetary Atmospheres grants) as well as reviews of the Computational Upgrade Supplements. I was part of the Planetary

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#6 26-OCT-1992 09:17:56.04 NEWMAIL
Astronomy Review Panel, 4-6 August 1992.

Together with Dr. Susan Hoban, I developed a plan for producing an Astronomy Sourcebook for area elementary school teachers. In cooperation with Dr. Donald Jennings and Dr. Dennis Reuter, we developed
and submitted two proposals to allow us to carry out the project. The latter proposal was accepted, and preliminary work commenced.

690-315

Michael L. Goodman
SPOF/ISTP/GGS
NASA/Goddard
Code 695
Planetary Magnetospheres Branch
(301)286-3497

10/27/92

USRA NASA Contract Number:NAS 530442

Ms. Denise Dunn
Administrative Assistant
USRA Visiting Scientist Program
Mail Code 610.3
NASA/Goddard Space Flight Center

Subject: Technical Report for 7/1/92-9/30/92, and
Planned activities for 10/1/92-12/31/92

Dear Ms. Dunn,

My activities are divided into two categories; operations within the SPOF, and research. My activities within each of these categories are as follows

OPERATIONS:

I have installed the SPOF ORACLE database on three of the four SPOF workstations I am in the process of setting up SQL*Net TCP/IP to connect the databases on the several workstations. Over the next two months I will begin design and SQL c development for the long term science plan which will be stored in the database.

I will be installing the PV-WAVE graphics language package on the remaining three workstations.

RESEARCH:

Alex Klimas, Bill Farrell, Adolfo Vinas, and I have submitted a Director's Discretionary Fund Proposal, "A Faster and More Accurate Plasma Simulation Metho to design, develop, test, and apply extensions of our present Vlasov simulation method to include multi-species and higher dimensional electromagnetic phenomena

I have been continuing with the development of an MHD equilibrium model which includes classical resistivity, thermal conductivity, viscosity, and thermoelecti effects.

Sincerely yours,

Michael L. Goodman

Michael L. Goodman

696-017

Dr. Harri Laakso
Code 696
GSFC/NASA
Greenbelt, MD 20771

Greenbelt, October 13, 1992

Quarterly Technical Report, July 1 – September 30, 1992

1 Analysis of work in progress

During the period Dr. Laakso has studied the following subjects:

- Double probe theory
- Current layers in a cometary environment
- Analysis of the CRRES data

1.1 Double probe theory

This work which was started during the previous period has considerably expanded and therefore we have not been able to submit the results during this period as we expected in the previous QTR. However, now the manuscript is almost finished, and we can probably submit it to *Journal of Geophysical Research* at the end of October. The results are not significantly different from those described in the previous QTR. The main difference is a theoretical section in the paper which accurately explains the magnitude of error electric fields in double probe measurements as a function of various parameters such as the electron density, the electron temperature and the floating potential. In addition several applications to the magnetosphere have been added. The current abstract is the following:

"We investigate possible errors in electric field measurements with double probes that are induced by abrupt electron density and temperature gradients. We show that in some occasions such gradients may lead to marked spurious electric fields if the probes are assumed to lie at the same floating potential. Around the space potential, the magnitude of these error signals, δE, vary like $\delta E \sim T_e (\Delta n_e/n_e)$, where T_e is the electron temperature and $\Delta n_e/n_e$ the relative electron density variation. This not only implies that the error signals will increase linearly with the density variations, but also that such signatures grow with T_e, i.e., these signals are 10 times larger in a 10 eV plasma than in a 1 eV plasma. We have applied our analysis to various physical situations. For instance, at the plasmapause, error signals can be about 1 mV m^{-1}. In double layers the double probe data can easily contain error fields of a few mV m^{-1} which, however, point outwards. Thus, these error signals tend to diminish the real dc electric field associated with the double layers. We conclude that although the double probe measurements are often free of these errors, occasionally significant error signals can occur especially at plasma boundaries and during strong transient processes."

1.2 Current layers in a cometary environment

This investigation was presented in the 4th COSPAR Colloquium on *Critical Problems in the Plasma Environments of Comets and Other Non-Magnetized and Weakly Magnetized Bodies*, held in Ann Arbor, Michigan, August 24–27, 1992 (see Appendix). The studies will be published in a proceedings (deadline: October 31). Our manuscript is almost finished, and the abstract is the following:

"We investigate physical processes in the vicinity of two current layers detected by Vega 1 during its encounter with comet Halley. The M_1 current layer crossed at 360,000 km inbound by Vega 1 coincides with a model enveloping paraboloid of heavy dust grains ($m > 10^{-8}$ g) which are positively charged at that distance. The dust envelope creates an electrostatic field of a few Volts across the boundary which may produce a hydromagnetic discontinuity. A very strong current layer, also detected during the Vega 1 encounter, appears to have been caused by the stagnation of the solar wind flow in the cometary plasma region. This current layer coincides with a flux enhancement of dust grains ($m < 10^{-10}$ g) which are negatively charged. We suggest that this solar wind stagnation is at least partially due to an enhanced dust flux."

1.3 Analysis of the CRRES data

We have obtained the first optical disk of CRRES electric and magnetic field data which covers the period of January 6–26, 1991. This period includes several ssc's during which CRRES is located near the plasmapause in the post-midnight sector around 2–3 MLT. Some analysis of these events have been made.

2 Work planned for the next quarter (Oct 1 – Dec 31, 1992)

The first two studies (sections 1.1 and 1.2) will be finished during the first month of this quarter. These studies may still take some more time in near future.

There are some interesting common features between comet Giacobini-Zinner and comet Halley. The former was approached by ICE and the latter by several spacecraft. For instance, in the vicinity of both comets drift mirror waves were observed. We have some data available during such events which will be further investigated during this period.

The emphasis during this quarter, however, is to survey research possibilities offered by the first CRRES data disk at GSFC. For instance, some investigations can be made on the electromagnetic waves during ssc's. The possible occurrence of cavity resonances and their coupling to field line resonances is an interesting subject where a lot of progress can be made. Also interesting processes occur in the post-midnight sector during substorms. For substorm studies, all the ASC data from Finland's ground-based stations in 1990/91 are available on a video tape at GSFC.

Harri Laakso

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Dr. Harri Laakso
Code 696
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Greenbelt, October 13, 1992

Appendix: Travel Report

Dr Laakso participated in the 4th COSPAR Colloquium on *Critical Problems in the Plasma Environments of Comets and Other Non-Magnetized and Weakly Magnetized Bodies* which was held in Ann Arbor, Michigan, August 24–27, 1992.

The conference contained a variety of theoretical and observational investigations on the Martian, Venusian, and cometary plasma environments. At this moment there are in-situ observations available in the vicinity of three different comets (Giacobini-Zinner, Halley, Grigg–Skjellerup): although some common features occur among these comets, a number of differences exist. These differences probably hinder that no proper comparison studies between these comets have not been presented so far. This conference did not present anything new in this aspect though a third of the reports considered various problems of cometary plasma environments and their interactions with the solar wind. A number of papers dealt with the dust-plasma coupling which is very important in the vicinity of comets but which may also have some significance in the Martian plasma environment.

Among the speakers were two scientists from the GSFC/Laboratory for Extraterrestrial physics. Dr J. Slavin (Code 696) presented an analysis of Phobos 2 observations of the Mars bow shock taken at unusually distant locations upstream of planet and recent efforts to model flow about the planets under low Alfvén Mach number conditions.

Dr Laakso reported an investigation on the dust-plasma coupling near current layers in the vicinity of comet Halley. A current layer crossing coincides with a model enveloping paraboloid of heavy dust grains ($m > 10^{-8}$ g). A mechanism was suggested for dust-plasma coupling which can lead into the formation of this current layer. Another current layer appeared to have been caused by the stagnation of the solar wind flow in the cometary plasma region. It was suggested that this stagnation is at least partially due to an enhanced dust flux.

Total attendance at the Colloquium was approximately 80 scientists and graduate students. All the papers will later be published in a proceedings of Pergamon Press (deadline of papers: October 31).

690-019

National Aeronautics and Space Administration
Goddard Space Flight Center
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NASA

Quarterly Technical Report

Task number: 5000-919
Period: August 10 to September 30, 1992.

October 21, 1992

U.S.R.A.
Visiting Scientist Program
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Since August 10, 1992 I have worked on three main projects: developing an analytic study of the parametric instability of large amplitude Alven waves, developing a Chebyshev-Fourier spectral algorithm with an infinite computation domain for more realistic solar wind studies in MHD and a vortex street model of fluctuations observed by Voyager 2 in the outer heliosphere.

The analytical study uses a time-dependent perturbation approach to extract information on higher-harmonics from a coupled set of amplitude equations for the daughter waves, obtained by linearizing the magnetofluid dynamic equations. Preliminary results indicate that under certain approximations, a closed set of solutions can be obtained for the amplitudes. Part of this study will be shown in a Fall AGU conference paper, San Fransisco, CA, december 1992.

The Chebysev-Fourier spectral algorithm with an infinite domain is derived from a standard Chebyshev-Fourier compressible MHD code (writen by this Author) by including mappings which transform the Chebyshev part of the spatial domain. Two mappings are used (Hyperbolic and Algebraic) as well as a scale factor which determines how large the effective computation domain is compared to the total number of grid points in the computation. This code will have many applications to space physics because it pushes boundary conditions out to infinity.

The final project is a model for the fluctuations observed in the outer heliosphere observed by Voyager and Pioneer spacecrafts (see [1]). The model is made up of two interacting shear layers which create a Karman vortex street. Since August I have finished a paper [2] to be submitted to JGR soon.

For the next quarter (October 1 to December 31 1992) I will continue working on these three projects. Comparison with linear theory will be made with the new approach to the parametric instability of the large amplitude Alfven wave. Accuracy tests and diagnostics have to be developed for the infinite Chebyshev-Fourier spectral MHD code. A switch will enable the use of either maps in the code. Warp in the current sheet will be tested on the vortex street model for additional realism. A study of flux transport by the vortex street is under way to address the 'flux deficit' problem in the solar wind.
A trip to San Fransisco, CA is planned for the fall AGU meeting in December.

Dr. Edouard Siregar

[1] E. Siregar, E., D.A. Roberts and M.L. Goldstein, 'The Formation of vortex streets through the nonlinear interactions of vortex sheets in a two dimensional compressible flow', Geophys. Res. Let., Vol. 19, NO. 14, p 1427, 1992.
[2] E. Siregar, E., D.A. Roberts and M.L. Goldstein, 'Quasi-Periodic Transverse Plasma Flow Associated with an Evolving MHD Vortex Street in the Outer Heliosphere', submittted to *J.G.R.*, 1992.

QUARTERLY TECHNICAL REPORT

July 1 to September 30, 1992

Yosio E. Shimabukuro

Task Number: 900-001A

INTRODUCTION

This is the third report under Universities Space Research Association (USRA) contract as a research scientist at NASA/Goddard Space Flight Center in the Earth Sciences Directorate. During this period, I have attended the regular Branch meetings and technical meetings at Goddard, when I had opportunity to be informed about the on-going researches. I have been working with several remote sensing data over different study sites in collaboration with Biospheric Sciences Branch scientists using the image processing systems located at the Laboratory for Terrestrial Physics Computer Facility and GIMMS Laboratory.

TECHNICAL ACTIVITIES

During this period, we have been analyzing the effect of scale of measurement on the information content. We finished the preliminary analysis of TM/Landsat and AVHRR/NOAA data acquired on July 29, 1988 over an area in the Central-western region of Brazil. The objective of this work is to present a technique, using coarse resolution AVHRR data in the visible, near-IR, and the reflective part of the 3.75 um band, to generate vegetation, soil, and shade fraction images. These images are formed by the proportion of each component within the AVHRR pixels. The results obtained was submitted to the International Journal of Remote Sensing for publication. ("Linear mixing model applied to coarse resolution satellite data" - copy attached). We continue analyzing TM and AVHRR data over Pacific Northwest and AVIRIS data over Howland Forest in Maine.

The abstract, "Neural network inversion of canopy LAI from high spectral resolution imagery" - J.A. Smith, Y.E. Shimabukuro, and W.T. Lawrence was accepted to be presented in the International Symposium on Spectral Sensing Research (ISSSR) in Maui, Hawaii, 15-20 November, 1992. The inversion of Leaf-Area-Index (LAI) from high spectral resolution imagery is obtained for a northern forest canopy area using a back propagation artificial neural network. The network is trained using input-output

pairs generated by a simple multiple scattering reflectance model. The network was applied to AVIRIS imagery collected from the Howland forest in Maine. General qualitative agreement was obtained with available ground control information and correctly indicated bare soil, road and forest edge boundaries as well as relative LAI density as compared to vegetation fraction images of the same areas computed using the linear mixture model technique.

We have been analyzing the NOAA/AVHRR GAC data from January 1990 to June 1991. The objective of this work is to develop a methodology using NDVI imagery derived from AVHRR and Thematic Mapper (TM) data for monitoring savanna vegetation in Brazil. This work is in collaboration with INPE's investigators. The results are going to be presented to the EMBRAPA (Brazilian Agency for Agricultural Research).

Field work in the Howland forest (Maine) to support the analysis of AVIRIS data (18-23 July, 1992). The study site is located near Howland in east-central Maine (45^{o} 13' N and 68^{o} 43' W) within International Paper Company's Northern Experiment Forest. It consists of small plantations, multi-generation clearings, as well as large natural forest stands. The natural stands in this boreal-northern hardwood transitional forest consist of aspen-birch, hemlock-spruce-fir, and hemlock-hardwood mixtures. Topographically, the region varies from flat to gently rolling, with a maximum elevation change of less than 68 m. There are some bogs and wetlands in the central portion of the forest. The nature of the soil varies from a very well drained to a very poorly drained soil. A 25 m walkup tower supporting meteorological instruments is located within the research forest.

Participation in the XVII International Society for Photogrammetry and Remote Sensing (ISPRS) Congress in Washington D.C. (August 2-14, 1992). The papers: "Use of features derived from proportions of classes in a pixel for the multispectral classification of remote sensing images" - A.P.D. Aguiar, N.D.A. Mascarenhas, and Y.E. Shimabukuro; and "The role of NOAA-AVHRR in vegetation monitoring of Amazonia" - S.C. Chen and Y.E. Shimabukuro, were presented and published in the Congress Proceedings.

Participation in the Payload Panel EOS Investigators' Working Group (IWG) Meeting at Dulles Ramada Renaissance (September 8-10, 1992). The program included the following presentations:

- "Introductory remarks and the issues: Charge to the Payload Panel" - Berrien Moore, University of New Hampshire;
- "EOS Status" - Shelby Tilford, NASA Headquarters;
- "Summary of the Red/Blue Team actions" - Chris Scolese, NASA Goddard Space Flight Center;
- "EOS Data products" - Ghassem Asrar, NASA Headquarters;
- "Update on Landsat-7/8 and their role in EOS" - Darrel Williams, NASA Goddard Space Flight Center and Shelby Tilford, NASA Headquarters;
- "Update on HIRIS-2" - Alex Goetz, University of Colorado; and
- "EOS, Climsat, and EOSDIS" - Lennard Fisk, NASA Headquarters.

Also, it was discussed the Flight of HIRIS-2, Flights of SAGE III / Aero mission, Science goals of WBDCS and plans to fly, MIPAS and SCIAMACHY and their relation to U.S. EOS instruments, POLDER and its relation to MISR/EOSP, MIMR, STIKSCAT on ADEOS-2, MLS/SAFIRE, and EOSDIS.

Participation in the meeting with visitors from the INPE (Brazilian Institute for Space Research) at GSFC and University of Maryland on 21 August, 1992. The visit included the discussion of regional remote sensing with personnel of the Biospheric Sciences Branch and the presentations of GIMMS Laboratory and LTP Computer Facilities.

WORK PLANNED FOR THE NEXT QUARTER (OCTOBER 1 TO DECEMBER 31, 1992)

- To analyze the AVHRR GAC data for vegetation phenology studies in Brazil.

- To analyze the AVHRR LAC data for study sites in Brazil (Amazon and Savanna region) and for Pacific Northwest.

- To work with Linear Mixing Model techniques for different remote sensor systems.

- Participation in the MODIS/EOS Science Team Meeting in Santa Barbara, California (27 - 29 October, 1992).

- Participation in the IGBP (AVHRR LAC Data) Meeting in Sioux Falls, South Dakota (9 - 10 November, 1992).

- To work with Forest-BGC Model for Howland forest in Maine.

- To write scientific paper to submit to a remote sensing journal.