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Date: October 21, 1996
Report Type: Final Technical Report
Grant Number: F49620-92-0284

Title: ORIGINS OF SOLAR ACTIVITY - Final Technical Report, AASERT Grant

Principal Investigator: Dr. David M. Rust
Organization: The Johns Hopkins University
Applied Physics Laboratory (JHU/APL)
Johns Hopkins Road, Laurel, MD 20723
Agency: Air Force Office of Scientific Research
Bolling AFB, DC
Attention: Dr. Henry Radoski

Summary of Effort:

Work under the subject grant began in August 1992, when Mr. J. J. Blanchette began study and data analysis in the area of solar flare research. Mr. Blanchette passed all requirements toward a Ph.D., except for the thesis. Mr. Blanchette worked with the APL Flare Genesis Experiment team to build a balloon-borne solar vector magnetograph. Other work on the magnetograph was partially supported by AFOSR grant F49620-94-1-0079.

Mr. Blanchette assisted the Flare Genesis team prepare the telescope and focal plane optical elements for a test flight. He participated in instrument integration and in launch preparations for the flight, which took place on January 23, 1994.

Mr. Blanchette was awarded a Masters Degree in Astrophysics by the Johns Hopkins University in recognition of his achievements. Mr. Blanchette indicated a desire to suspend work on the Ph.D. degree, and he left the AASERT program on August 31, 1994. Under the guidance of his advisor at JHU/APL, Dr. David M. Rust, Mr. Blanchette gained enough background in solar physics so that he can contribute to observational, analytical, and presentation efforts in solar research.

Beginning in August 1995, Mr. Ashok Kumar was supported by the grant. Mr. Kumar demonstrated remarkable theoretical insight into the problems of solar activity. He developed the concept of intrinsic-scale magnetic flux ropes in the solar atmosphere and interplanetary space. His model can explain the heating of interplanetary magnetic clouds. Recently, his idea has been extended to explain solar wind heating. If the idea is confirmed by further comparison with observations, it will be a major breakthrough in space physics and it may lead to an explanation for why the solar corona's temperature is over a million degrees.

In another part of his Ph. D. thesis work, Mr. Kumar collaborated with Dr. Rust in a study of solar flare-associated coronal X-ray brightenings. He was able to show that the brightenings have the characteristic dimensions of helical kink instabilities, known from research on laboratory plasmas. This was the first time that actual measurements of solar eruption parameters could be definitively linked with a magnetohydrodynamic instability.

Dr. Kumar also assisted in test and preparation of the Flare Genesis Experiment, which made its first scientific flight, January 7 - 26, 1996. After the flight, Mr. Kumar completed his analysis of interplanetary magnetic clouds. He successfully defended this work on October 9, 1996, and submitted his thesis, "Magnetic Flux Ropes of Solar Origin," to the University. He has now completed all degree requirements for a Ph. D. in Astrophysics.

In summary, the subject grant supported two students, one of whom received a Master's degree and the other received a Ph. D. degree. A list of publications is attached.

Key Words: Solar Research, Graduate Training, Solar Magnetograph

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Publications partially supported by the grant:

Kumar, A. and D. M. Rust, Interplanetary Magnetic Clouds, Helicity Conservation and Intrinsic-Scale Flux Ropes, *J. Geophys. Res.* 101, 15667, 1996.

Kumar, A. and D. M. Rust, Helicity Conservation in Expanding Plasmas: Application to Interplanetary Magnetic Clouds, *Solar Wind 8* (in press) 1996.

Kumar, A. and D. M. Rust, Helicity Conservation in Expanding Magnetized Plasmas: Flux Ropes in the Solar Wind, in *Solar Drivers of Interplanetary and Terrestrial Disturbances*, ASP Conf. Ser. 95, p. 315, 1996.

Rust, D. M. and Kumar, A., Evidence for Helically Kinked Magnetic Flux Ropes in Solar Eruptions, *Astrophys. J. Lett.* 464, L199, 1996.

Conference Presentations partially supported by the grant:

Blanchette, J. J., Rust, D. M., Murphy, G. A., Cauzzi, G., Keil, S., and Balasubramaniam, K. S., Vector Magnetography of a Large Sunspot AAS Solar Physics Division Meeting, Palo Alto, July, 1993.

Rust, D. M. and A. Kumar, Helical Magnetic Fields in Solar Filaments, American Geophysical Union Meeting, Baltimore, May 23-27, 1994.

Rust, D. M. and A. Kumar, Helicity Charging and Eruption of Magnetic Flux from the Sun, 3rd SOHO Workshop, Estes Park, Colorado, Sept. 26 - 29, 1994.

Kumar, A. and D. M. Rust, Evolution and Solar Origins of Interplanetary Magnetic Clouds: Role of Magnetic Helicity Conservation, AGU Spring Meeting, Baltimore, May 29-June 2, 1995.

Rust, D. M. and A. Kumar, The Origin of Solar Eruptions: Helical $m=1$ Kink Instability in Chromospheric Filaments, AGU Spring Meeting, Baltimore, May 29-June 2, 1995.

Kumar, A. and D. M. Rust, Evolution of Solar Filaments into Interplanetary Magnetic Clouds: Effect of Magnetic Helicity Conservation, American Astronomical Society, 26th Meeting of the Solar Physics Division, Memphis, TN, June 4-8, 1995.

Kumar, A. and D. M. Rust, Helicity Conservation in Expanding Magnetized Plasma: Implications for Interplanetary Processes, 16th Intl. Workshop on Solar Physics, "Solar Drivers of Interplanetary and Terrestrial Disturbances," National Solar Observatory, Sunspot, NM, October 16 - 20, 1995.

The Johns Hopkins University
Applied Physics Laboratory



Attn: M.J. McKee
AFOSR/PKA

October 21, 1996

Dr. Henry T. Radoski
AFOSR/NM
110 Duncan Ave., Suite B115
Bolling Air Force Base
Washington, DC 20332-8080

Dear Dr. Radoski:

The Johns Hopkins University Applied Physics Laboratory is pleased to submit the enclosed final technical report on activity under grant number F49620-92-0284 for support of graduate student training at our Laboratory. This program has been a joint effort of the Applied Physics Laboratory and the Department of Physics and Astronomy of The Johns Hopkins University.

I hope you find the enclosed report satisfactory. If you require further information, please do not hesitate to call (301-953-5414). I appreciate your continuing encouragement and support of our work.

Sincerely yours,

A handwritten signature in cursive script that reads 'D. M. Rust'.

D. M. Rust

Enclosure