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(NASA-CR-174290) CORONAL AND CHROMOSPHERIC
PHYSICS Semiannual Status Report, 1 May -
31 Oct. 1984 (Hawaii Univ., Honolulu.) 7 p
HC A02/MF A01 CSCI 03B

N85-17921

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NASA GRANT NGL 12-001-011
Semiannual Status Report
CORONAL AND CHROMOSPHERIC PHYSICS

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For the Period
May 1, 1984 - October 31, 1984

A. Solar Maximum Mission Support Program

Our ground-based synoptic support program for the revived Solar Maximum Mission satellite has been in operation since the restart of spacecraft observations. In this connection we have built and installed two new microcomputer-based camera controllers for the dual coronagraph (H α , Fe XIV λ 5303) and tunable narrow-band Zeiss H α systems. These instruments, together with the Stokes polarimeter and K-Line Filtergraph, are run in routine support of current SMM programs on an ongoing basis. More specialized data are obtained by interested staff scientists in collaboration with SMM experiment team members on projects of mutual scientific interest.

B. Solar Activity

M. McCabe (with D. G. Sime and C. J. Garcia [HAO]) carried out an objective statistical comparison of bright features higher than $1.3 R_{\odot}$ in the corona and neutral lines in the photospheric field seen at λ 6303. Some correlation was found but not a unique and prevailing relationship. Many coronal features are associated with specific neutral lines, but the conditions that are necessary and sufficient are not yet identified. They are continuing this investigation by identifying individual neutral lines and prominences and looking for any related coronal feature and vice versa.

Observations at Haleakala are continuing in support of SMM II. Solar activity has been very low, but we have H α and λ 5303 data on several prominences and surges and at least one eruptive event is known to correlate with a C/P transient. Observations of the filaments and filament channels, as well as magnetograms of active regions have been recorded in an attempt to obtain simultaneous data with the UVSP experiment. We plan to compare and collate their data at the next meeting on Prominence and Coronal Plasmas at Goddard in April 1985. In October a joint program was initiated to obtain concurrent measurements of H α (Haleakala) and L α (UVSP) integrated intensities and profiles of prominences to test theoretical modeling of the hydrogen excitation including the importance of partial redistribution effects.

McCabe completed the study of the H α manifestation on a gamma-ray flare event at the limb on 21 June 1980 (SMM I).

C. Prominence and Chromospheric Studies

During this grant period, Landman has continued work on his program of prominence and spicule spectral analysis. This effort has led to the establishment of a powerful and practicable method of plasma diagnostics for the cool parts of these objects. Using measurements of the resonance lines of Na, Mg (triplet system), and Sr⁺, together with the middle H Balmer or Paschen lines, we are able to determine the basic parameters: temperature, microturbulence, vertical flare velocity, electron density, degree of hydrogen ionization, and line-of-sight thickness of the emitting region. Using data obtained at Haleakala and elsewhere, we have applied this method to evaluating conditions in quiescent prominences and spicules, and this work has been reported in several Astrophysical Journal articles. A result of major significance is the relatively low degree of hydrogen ionization that obtains in these

features (~10%), so that with our value of $n_e \sim 10^{11} \text{ cm}^{-3}$, the total gas pressure is about an order of magnitude greater than that of the neighboring corona. Our most recent study along these lines involves a comparison of Sr^+ and Ba^+ resonance line intensities to estimate the internal H Ly α flux. This work also includes new calculations of the Sr^+ and Ba^+ oscillator strengths and photoionization cross sections with spin-orbit and core polarization effects taken into account.

Landman has also completed a study of the small-scale nonthermal velocity field in quiescent prominences using simultaneous, high-precision measurements of the Mg $\lambda\lambda 5173, 5167$ and $\text{Fe}^+ \lambda 5169$ lines obtained at Haleakala. We find that the Fe^+ line is systematically narrower than would be expected from the corresponding Mg line widths and the assumption of a common temperature and microturbulence parameter for both constituents. The detailed behavior of this new effect apparently implies a systematic decrease in the Fe^+ microturbulence parameter compared to that for Mg, which suggests the presence of some type of magnetic rigidity phenomenon acting selectively on the ionic component.

Continuing his series of calculations on proton impact excitation in transition region and coronal ions, Landman is completing work on transitions among the $2p^5 3s$ configuration levels of the Ne isoelectronic sequence ions Na II-Ni XIX.

D. Far-Infrared and Submillimeter Photometry

C. Lindsey is continuing analysis of far-infrared observations made from the Kuiper Airborne Observatory (KAO) in the total solar eclipse of 31 July 1981 with Becklin, Jefferies, Orrall, Werner, and Gatley. He has computed the extreme limb brightness profiles of the Sun in 30, 50, 100 and 200 μm radiation from observations of occultation of the solar limb during eclipse. The results are published in the proceedings of the Airborne Astronomy Symposium (Becklin et al. 1984). Results of a more detailed analysis are being prepared for publication in The Astrophysical Journal.

Lindsey and graduate student L. Hermans have completed a project on chromospheric modeling independent of the assumption of gravitational-hydrostatic equilibrium based on the far-infrared limb profiles discussed above. This work is the subject of Herman's recently completed thesis, and is being prepared for publication in The Astrophysical Journal.

Lindsey is working with graduate student E. Pilger on analysis of extensive two-beam infrared scans of the Sun made from both the KAO and the NASA Infrared Telescope Facility (IRTF). The results of this analysis will yield maps of the Sun useful for studying active region brightness dependence on distance from the solar limb.

Lindsey is working with T. Roellig (NASA-Ames Research Center) on a project to use the IRTF to study continuum solar variations in several submillimeter bands concurrently. Roellig has constructed a photometer especially for this purpose, originally designed for eclipse observations from the KAO. They are preparing optical components to adapt this system to the IRTF. This is a continuation of work started by Lindsey and Kaminski (1984).

E. Coronal and Transition Region Studies

In a continuing collaborative program of EUV spectrophotometry with G. J. Rottman of the Laboratory for Atmospheric and Space Physics (LASP), Orrall took part in a successful flight of the LASP rocket-borne EUV Coronal Spectrometer from White Sands on 19 June 1984. Co-pointed with the spectrometer was an XUV broad-band imaging telescope that employs a 32 x 32 Codacon detector. As the SPARCS guiding system scanned the spectrometer and imaging telescope back and forth along a solar diameter, XUV images of a strip of the Sun 10 arcmin wide were formed. Both the spectrometer and imaging telescope returned good data. First order reduction of both data sets has now been completed. The data set includes observations of active regions, quiet Sun, coronal holes, and a prominence.

In a collaborative program with the SMM experimenters, SMM observations were obtained on the day of the flight along the entire strip of the Sun studied by the rocket-borne instruments. A comparative study of data obtained with the SMM Flat Crystal Spectrometer and the XUV imaging spectrometer is in progress.

There has been a long-standing discrepancy between models of the corona based on EUV data and models based on radio data. To obtain the necessary co-spatial and co-temporal observations at EUV and centimetric wavelengths, Orrall and Rottman, together with G. Dulk and T. Bastian (U. Colorado), obtained observing time on the VLA and at Greenbank on 19 June 1984, the day of the rocket flight. Successful observations were obtained, and the second order cleaning of the maps is being carried out by Dulk and Bastian. Similarly, M. Kundu (U. Maryland) obtained radio maps at several metric wavelengths on the same day from Clark Lake.

Orrall and Rottman have had a continuing collaboration with R. Fisher and R. Munro (HAO/NCAR) to make an absolute photometric comparison of the K-coronal brightness pB with the EUV emission line corona. Co-spatial and co-temporal observations of pB were made successfully from Mauna Loa with HAO's Mark III K-coronameter during flights of the LASP EUV Spectrometer in 1980, 1983, and 1984. The combined analysis of this data has been completed. One important result is that the inner corona is more irregular on small scale than was previously known. A paper for The Astrophysical Journal is in preparation, and an abstract describing results was submitted for the January AAS meeting.

F. Stokes Polarimetry and Magnetic Fields

D. Mickey attended a workshop on measurements of solar vector magnetic fields at Marshall Space Flight Center (MSFC) in May.

Mickey is studying Stokes profiles obtained from sunspot observations with the Haleakala polarimeter in order to understand the net circular polarizations obtained when sunspots are observed in broad wavelength bands. Haleakala observations were obtained for one of the spots described by Henson and Kemp (1984, Solar Phys. 93, 289), and integrals over our line profiles give similar results: a net polarization of one sign in the penumbra, with a reversal in the umbra. Specifically, our sunspot maps show a net polarization

with the same sign as the spot magnetic field in the penumbra at points where the magnetic field is nearly transverse to the line of sight. In the umbra, the net polarization is almost as large, but in the opposite sense. Mickey is analyzing observations of other spots and different spectral lines to determine the generality of this behavior.

The polarimeter has also been used to obtain Stokes profiles of a single spot in several spectral lines, formed at different heights in the solar atmosphere to test magnetic field predictions of sunspot models.

Mickey has participated in collaborative projects with M. Hagyard and E. West at MSFC, designed to obtain near-simultaneous vector magnetograms of the same region with the Haleakala polarimeter and the Marshall magnetograph—and in one attempt, the SMM UVSP as well. Some success was achieved with the ground-based instruments, particularly a series of observations of NOAA region 4474 in late April and early May. The combination of the data sets should give useful information on the relation calibrations of the two instruments, as well as providing more complete data on evolution of the magnetic field in this region.

There has been some indication of a 13-day periodicity in global solar velocity measurements by the Birmingham group. To investigate the effect of plage and spot regions on the $\lambda 7699$ global velocity observations, Mickey has made several Stokes spectroheliograms in this line.

G. Publications

The following publications pertinent to this grant were published during 1984, were accepted or submitted for publication, or are presently being edited for publication:

- Becklin, E. E., Lindsey, C., Jefferies, J. T., Orrall, F. Q., Werner, M., and Gatley, I. 1984. Extreme Limb Profiles of the Sun at Far Infrared and Submillimeter Wavelengths. Proceedings of the Airborne Astronomy Symposium, NASA-Ames Research Center, in press.
- Bruning, D. H., and LaBonte, B. J. 1984. Integrated Light Observations of the Asymmetry of the $\lambda 5250$ Line. In Conference on Small-scale Dynamics of Stellar Atmospheres, Sacramento Peak, in press.
- Fisher, R., McCabe, M., Mickey, D., Seagraves, P., and Sime, D. G. 1984. The Sun as a Star: 14 June-13 August 1982. Ap. J., 280, 873.
- Foukal, P., and Landman, D. A. 1985. Interpretations of Electric Fields in Coronal Magnetic Loops. IAU Colloquium No. 86, Washington, DC, in press.
- Gergeley, T. E., Kundo, M. R., Erskine, F. T., III, Sawyer, C., Wagner, W. J., Illing, R., House, L. L., McCabe, M. K., Stewart, R. T., Nelson, G. J., Koomen, M. J., Michels, D., Howard, R., and Sheeley, N. 1984. Radio and Visible Light Observations of a Coronal Arcade Transient. Solar Phys., 90, 161.
- Hermans, L. 1984. Modeling the Solar Chromosphere Based on Submillimeter Limb Profiles, M.S. Thesis, University of Hawaii, Honolulu.

- LaBonte, B. J. 1984. Is Stellar Differential Rotation Observable? Ap. J., 276, 335.
- LaBonte, B. J. 1984. On Measuring Solar Torsional Oscillation Using Sunspot Motions. Astr. Ap., 135, 175.
- LaBonte, B. J. 1984. Recent Ground-Based Observations of the Global Properties of the Sun. In Solar Irradiance Variations on Active Region Timescales, B. J. LaBonte, G. A. Chapman, H. S. Hudson, and R. C. Willson, eds. NASA Conference Publication 2310.
- LaBonte, B. J. 1984. H α as a Stellar Diagnostic, in preparation.
- LaBonte, B. J., Chapman, G. A., Hudson, H. S., and Willson, R. C., eds. 1984. Solar Irradiance Variations on Active Region Timescales, NASA Conference Publication 2310.
- LaBonte, B. J., and Rose, J. A. 1984. Magnetic Plages and the Hyades Anomaly, in preparation.
- Landman, D. A. 1984. Physical Conditions in the Cool Parts of Prominences II. The Mg Triplet Lines. Ap. J., 279, 438.
- Landman, D. A. 1984. Physical Conditions in the Cool Parts of Spicules. Ap. J., 284, 833.
- Landman, D. A. 1985. Physical Conditions in the Cool Parts of Prominences. III. The Sr⁺/Ba⁺ Resonance Line Ratios and the Internal Ly α Flux. Ap. J., in press.
- Landman, D. A. 1985. A Spectral Analysis of the Low Temperature Material in Spicules. In Proceedings of the Workshop on Chromospheric Diagnostics and Modelling (13-16 August 1984), B. W. Lites, ed. (Sunspot: National Solar Observatory/Sacramento Peak), in press.
- Landman, D. A. 1985, A New Property of the Small-Scale Non-Thermal Motions in Quiescent Prominences. Ap. J., submitted.
- Lindsey, C., Becklin, E. E., Hermans, L., Jefferies, J. T., Orrall, F., Gatley, I. I., and Werner, M. W. 1984. A Determination of the Submillimeter Brightness Profile of the Extreme Solar Limb from Observations of the Eclipse of 1981 July 31, in preparation.
- Lindsey, C., Becklin, E. E., Jefferies, J. T., Orrall, F. Q., Werner, M. W., and Gatley, I. 1984. Observations of the Brightness Profile of the Sun in the 30-200 Micron Continuum. Ap. J., 281, 862.
- Lindsey, C., de Graauw, Th., de Vries, C., and Lidholm, S. 1984. Solar Limb Brightening at 820 Microns. Ap. J., 277, 424.
- Lindsey, C., and Kaminski, C. 1984. Temporal Variations in the Solar Submillimeter Continuum. Ap. J. Lett., 282, L106.
- McCabe, M. K. 1984. H α Manifestation of an Energetic Gamma Ray Event at the Solar Limb. Solar Phys., submitted.

- Orrall, F. Q., Rottman, G. J., Fisher, R. R., and Munro, R. 1985. A Photometric Comparison of EUV- and K-coronas. Ap. J., in preparation.
- Pasachoff, J. M., and Landman, D. A. 1984. High-Frequency Coronal Oscillations and Coronal Heating. Solar Phys., in press.
- Sime, D. G., Fisher, R. R., McCabe, M. K., and Mickey, D. L. 1984. The Corona Near the Time of the 1983 June 11 Total Solar Eclipse. Ap. J. Lett., 278, L123.
- Strong, K. T., Smith, J. B., McCabe, M., Machado, M., Saba, J. L. R., and Simnett, G. M. 1984. Homologous Flares and the Evolution of NOAA-Region 2372. Advances in Space Research, submitted.
- Woodgate B. E., Martres, M. J., Smith, J. B., Strong, K. T., McCabe, M. K., Machado, M. E., Gaisauskas, V., Stewart, R. T., and Sturrock, P. A. 1984. Progress in the Study of Homologous Flares on the Sun. Advances in Space Research. Proc. of 25th Plenary Meeting of COSPAR, Austria, 1984, submitted.

The following are abstracts of papers presented or to be presented to the American Astronomical Society or the American Geophysical Union:

- Garcia, C. J., Sime, D. G., and McCabe, M. K. 1984. Photospheric Magnetic Fields and the White Light. B.A.A.S., 16, 533.
- Landman, D. A. 1984. Physical Conditions in the Cool Parts of Spicules. B.A.A.S., 15, 970.
- Landman, D. A. 1984. Conditions in Solar Prominences: Relative Ba⁺/Sr⁺ Line Intensities and the Internal Ly α Flux. B.A.A.S., 16, 531.
- Landman, D. A. 1984. On Helium Excitation in Quiescent Prominences. B.A.A.S., 16, 1004.
- Lindsey, C., Becklin, E. E., Orrall, F. Q., Werner, M. W., Jefferies, J. T., Gatley, I. 1984. Extreme Limb Profiles of the Sun at Far-Infrared and Submillimeter Wavelengths. B.A.A.S., 16, 992.
- Orrall, F. Q., Rottman, G. J., Fisher, R. R., and Munro, R. 1985. B.A.A.S., in press.
- Yasukawa, E. A., Sime, D. G., and McCabe, M. K. 1984. EOS Trans., 65, 1071.