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Semiannual Status Report

CORONAL AND CHROMOSPHERIC PHYSICS

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For the Period
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In this report prepared in the middle of the grant year, we summarize our achievements and completed research of the past year and outline projected research for the remainder of the current grant period. At the end of this report, we list current publications pertinent to this grant.

A. Solar Activity during the Solar Maximum Mission and Solar Maximum Year

1. During the Solar Maximum Mission (SMM), the facilities at Haleakala were used to monitor solar activity both at the limb and on the disk in coordination with the SMM experiment teams' programs. Consequently, a large volume of data was assembled and catalogued and has provided material for data exchanged with space and ground-based investigation as the continuing analysis proceeds. There were many events of particular interest and importance which still require detailed investigation and have been described in previous reports. During the grant period, M. K. McCabe has concentrated on the study of a well-observed limb flare that occurred on 21 June 1980. The event was particularly significant because of several factors:

a. The timing was such that Haleakala was almost the only observatory able to record data.

b. Although the SMM-pointed instruments were focused on another region that had produced a large flare some hours earlier, the gamma-ray and HXRB experiment recorded extremely energetic X-ray and gamma ray emission.

c. The flare, although small in area, occurred at the solar limb, providing a favorable geometric configuration for observing the small flare

loops above the limb while the underlying chromosphere that was excited could be detected against the disk.

d. The Hα observations at Haleakala were made with a time resolution of 12 sec during the impulsive phase, making it possible to examine Hα intensity variations during this phase and at the same time to locate the positions of the emission centers.

e. The flare was followed by Hα ejecta above the limb which can be related in time and position with radio observations.

Because the flare was very small and examination of the film sequence showed rapid small-scale intensity changes, microdensitometer tracings were made for a series of frames during the impulsive and decay phase. (Raster scans of an area 80 x 40 arcsec with a step size of 1.6 arcsec.) The data were used to determine variations of intensity with time and position and generate contour plots. The results show that the flare consisted of several small loops which brightened consecutively, with emission commencing near the top of the loops, then along the legs, followed by bright foot-points at a lower height visible against the disk. For one of these loops, the intensity variation correlated with those of the hard X-rays from the SMM HRBS experiment but with a time delay of up to 12 sec. These results will be presented at the Solar Physics Division Meeting of the AAS in June 1983. A paper discussing the complete analysis of the Hα observations is currently in preparation.

2. The analysis by McCabe of Hα mass ejections observed at Haleakala during SMM in collaboration with the SMM Coronograph/Polarimeter (C/P) experiment and other ground-based observatories is a continuing process. In particular, the

study of simultaneous visible and radio observations of a coronal transient that occurred on 9 April 1980 has been completed with a paper submitted to Solar Physics (1983, Gergely et al.). Visible light observations of the transient and associated erupting prominence were available from the C/P carried aboard SMM, from the P78-1 coronograph, and from Haleakala Radio observations of the related type III-II-IV bursts were available from the Clark Lake and Culgoora Observatories. The transient was extremely complex and the results suggest that an entire coronal arcade rather than just a single loop participated in the event.

3. Selected Hα observations from Haleakala have been analyzed by McCabe in support of other SMM projects. The positions of flare kernels were determined for comparison with VLA radio maps obtained by M. R. Kundu for an active region observed on 15 May 1980. A study was made of the flares in an active region that crossed the solar disk in November 1980 for correlation with HXIS data being reduced by Z. Zvestka.

4. McCabe has continued her participation in the Flare Build-up Study (FBS) of the SMY program. She worked with the Homologous Flares Group organized by Bruce E. Woodgate at Annecy (1981). She coordinated Hα observations from Haleakala and three other observatories to locate possible homologous flares in two complex active regions that crossed the solar disk in April 1980. These two regions together with three other candidates had been selected for further study. An interim report from the wealth of data available offered three tentative conclusions:

a. Homologous flares are common when defined as having footpoints very near the same places and can occur in sets of from two to more than ten members.

b. Maintenance of the magnetic structure is not a necessary condition for homologous flares. Dramatic disruption through filament eruptions and mass ejections can occur between members of a set.

c. No connection was found between the X-ray brightness of a homologous flare and the time since the last one of the same set.

Following the discussion of proposed homologous sets in individual active regions, an attempt was made to see if groups of sets showed similarities between them and three tentative groups were suggested, based on their circumstances within magnetic patterns. These homologous supersets are being further studied. McCabe has been invited to attend a FBS Special Workshop at Big Bear Solar Observatory in June when study groups will be reorganized to carry out the evaluation and interpretation of FBS results for the coming three years.

B. Other Studies of Solar Activity and Variability

1. A paper was completed by B. J. LaBonte and D. H. Bruning (Mount Wilson Observatory) on the interpretation of solar irradiance measurements from the ACRIM experiment on the SMM satellite. Their most important conclusion is that the flux deficit in sunspots is matched by the flux increase in faculae, averaged over a period of months. As a followup to that study, LaBonte has made two observing runs at Mees Observatory to measure the spectrum of the brightness excess of faculae. The precise determination of the facular excess brightness will tell whether the solar luminosity varies with activity, even though the Earth-directed flux does not.

2. LaBonte and R. F. Howard (Mount Wilson Observatory) made a further study of the solar torsional velocity oscillation and its relation to the magnetic activity. A third mode of torsional oscillation was detected, in which the north and south hemispheres move oppositely. The westward moving phase of the wavenumber 2 hemisphere^{-1} wave was found to increase its amplitude ~1 year before the onset of magnetic eruption at the surface in spot cycle 21.

3. LaBonte has continued studies of the calibration of stellar activity measurements by reference to the Sun. The first paper, now published, dealt with the basic properties of solar (stellar) rotation that can be measured from disk integrated observations of magnetic activity (Ca II H and K plage emission). The second paper, recently submitted, deals with the detectability of stellar differential rotation. The decreasing latitude of active regions through the activity cycle, coupled with differential rotation, should produce a detectable rotation variation through the cycle. The variation is not in fact measurable; however, the problem is not a systematic property of solar activity, but only the random appearance and evolution of active regions. The implication is that more sophisticated analysis of high precision data could identify individual active regions, reducing the error in the measured rotation period and allowing detection of the differential rotation signal.

4. Observations of the line continuum contrasts of facular regions by LaBonte are continuing. Both the coude spectrograph and Stokes polarimeter are used for this project. It is expected that by the end of the grant period, definitive results should be obtained, permitting a substantial improvement in present models for the interpretation of solar irradiance variations observed by the SMM and Nimbus satellites.

5. Graduate student Linda Hermans and S. F. Martin (Caltech) have analyzed the rates of growth of a representative sample (65) of active regions (ARs) that developed on the sun from August 1978 through October 1979. The distribution of ARs by rate of growth of their total magnetic flux is characterized by decreasing numbers with an increasing rate of growth ranging from 1 x 10^{20} to 160 x 10^{20} Mx/day. The distribution is similar in pattern to the known distributions of both sunspot group and AR lifetimes. As measured from the daily Mt. Wilson magnetograms, the majority of ARs exhibit their most rapid rates of growth before the third day of observation; 30% were still growing after the third day. Forty-five percent of these were cases in which new ARs (major quantities of discrete new magnetic flux) subsequently arose in the original ARs. Such clearly "multiple" ARs also comprised at least 42% of the 26 regions with maximum early rates of growth exceeding 30 x 10^{20} Mx/day. We expect and find that the maximum rate of growth of ARs is correlated with their ultimate maximum size as measured by total magnetic flux, area x intensity of the corresponding Ca II plage or maximum sunspot area. It appears possible to use the daily rates of growth to distinguish with a confidence of about 80% whether a given new AR will ultimately become large (AxI > 1000 units) or remain small. We speculate that more frequent and accurate measures of AR rates of growth would yield tighter correlations between rate of growth, maximum AR magnitude, and time to fully emerge, especially if each new discrete emergence of one AR within another is measured independently.

C. Infrared and Submillimeter Photometry

1. E. E. Becklin, Jefferies, C. Lindsey, and Orrall are continuing analysis of infrared data obtained in airborne solar observations from the Kuiper Airborne Observatory (KAO) in July 1981, in collaboration with M. Werner

(NASA-Ames) and I. Gatley (UKIRT). Extensive observations of the Sun were made simultaneously at 30, 50, 100, and 200 microns. The program culminated in an observation of the limb occultation of the Sun during the total eclipse of 31 July 1981, providing high-resolution information on the limb intensity profiles of the Sun in the submillimeter continuum. This program represents, so far, the only solar observations made by the KAO. The results of data analysis to date are summarized as follows:

a. The 200-micron intensity profile shows radial darkening of approximately 2% at $\rho = 0.6$, which then reverses to brightening toward the limb of several percent above the brightness at disk center. The 100-micron profile shows a similar character with somewhat less radial darkening and less limb brightening, and with the reversal to limb brightening delayed to $\rho = 0.7$. The 30- and 50-micron profiles show gradual radial darkening somewhat weaker, with no indication of brightening at the extreme limb. Plane-parallel model solar chromospheres predict only radial brightening for wavelengths longward of 200 microns. The existence of strong radial darkening suggests that the onset of nonradiative heating in the low chromosphere is characterized by components recessed downward into vertical magnetic flux tubes, which are thus obscured by surrounding opaque cooler material when viewed at increasing incidence. These results have recently between submitted for publication in the Astrophysical Journal. We are now starting to consider the task of studying LTE radiative transfer in heated-magnetic-flux-tubes models of the low chromosphere.

b. The 100- and 200-micron limbs lie considerably further above the visible limb than smooth model chromspheric models predict. The 200-micron limb is 3" above the visible limb, which is 1000 km higher than the most

recent models of Vernazza, Avrett, and Loeser (1981, Ap. J. Supp. 45, 635) predict. This is almost certainly due to fine structure in the middle chromosphere. These results have recently been published (cf. Lindsey, Becklin, Jefferies, Orrall, Werner, and Gatley, 1983, Ap. J. (Letters) 264, L25).

c. Solar plages, which have a low (1-2%) contrast in the 10-micron continuum, show a strong increase in contrast (to about 10%) in the 100- to 200-micron continuum. This is a strong indication that the perferentially heated elements, thought to be confined to narrow magnetic flux tubes in the low photosphere, diffuse rapidly to a much larger filling factor near the temperature minimum.

2. A careful analysis of limb occultation data obtained during the eclipse observation is continuing to determine the extent and profile of the extreme limb brightening at the longer wavelengths. This requires a careful account of saturation effects as the solar crescent approaches the width of the resolving beam (~100"). The importance of this problem arises from its diagnostic relevance to the structure of the hydrogen ionization plateau of the chromospheric models of Vernazza, Avrett, and Loeser. (The existence of partially ionized hydrogen at 6000 K in the middle chromosphere can bring about a brightness excess of up to 20% at the extreme limb at 200 microns.) Analysis of this problem has met with greater difficulties than initially expected, but we expect to dispose of these in the near future.

3. We soon hope to turn to the task of deconvolving raster scans made earlier in July during the KAO airborne program. The resulting maps will be used to compile statistics of active region contrasts measured simultaneously at 30, 50, 100, and 200 microns.

4. Analysis of data on the comparative brightness of the Sun and Moon is proceeding at NASA-Ames Research Center under M. Werner. The purpose is to use the Moon as a photometric standard in an absolute determination of the solar brightness at all four wavelengths. We are collaborating closely with Werner on this project.

5. C. Lindsey is continuing his study of local submillimeter continuum brightness variations on the Sun. Most recent observations made at the IRTF show brightness temperature variations of order 15 K rms in a resolving beam of ~50" FWHM. Power spectral statistics taken over four observing sequences covering a total time of ~7 hours show significant power spectral enhancements of periods ranging from 2.5 to 4 minutes, having an rms variation of 5 K. These and shorter period variations (of less than a minute) are thought to be due primarily to adiabatic heating of the chromospheric medium in response to compression due to hydrodynamic waves such as those associated with velocity field oscillations (cf. Lindsey, 1977, Solar Phys. 52, 263). Extensive tests have been made to assure that the intensity variations are indeed solar in origin (rather than due to transparency variations in the terrestrial atmosphere or errors in tracking over regions with spatial variations in intensity, for instance). These results are being prepared for publication in the Astrophysical Journal. During the remainder of the current grant period, we will continue these studies.

D. Solar-Related Atomic Physics

1. Landman, together with a number of summer research assistants, has undertaken several atomic physics calculations in support of various aspects of our solar research program. These are summarized as follows:

a. As part of an extended program of the calculation of proton impact excitation of transition region and coronal ions (cross sections and rates), we have been studying the $p^3\ ^2D_{3/2} \rightarrow 5/2$ and $^2P_{1/2} \rightarrow 3/2$ transitions in N and P isoelectronic sequence ions. Because the LS-coupled interaction (electric quadruple) matrix elements vanish for these transitions, we have an interesting test case for assuring the various approximations entering into the computations. During this contract period we have implemented a version of Kastner and Bhatia's two-level procedure (Astro. Ap. 71, 211 [1979]) to compare with the results of our five-level ($p^3\ ^4S_{3/2}$, $^2D_{3/2}$, $5/2\ ^2P_{1/2}$, $3/2$) and two-level calculations obtained by numerical integration of the Schrodinger equation in the semiclassical Coulomb scattering formulation. Our initial applications of the Kastner-Bhatia method yield values at variance with those quoted by these authors. This work is also supported by NSF Grant AST 80-00695.

b. As part of the research associated with the prominence spectrophotometry program, and also for application to plasma diagnostics of the middle chromosphere, we have been calculating the excitation-ionization equilibrium of various constituents (currently Na, Mg, Sr^+, and Ba^+) under conditions appropriate to features situated just above the solar surface. This work involves the critical review and evaluation of the relevant atomic (and solar) data on collisional and radiative rate processes, and the estimation of cross sections and rates for cases where previously results are either lacking or out of date. Among the various aspects of this work, we have extended our scaled Thomas-Fermi radiative rate program (for radiative decay and photoionization rates) to include the spin-orbit interaction and a polarization potential term in the manner described by Hofsaess (Z. Phys. A281, 1 [1977]).

c. We have implemented a program to solve the radial part of the Schrodinger equation and used it to compute the wave functions and radiative rates for the middle H Balmer lines in a Debye potential. The deviation from Coulombic rates are found to be unimportant at prominence--or even flare--densities.

E. Coronal and Transition Region Studies

1. During this period Orrall completed a collaborative paper (Orrall, Rottman, and Klimchuk, 1983, Ap. J. 266, L65) on coronal and transition region velocity fields measured with a high resolution EUV rocket-borne spectrometer built at LASP under the direction of G. J. Rottman and flown on 23 November 1981. In two earlier flights of this experiment, it was found that there is an apparent systematic outflow from low-latitude coronal holes in lines formed both in the transition region and corona. This outflow velocity was found to increase with height from the transition region to the corona where this velocity was about 12 km s^{-1} as measured in λ625 MgX. The hypothesis that these velocities represent a real net outflow of mass into interplanetary space was shown to be consistent with the conservation of mass, with current empirical models of the structure of the transition region and inner corona, and with the observed mass flux at 1 AU (Rottman, Orrall, and Klimchuck, 1981, Ap. J. 247, L135; 1982, Ap. J. 260, 326). One result of the recent study of the 1981 flight was that this outflow was also observed from a large polar hole with a low latitude extension similar to (but less extensive than) the large holes of late solar cycle 20 which produced great persistent high-speed solar wind streams. The results of this study are now in print in the Astrophysical Journal and further data reduction is in progress. The existing observations suggest that negative Doppler shifts are common and

perhaps universal signature of coronal holes, since they have been detected in compact low latitude holes closely associated with active regions, in the low latitude extensions of polar holes, and in a well-developed polar hole. Other implications of these results are discussed by Rottman and Orrall in an invited paper prepared for presentation at an AGU Chapman Conference Solar Wind Fire. An improved absolute wavelength standard and a broadband imaging detector have been incorporated into the LASP spectrometer. This was flown in November 1982 but the rocket was cut down because it went off course. We hope to fly it again in May 1983 and to measure absolute Doppler shifts.

2. Landman and J. M. Pasachoff (Williams College) have continued work on their eclipse experiment to search for short period variations in the Fe^{13+} λ5303 line intensity. The measurements made during the 1980 eclipse in India have now been analyzed and submitted for publication. Preparations are underway for an improved version of the experiment to be used at the 1983 eclipse in Indonesia.

F. Prominence Research

1. Landman has completed a study of the excitation-ionization equilibrium for the low-lying levels of Na, Sr^+, and Ba^+ under prominence and chromospheric conditions. The level populations were calculated as functions of electron density, temperature, microtubulence, vertical flow velocity, height above the limb, and local Lα integrated intensity. The metastable ^2D-term photoionization cross sections play an important role, but were not readily available. A version of the scaled Thomas-Fermi method was used to evaluate these ^2D cross sections, and also those for the ground ^2S and first excited

^2P terms, which are compared with quantum defect method results. The ratio of the NA-to-Sr^+ resonance line integrated intensities is shown to provide a useful and sensitive electron density diagnostic for prominences, yielding values in the neighborhood of 10^{11} cm^{-3}. A paper describing this work has been accepted for publication in Ap. J. This and other prominence work by Landman is also supported under NSF Grant 78-19006.

2. Building on the above work, Landman has determined the principal plasma parameters--including the electron density, degree of hydrogen ionization, and total gas pressure--for the cool parts of seven prominences (spectra reported by Shih-Huei (1961, Izv. Kryusk. Ap. Obs. 25, 180) and Yakovhin and Zel'dina (1964, Sov. Astron.-AJ, 7, 643). The method uses measurements of the Na and Sr^+ resonance lines together with those of the middle H Balmer lines. It is also shown that the Na/H integrated intensity ratios alone are sufficient to determine the degree of H ionization, and this is illustrated with additional Na D-line and H Paschen data recently obtained at Haleakala. The major results of this study are that the degree of H ionization in the cool prominence parts is found to be substantially lower than currently accepted (we find $n_p/n(HI) \sim 0.08$, on average) and the total gas pressure high ($(n(HI) + nP)\ kT \sim 3.0$ dynes cm^{-2}, on average). An account of this work has been submitted to the Astrophysical Journal for publication.

3. Landman has used the close-lying lines Mg λλ5167, 5173 and Fe^+ λ5169 to study the microturbulence parameter ξ in quiescent prominences. Simultaneous high-dispersion profiles of these lines were obtained with the 25-cm coronograph/3-m spectrograph at Haleakala using the OMA detector. Single component Gaussian profiles (with minor optical depth corrections) were measured at 51 positions in 16 prominences. The relative behavior of the Mg

and Fe^+ lines indicate that $\xi(Fe^+)$ is generally ~10% smaller than $\xi(Mg)$--i.e., the Fe^+ line widths are narrower than expected from the corresponding Mg ones. A similar result was tentatively suggested in our previous work with Ca^+ λ8498 and Na $D_{1,2}$ profiles, where the lines had to be recorded in sequence. The present data conform strongly to the empirical relation $v(Fe^+ \lambda5169) = 0.86\, v(Mg\ \lambda5173) - 0.13$ (when $v = c\, \Delta\lambda_D/\lambda$ in km s^{-1}) over the observed range $2.72 < v(Mg\ \lambda5173 < 8.58$, in marked contrast to the relation expected for a common homogeneous emitting region. An account of this work was presented at the AAS meeting in Boston.

4. Landman has obtained high-dispersion spectra of a number of filaments against the disk in the region of He D_3. These data are being analyzed in the same manner as for our earlier plage study (Landman, 1981, Ap. J., 244, 345) to determine the character of the systematic vertical velocity field in prominences.

5. Landman and J. M. Pasachoff (Williams College) have continued work on their collaborative projects, which include (i) a study of H Balmer/Paschen line intensity ratios in prominences (data obtained with the MCS system at Haleakala), and (ii) analysis of the prominence spectra obtained by the IFA team during the 1980 total eclipse in India. Several students at Williams College have also been involved in this work, and their contributions have been reported in the form of honors theses.

6. Landman and a summer research assistant have begun a study of an apparently active prominence observed above the limb with the HRTS II instrument. During this period, line intensities from various species of differing ionization have been determined from the rocket spectra.

7. Orrall and E. J. Schmahl (U. Maryland) a few years ago published observations and analysis of the H I Lyman continuum in nine prominences observed from ATM-Skylab with the Harvard EUV spectrometer (Orrall and Schmahl, 1976, Sol. Phys. 50, 365; 1980, Ap. J. 240, 908; Schmahl and Orrall, 1979, Ap. J. 231, L41). Analysis of the He I EUV continuum is more difficult because of blends and decreased sensitivity at shorter wavelengths. A preliminary study (Orrall and Schmahl, 1980, BAAS, 12, 477) was made of the five best observed prominences. We are presently reexamining all of our data assisted by undergraduate student Pamela Walton. This recent work has been stimulated by recent detailed new calculations of the H and He ionization continua in prominences by J. N. Heasley and R. W. Milkey of the University of Hawaii (1983, Ap. J., in press).

G. Chromospheric Research in Quiet and Active Regions

1. Graduate student S. R. Walton, in dissertation research done in part under this grant, has been constructing two-component plage models, with radiative transfer calculations carried out using the "1-1/2 dimensional" approximation. These models are constrained by observations of a number of Fraunhofer lines and the inner wings of the Ca II K line in ten plages that he obtained with the Optical Multichannel Analyzer at Mt. Haleakala. This research is now completed and his dissertation will be completed by the end of the current grant period.

2. Landman has also applied his Na, Sr^+, Ba^+ statistical equilibrium calculations (see Section F above) to a spectral diagnostic study of the middle chromosphere (at heights 1500 and 2100 km, using the measurements of Dunn et al. (1968, Ap. J. Suppl. 15, 275). At the lower height we find the assumption of a common emission region to be untenable; the Na lines are

formed in low-velocity regions (microturbulence + | vertical flow | < 5 km s^{-1}), while the Sr^+ emission arises in higher velocity material. Several two-component models are explored. The utility of the Ba^+ lines is compromised at present by the uncertainty in the ground state photoionization cross section near threshold (i.e., at Lα). At 2100 km the data support a broad range of common emission region solutions, including ones with parameter values approximating those typically associated with spicules.

3. Bernat and Landman, together with a summer research student, have developed some initial processing software for the PDP 11/45 at the Mees Observatory in order to survey the large volume of CCD active region data they obtained at the Sacramento Peak Observatory last year. These data consist of time series of high-dispersion spectra of the He D_3 line and nearby photospheric lines throughout a number of active regions. The present programs will enable us to identify and separate out the most scientifically interesting sequences for subsequent analysis.

H. Solar Dynamics Project

1. During summer 1982, a joint project on Solar Dynamics was undertaken by groups at Haleakala and the High Altitude Observatory (HAO) at Mauna Loa. The objective was to study the relationship between the white light corona and the Sun's magnetic field at the level of the photosphere during a period (June-August) covering two solar rotations. At Haleakala, McCabe organized a program with D. Mickey, J. Lieberman, and Joan Najita (summer student). Daily observations of the full Sun were made using the Stokes' polarimeter to measure the polarization across the line Fe I-λ6302.5 and so determine the longitudinal magnetic field. In addition, photographic filtergrams were

recorded of the solar disk in Hα and Ca-L and prominences in Hα. The complete sets of data are being assembled to be printed as two NCAR Technical Notes. The first one has been completed (NCAR/TN - 202 + STR) and consists of the Haleakala photographic data and Mauna Loa white light coronal maps for each day of the period; the second will include the polarimeter data and synoptic charts of both coronal and magnetic field measurements.

Considerable progress has been made with the polarimeter data reduction so that using a computer code provided by D. Elmore (HAO) for determining the line of sight component of the longitudinal magnetic field from the Stokes V-profile, magnetograms have been produced for several days to date. The scanning aperture for the polarimeter measurements was 30 x 5 arcsec^2 with a distance between data point 40 arcsec. Allowing for the different spatial resolution the magnetograms compare well with KPNO data (2 arcsec); this resolution is adequate for correlation with coronal structures that can only be defined on a much coarser scale.

Another reason for running the program was to use the polarimeter in its newly developed configuration over a period of time on a repetitive straight forward program. This provided a test of the sensitivity, calibration and other instrumental properties and has led to making several adjustments and improvements.

2. By a fortunate set of circumstances, the active regions during the observing period were located so that as the Sun rotated one hemisphere was very active while the opposite one was virtually spot-free. Thus, the amplitude of rotational modulation of various integrated parameters--e.g., sunspot areas, Ca plages, daily coronal pB values, GOES-4 1-8 Å background flux estimates--was approximately equal to the modulation observed over an

entire solar cycle. Thus, the solar data when integrated over the visible hemisphere could be used as diagnostics of generalized stellar activity. A linear relationship was found between the Ca II K line flux and total inferred coronal mass, which leads us to hypothesize that the Ca II flux modulation in other stars can be used to infer stellar coronal conditions. A paper discussing these results is in its final stages (Fisher, McCabe, Mickey, Seagraves, and Sime, 1983, in preparation).

I. Eclipse Studies

1. Landman and Orrall have prepared an experiment for the 1983 eclipse in Indonesia to obtain prominence and coronal spectra throughout the range λλ3000-9000. The observations will be made with the Eclipse Telescope/Spectrograph used at a number of previous eclipses by Jefferies, Orrall, and Zirker. For the forthcoming, eclipse the instrument has been refurbished both electronically and mechanically. Eclipse conditions offer unique advantages for accurately measuring simultaneously the large variety of weak, but diagnostically important, lines and continua that are extremely difficult to obtain otherwise for ordinary prominences. The spectra will allow interlocking tests of various multi-atom, non-LTE theoretical prominence models, developed here and elsewhere, and will thereby provide critical information on the accuracy with which we can determine the basis prominence plasma parameters. In addition, the coronal forbidden line spectrum will be measured around the limb, providing valuable diagnostic data of use to all eclipse teams.

2. Pasachoff and Landman are also repeating, again in a significantly upgraded version, their 1980 eclipse experiment to search for high frequency (0.1-2 Hz) oscillations in the λ5303 coronal green line intensity as a test of predictions of theories of coronal heating via surface Altvin waves. The 1980

data exhibit small power enhancements in this frequency range but their solar origin is not indisputable (Pasachoff and Landman, 1983, Sol. Phys., submitted). The improvements planned for the upcoming eclipse should provide a much more conclusive test of this point.

3. During a period from of one week before through one week following the 1983 June 11 total solar eclipse, we expect to reactivate the coronal dynamics program (see Section II-H above) at Haleakala in collaboration with Mauna Loa. The purpose is to provide a data base of photospheric, chromospheric, and coronal observations to provide information related to the development of coronal and prominence structures and underlying physical conditions at the solar limb during eclipse. Daily measurements of the line of sight component of the longitudinal magnetic field over a rectangular area $\geq \pm 15°$ on each side of the rotation axis will be used to build a synoptic chart for estimating the photospheric field at each limb. Under favorable conditions we should be able to record prominence activity very close to the actual eclipse time (near sunset at Haleakala).

J. Polarimetry and Magnetic Field Measurements

1. During the previous grant period, Mickey replaced the discrete diode detectors in the Stokes-Vector Polarimeter-Spectrometer with linear Reticon arrays with 128 channels. This increased the throughput of the system by at least a factor of 100 and improved the stability of the instrument against comporal changes in sky transparency and seeing. Software for system operation, calibration, data reduction, and display are fully operational.

2. In June-August 1982 the polarimeter was used to make daily full-Sun magnetograms as part of the Solar Dynamics program described in Section II-H.

New software for reduction and display of these maps was written for this program.

3. Mickey and Orrall have undertaken a series of tests of the polarimeter-spectrometer aimed at reducing residual spurious sources of modulation, instrumental polarization, noise, and drift. Some of these spurious effects have been traced to small timing errors and to the rotating waveplate modulater. These are relatively simple to correct. More difficult to improve are sources of drift and spurious modulation that arise in the spectrometer. We have considered removing the spectrometer from the spar and coupling it to the telescope-polarimeter by means of fiber optics. This would enable the spectrometer to be maintained in an environment of constant temperature and gravity and would reduce spurious modulation at the slit. A preliminary design for achieving this seems inexpensive and straightforward. Optical bench tests of its feasability are in progress. Concurrently, measurements of center-to-limb polarization in the continuum and Fraunhofer lines are in progress.

K. Other Activities

1. During this time LaBonte spent 2 months working on the Definition Phase of the Photometric Filtergraph Instrument for the Solar Optical Telescope (SOT). He is a co-investigator on this instrument. Jefferies and Orrall are co-investigators on the Combined Filter-Spectrograph on SOT and have been contributing to the design of that experiment.

2. Orrall has continued as chairman of the Working Group for the Solar Corona Diagnostic Mission (SCDM). During this period he prepared and submitted an invited paper on the scientific aims and implementation of this mission for the American Institute for Aeronautics and Astronautics.

L. Publications

The following publications pertinent to this contract came into print, or were accepted for publication, or were submitted during the past year as indicated.

Bruning, D. & LaBonte, B. J. 1982. Interpretation of solar irradiance variations using ground-based observations. Ap. J., in press.

Bruning, D. H., LaBonte, B. J. & Howard, R. 1982. Observations of solar irradiance variations. In Highlights of Astronomy, IAU General Assembly, contributed paper to Session on Solar Variability, in press.

Fisher, R. R., et al. (NCAR) and McCabe, M. K., Mickey, D. L., et al. (UH) 1982. Joint Solar Dynamics Project Data Summary. Vol. 1, Chromospheric and Coronal Observations. NCAR Technical Note TN-202 + STR.

Fisher, R., McCabe, M., Mickey, D., Seagraves, P. & Sime, D. C. 1983. The Sun as a star: 14 June-13 August, 1982. Ap. J., submitted.

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