radiation by vibrationally excited oxygen molecules was investigated as a possible probe of the vibrational temperature of the atmosphere.

Dr. B. Bell and J. G. Wolbach are undertaking a computer analysis to search for time-variants in the three basic meteorological parameters of rainfall, temperature, and pressure over the period of existence of modern quantitative records.

Menzel studied the distribution of heat within the moon under various assumptions about its sources and obtained the temperature distribution throughout the moon as a function of time, radius, and latitude for models having different thermal properties.

Whipple continued his research on problems of the origin and evolution of the solar system. With Drs. M. Lecar and F. A. Franklin (Smithsonian), he showed that the high-inclination and high-eccentricity asteroids such as the prototype, Pallas, could not have been formed in situ without a hypothetical catastrophic event, but probably formed in the Jupiter-Saturn region along with the Trojan asteroids. Disturbing effects of the giant planets and the last vestiges of the solar nebula are considered to be responsible for the present orbit of Pallas. With Dr. S. E. Hamid, Whipple continued research efforts to uncover records of early observations of Comet Encke, to extend information on its orbit backward in time.

DEPARTMENT OF ASTRONOMY

Enrollment in the Department comprised 20 undergraduate concentrators and 30 graduate students. Two students received the A. B. degree in June 1972; two received the A. M. degree in March and three in June. The Ph.D. degree was awarded in March to Catherine J. Cesarsky, Diego A. Cesarsky, James L. Elliot, and Sandra M. Faber, and in June to Eric J. Chaisson, Eric G. Chipman, Paul M. Kalaghan, Joseph H. S. Schwarz, Jorge E. Vernazza, and Arthur T. Wood, Jr.

MISCELLANEOUS

In connection with the 400th anniversary of Johannes Kepler in 1971, Gingerich worked extensively on historical problems related to this 17th-century German astronomer. Whitney is doing research for a biography of Edwin Hubble. Dedication of the Richard Scott Perkin Laboratory for Astrophysics took place on 12 May 1972 with former Observatory Directors Menzel and L. Goldberg, Acting Director Dalgarno, and Director-designate Field in attendance. The building contains 70,000 sq ft of laboratory, office, and library space, doubling the facilities on Observatory Hill. Named in honor of the late Chairman of the Perkin-Elmer Corporation, the building was made possible by substantial donations from the Perkin Fund, the National Science Foundation, and friends of the Observatory. The new library bears the name of John G. Wolbach, and the conference rooms are named for H. Irving Pratt, in honor of their contributions to the Observatory.

Dr. Frank H. Shu received the Bart J. Bok Prize this June in recognition of "his important contributions to the density-wave theory of galactic spirals".

A bibliography of Observatory publications for the year 1971-72 is available on request from the Librarian, Harvard College Observatory.

A. DALGARNO, Acting Director

University of Hawaii, Institute for Astronomy, Honolulu, Hawaii

This report covers progress at the Institute for Astronomy over the twelve month period July 1971 through June 1972.

I. STAFF


Of these, Landman joined during the report year while Fisher and Lagnado left to take positions elsewhere. Visiting colleagues in residence were James C. Kemp, Department of Physics, University of Oregon, David Wilkinson, Department of Physics, Princeton University.

Operations at the Haleakula Observatories were supervised by Fisher and, following his departure, by Mickey as Resident Astronomer. Richard Wolff was Resident Astronomer for Mauna Kea Observatories. Administrative services came under the direction of R. LoForty following the departure of Donald Tam. Hans Boesgaard continued his responsibilities as Chief Engineer.

II. FACILITIES AND INSTRUMENTATION

A. Haleakula Observatory

During the year, several of the remaining problems in the Stokes vector polarimeter (cf. Orrall, F. O., Solar Magnetic Fields, edited by R. Howard, Reidel Publ. Co., 1971) were resolved, permitting its use as an operational scientific instrument. A thorough investigation of possible noise sources led to the conclusion that, in most cases, noise in the polarization signal arises from flicker caused by 'seeing' or by spar vibration. These appear to be even more severe problems in the corona, where the brightness gradients are much larger. The uncertainty in measured polarization is greatly reduced by using the two orthogonal channels differentially. In this way we have been able to measure polarization of the disk continuum as small as 10⁻⁶.

A new multichannel coronal spectrophotometer has been designed and is presently under construction for installation on the 12-ft spar of the Mees Solar Observa-
B. Mauna Kea Observatory

New instrumentation acquired for programs at Mauna Kea includes a Fourier Transform Spectrometer system delivered in March 1972. Pending completion of the sky compensating fore optics by the manufacturer, the spectrometer has been used in laboratory studies. Installation at Mauna Kea is anticipated in October 1972.

Other observing equipment acquired for, or installed at, Mauna Kea includes an RCA image tube—which is currently under test—a further camera (No. 3) for the coudé spectrograph, and a double-beam photometer.

A new electronic control system for the 224-cm telescope has been designed the first part of which is to be installed at the telescope in Spring of 1973. We anticipate that this will greatly increase the flexibility and ease of operation.

Design of a paved road to Hale Pohaku (9000 ft elevation) was completed and bids are to be called in the fall of 1972. This will provide easy access about halfway up Mauna Kea; the method of access from Hale Pohaku to the summit is still under study. The site for a permanent mid-elevation support complex has been determined and the University has been granted a long-term lease over the property. Architectural design is to begin in early 1973. A new line to supply electricity from the public utility company to Mauna Kea is also under study.

On completion—projected for the end of 1973—it will eliminate the need for our generating power at the site, together with the associated problem of having to haul fuel to the mountain top.

C. University Campus

Following some modifications, a final design and specifications for the Institute’s Manoa campus head-quarters have been completed. Construction is planned to begin in early 1973.
Orrall, with M. Altshuler and D. Trotter of the High Altitude Observatory, has made a study (Solar Physics, in press) of coronal holes based on the K-coronometer coronal density models of Altshuler and Perry. They find that these structures have lower density than the polar regions even though they occur in low latitudes. The chromosphere underlying them is extremely quiet and the holes are characterized by divergent magnetic field lines.

J. Kleczek (Ondrejov), J. Leroy (Pic-du-Midi), and Orrall have completed and submitted for publication a general Bibliography of Solar Prominence Research from 1880 (the date of the Bibliographie Generale de l’Astronomie de Hougue and Lancaster) to 1970.

Mickey and Orrall have completed center-to-limb measurements of the polarization of the Sun’s disk in a 20 Å band, with few Fraunhofer lines, around $\lambda 5830$, using the complete Stokes vector polarimeter described above. Their results are in good agreement with the observations of Leroy made at nearby wavelengths, but extend much closer to the limb (to $\mu = 0.065$). The polarimeter has also been used as a K-coronometer, in which mode it works well being relatively free from scattered light and insensitive to brightness fluctuation. Other programs underway include polarization measurements in active regions on the disk, and in the emission line corona.

Landman (Solar Physics, in press) has studied the effects of intermediate coupling on proton excitation of the $Fe^{+1}$ ground configuration under coronal conditions, and has given new estimates for the cross sections and associated rate constants. More detailed calculations are presently underway.

Jeffries and Landman have started a program to determine velocity fields in selected active regions on the Sun’s disk. Data is obtained by matching up Hα spectra obtained with the Mees Coude spectrograph with Hα slit monitor photographs.

Landman has studied the characteristics of vidicon camera tubes, especially with regard to their suitability in astronomical applications. Particular attention was given to spectral sensitivity, signal integration, signal-to-noise ratio, modulation transfer function, temperature dependence, and read-out processing. A variety of performance tests were conducted with an RCA 4532 tube, all results proved encouraging.

Finn has completed an investigation into the excitation of ionic species either identified or expected in the solar corona. Specifically, he has calculated the level populations of ions in the isoelectronic sequences of neutral aluminum (from Sc Ix to Ni XVI); silicon (from Ti IX to Ni XV); phosphorus (from V IX to Ni XII); sulphur (from V VIII to Ni XIII); chlorine (from Cr VIII to Ni XII); and argon (from Fe IX to Ni XI). Large systems of linear algebra equations were formulated and solved for numerical values of the level populations. Extensive results were obtained for each ion covering the wide variety of physical conditions which can exist in the solar corona. From these results he has calculated theoretical values for the intensities of identified spectral lines. A paper discussing these calculations and containing numerous figures illustrating the results obtained.

B. Rocket Spectroscopy

A high-resolution rocket-borne spectrograph was successfully used to obtain UV spectra, in 1969 and 1971, covering the spectral region 1950 to 1780 Å at a resolution of 0.013 Å and dispersion of 2.0 mm/Å. Several aspects of the spectra are currently under study. In particular, McAllister and Jeffries have analyzed in some detail the emission lines of Si II at 1808.0, 1816.94, and 1817.42 Å. A preliminary description of these features was reported at the IAU Symposium No. 14 held in Utrecht in August 1971 (Space Science Reviews, in press). A further study concerns the center-limb variation of the Al I autoionization doublet at 1932-1937 Å. It has been realized for some years that a proper analysis of the profiles of these lines should yield important information on the structure of the solar atmosphere in the region of the temperature minimum. For this reason, Finn has formulated and solved the coupled equations describing the transfer of radiation in these two lines. It is hoped that comparison of the computed profiles with those measured by the rocket spectrograph will allow us to distinguish between different current models of the solar atmosphere.

Line identifications from the September 1969 flight should soon be ready for publication. Some initial results from this flight have already been reported (Solar Physics 33, 160, 1971).

A second spectrograph with greatly improved spatial resolution is scheduled to be flown in early 1973. We plan to fly it to a higher altitude on an Aerobee 170 rocket, and by an in-flight grating rotation, to obtain spectra in the $\lambda 2800$ and $\lambda 1640$ regions.

C. Solar System Studies

1. Interplanetary Medium

Under Wolstencroft’s direction, regular observations of the zodiacal light have continued with the night sky polarimeter at Haleakala. Using results dating from the start of this observing program (in 1968), maps of the polarized intensity, and the orientation of the polarization plane of the zodiacal light over almost the entire sky have been prepared from observations using narrow interference filters centered at 3650 Å, 4510 Å, 5305 Å, 7075 Å, and 9515 Å. In several areas in the antisolar hemisphere, and in all colors, the polarization orientation is found to deviate from either the radial or tangential orientation expected for scattering of sunlight by spherical interplanetary dust particles. This result is readily understood if the interplanetary dust particles are elongated and partially aligned; such an hypothesis is supported by the detection of a small component of circular polarization in the zodiacal light referred to elsewhere in this report.

Spectra of the night sky in and away from the Zodiacal Cone, taken with the Ebert-Fastie scanning spectrometer at the Kitt Peak National Observatory, have been used to obtain the spectrum of the zodiacal light between 3900 Å and 7450 Å with a resolving power of about 20 Å. Two absorption bands at 4283 Å and 5187 Å have been found, presumably produced by impurities in the
interplanetary dust grains. A higher resolution of study these features is in progress.

At the 224-cm Mauna Kea telescope, circular polarization of the zodiacal light was detected by Kemp and Wolkstencroft. Its variation along the ecliptic showed a clear antisymmetry between the morning and evening hemispheres indicating that the dust grains are nonspherical and partially aligned. Bandermann and Wolkstencroft have studied scattering from submicron particles with a complex index of refraction and have calculated the fourth Stokes parameter for various assumed spatial distributions and orientations of the grains in the solar system. They have considered several alignment mechanisms, and have been partially successful in explaining the observed ellipticity.

Bandermann has continued theoretical studies of the dynamics and evolution of interplanetary dust. The effect of particle collisions on the size distribution of dust grains was further investigated. It was found that, for a variety of physical conditions, the evolution of the distribution due to fragmentation and erosion of grains, and for a given total size range depends most strongly on the value of the velocity during collision. For small values, the distribution is unstable.

Bandermann and S. F. Singer obtained a concise derivation for the expected flux of meteoroids (and dust) and on the surfaces of Earth and Moon. It was found that the accretion rate is greater on the lunar far side than the near side, and greater for the earth than for the Moon, for all Earth-Moon distances and meteoroid velocities.

2. Planetary Program

Observations of the circular polarization of the planets have been pursued by Kemp and Wolkstencroft. The circular polarization of the polar regions of Saturn was monitored through the opposition of November 1971, as a function of wavelength over the range \(\lambda 4000-8400 \) A. An extraordinary “opposition effect” was discovered, wherein the fractional circular polarization reached very large values, up to 0.1% (both signs) at phase angles \( \pm 2 \) degrees at far red wavelengths. The handedness of the polarization was in all cases opposite to that seen on Jupiter. Though not quantitatively investigated, the result indicates that, near opposition, an appreciable part of the reflected light may come from either a deep aerosol layer or a solid surface on Saturn.

The circular polarization of Mars was studied in the spectral range 4030-8500 A during a five-month period covering the 1971 opposition. Two broad features were seen, one shortward of 4500 A and the other longward of 7400 A. Narrower features of smaller intensity were often (but not always) seen between 6800 A and 7400 A.

Bandermann has considered the possibility that multiple reflection of light from rough absorbing surfaces is the principal cause of the elliptical polarization observed on the Moon, Mars, and Mercury. Assuming two reflections and using Fresnel laws for the reflected amplitudes, he calculated values for the fourth Stokes parameter, \( V \), for simple models of rough surfaces. The dependence of \( V \) on the scattering geometry is in fair agreement with the planetary observations and the results obtained in the laboratory by Posperrliss for light scattered from volcanic rocks.

D. Morrison and Cruikshank have completed a study (to be published in Icarus) of the thermal properties of the Galactic satellites based on 20 \( \mu \) radiometric observations of eclipses. The cooling and heating curves for Callisto, Ganymede, and Io indicate that the surfaces of these objects have very low thermal inertias, with values of \( \gamma \) between 3000 and 4500 cal \( \text{cm}^2 \text{s}^{1/2} \text{K} \). The detailed shapes of the curves cannot be matched by homogeneous thermal models; rather a rapid transition to higher thermal conductivity a few millimeters below the surface is required. It is suggested that the surfaces are largely composed of ices; a thin coating of frost providing the upper, low-conductivity layer, while the subsurface material maintains a high thermal conductivity by fusion of a mixture of ice and rock. The eclipse data for Europa are complicated by a large variation of 20 \( \mu \) flux with orbital phase. The study of this phase dependence for both Europa and Io is to be continued next year.

D. Morrison, Cruikshank, and Murphy (Astrophys. J., 1973, L143) published temperatures of Titan and the Galilean satellites measured at Mauna Kea in the 17 to 28 \( \mu \) band. Values found for the Galilean satellites were: Io, 127 \( \pm \) 5; Europa, 119 \( \pm \) 5; Ganymede, 134 \( \pm \) 5; Callisto, 147 \( \pm \) 7 K. The temperature of Titan at this wavelength is 93 \( \pm \) 2 K, much lower than that measured in the 8 to 14 \( \mu \) band, suggesting that Titan’s atmosphere is highly opaque, and that a consequent greenhouse effect produces a substantially elevated surface temperature. The gas most likely to provide the required opacity is molecular hydrogen, but suprisingly high pressures are needed. Cruikshank and Morrison further developed these ideas in an article (Sky and Telescope, August 1972) on the atmosphere of Titan. It is now evident that the atmosphere of this satellite is much more sensitive than had been thought previously.

D. Morrison and Cruikshank (Astrophys. J., in press) measured the brightness of Uranus and Neptune in the 17-28 \( \mu \) band at Mauna Kea, obtaining values of 54.7 \( \pm \) 1.8 and 57.2 \( \pm \) 1.6 K respectively. The temperature for Neptune, the first time measured in the infrared, is higher than expected. The observed radiation from both planets probably arises high in the atmospheres in the strong pressure-induced \( H_2 \) band.

Cruikshank and D. Morrison have used the infrared radiometer at Mauna Kea to measure the 10 and 20 \( \mu \) fluxes of the bright asteroids Ceres, Pallas, Juno, and Vesta. Investigations are now being extended to a few fainter asteroids of particular interest. Morrison is also analyzing the inherent accuracy of one and two color infrared radiometry for the determination of radia, albedos, and emissivities of asteroids and satellites.

Murphy and D. Morrison made a large number of scans of Mars at 10 and 20 \( \mu \) during the late summer and early fall of 1971. A 2-arc sec diaphragm was used to optimize the spatial resolution at 10 \( \mu \). All data were taken before the arrival of Mariner 9, and all but one night was before the great dust storm. The data imply thermal properties of the surface which are consistent with earlier ground based studies.
Murphy, Cruikshank, and D. Morrison also made
scans of Saturn and its rings at 10 and 20 μ. The rings
were found to be significantly hotter than has been found
in the past, suggesting that they are optically thick. The
subsolunar latitude is still increasing so a further increase
in the temperature is anticipated in 1972. Polar limb
darkening at 20 μ was found to be slight, suggesting
either an internal heat source or a very efficient mech-
anism for latitudinal heat transport.

These workers also detected two of Saturn's
satellites, Iapetus, and Rhea, at 20 μ. From the infrared
fluxes they derived new radii (850 ± 100 km and 275 ±
km respectively) and albedos (0.04 for the dark side of
Iapetus, 0.28 for the bright side, and 0.57 for Rhea).
The derived mean densities are about 1 g cm⁻³.

Murphy and Cruikshank continued their photometric
investigations of Jovian satellite eclipses. One possible
post-eclipse brightening event was observed in 1971.

Pending completion of the sky compensating fore
optics, the Fourier Transform spectrometer was used for
laboratory studies of frost in the region 1.2 to 5.0 μ by
Cruikshank and graduate students, N. Morrison and T.
Martin. Spectra of frost of H₂O, CO₂, NH₃, CH₄, HCN
alone and in various combinations, were obtained at
resolutions of 16, 8, and 2 cm⁻¹ in order to search for
spectral features diagnostic of these compounds on vari-
ous low temperature solar system bodies. The spectra
provide a useful library of data for reference when astro-
nomical spectra are obtained with the system on the
224-cm telescope.

D. Stellar Astronomy

Analysis of the equivalent width and profile vari-
ations in the Ap star 56 Arietis of the lines H\(\beta\), H\(\gamma\), Mg II λ4481, and Ca II K was completed by Bonsack; this work
complements previously published studies of the Si II and
He I lines. All of the lines in this study were found to
vary with a 0.728 period in phase with He I, and not with
Si II. Radial velocity variations predicted by the rigid
rotator model were not found. Evidence for rapid
fluctuations superimposed upon the regular cycle, simi-
lar to those found for He I, were found for Mg II λ4481,
and marginally for the other lines. The prediction that
the strength of the Balmer lines should vary in synchro-
nism with Si II, in response to a variation in the con-
tinuous opacity due to Si, was not confirmed. These
results have been published (Publ. Astron. Soc. Pacific 84,
260, 1972). Bonsack and S. Wolff looked for possible
systematic differences between values of stellar magnetic
fields obtained from Mauna Kea spectrometers and those
obtained elsewhere. To this end, the Zeeman effect was
measured in a series of spectrometers of β CrB, 73 Dra,
and 78 Vir. They concluded that the Mauna Kea mag-
netic fields agreed with those published by Preston ex-
cept for a marginally significant zero point shift, and that
previously suggested long-term secular changes in the vari-
ation pattern of 73 Dra and β CrB could not be confirmed.

Bonsack, S. Wolff, and graduate student, C.
Pilachowski, have begun a program of measurement of
magnetic field and spectrum line strength variations for
several Ap stars for which the variation patterns have not
been previously established. The work is particularly well
advanced for the stars 49 Cam and γ Equ; the investiga-
tion of the latter includes remeasurement of plates taken
in previous years by G. W. Preston and H. W. Babcock.
In addition, a spectrophotometric study of HR 5355 (HD
125248) is under way to determine the variation of the
line-blocking coefficient in the v and b bands of the uvby
photometric system, in order to determine to what de-
ger the observed light variation is due to local line block-
ing.

With the help of N. Morrison, S. Wolff has obtained
photoelectric and spectroscopic observations of 52 Her.
The results are being combined with much more exten-
sive spectroscopic material obtained by G.W. Preston of
the Hale Observatories for a complete discussion of the
variations of this star.

A search for manganese stars among field stars and
members of the Scorpio–Centaurus association has been
undertaken by S. and R. Wolff. Preliminary results indi-
cate that at least 20% of the field stars with spectral
types in the range B7–B9 have abnormally strong Mn
lines. In addition, at least two members of the Scorpius
complex have enhanced lines of both mercury and man-
ganese.

The suggestion that lines of promethium are present
in the Ap star HR 465 has been reexamined by S. Wolff
and N. Morrison. They find that Aller and Cowley greatly
underestimated the probability of chance coincidences
between laboratory and stellar wavelengths and that
there is considerable doubt that the proposed identifi-
cation of Pm is correct. Wolff and Morrison have also
continued their photometry of the Ap stars with very
sharp lines. They find that at least two stars, HD 2453
and HD 18078, have periods that are considerably longer
than one year. N. Morrison and S. Wolff have made
uvby observations of the Wolf–Rayet star CV Ser. For
this star, the u, v, and γ filters measure the continuum,
while b measures the strength of the C III blend at λ 4652.
In agreement with earlier work by Tcherepaschuk, Mor-
rison and Wolff report that the largest variation occurs
in b (amplitude ∼ 0.016) and is apparently due to changes
in the strength of the C III lines. There is evidence for
a shallow minimum (∼ 0.003) in u, v, and γ at the same
place as minimum light in b.

A. M. Boesgaard has made a study of the ultraviolet
Fe I emission lines in α Orionis (M2 IIa). About 17
lines from multiplets 1, 6, and 7 at wavelengths between
3150 and 3300 Å, are in emission. A series of four 3.3
A/mm spectrographs spanning a time period of one year
were obtained with the 96-inch camera of the 88-inch
reflector. Line profiles have been examined and radial
velocities determined. The strong emission features all
show a central reversal. There is a close correlation
amongst the emission intensity, the half-widths of the
emission lines, and the strength of the central reversal.
Although the lines are all asymmetric such that the short
wavelength side of the profile is steeper, there are plate-
to-plate variations in the degree of the asymmetry.
Radial velocities were measured for the photospheric
lines, for the emission features, and for the central rever-
sals. Whereas the absorption lines showed the expected
variations in the photospheric velocity, the emission
lines appear to have a constant velocity which is red
shifted relative to the photosphere by about 5 km/sec.
The amount of the redshift is small, however, compared

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with the linewidths of about 40–80 km/sec. Simultaneous
information on the Ca II emission, the K2 feature, shows
that it too is similarly red shifted by a small amount.
(Reported at the Stellar Chromospheres Conference in
February 1972).

A survey at lower dispersion (25 A/mm) is currently
underway by Boesgaard to determine the extent of the
presence of these Fe II emission lines in red giants.
By the end of the report year, information had been
obtained for 31 stars to add to previous data on about 12
stars primarily from the work of Bidelman and Pyper

Zeeman spectrograms at 3.3 A/mm of young main
sequence stars have been taken by A. M. Boesgaard to
search for magnetic fields. The eight stars selected as
young FO-KO dwarfs have strong Ca II emission and/or
high lithium abundance and/or larger than normal axial
rotation. Two to five spectrograms of each star were
obtained. No evidence for a magnetic field was found in
four of the stars with probable errors ranging from ±
20 to ± 100 gauss. Two late-type stars give consistent
indications of marginal fields (the other of 110 ± 30 gauss),
but more data will be needed to confirm this. A third,
hotter star with broader lines give uncertain results of
190 ± 60 gauss averaged from four plates. Five spectro-
grams of α Vir N (FO V) show a possible variable
field ranging from -330 to +440 gauss with probable
errors of ± 85 gauss. (Reported at the A. S. P. Meeting in
June 1972).

Ultraviolet spectrograms of 20 O and B stars at 3.3
A/mm taken by Boesgaard to search for interstellar Be II
lines at 3130 Å have revealed no evidence for beryllium.
However, interstellar lines of Ti II, Na I, and Ca II have
been found on many of the spectrograms. With occasional
exceptions, the strengths of the Na I lines (3302, 3303 Å)
and the TiII lines (3229, 3241, 3383 Å) are well-correlated
related with the interstellar Ca K line. No evidence for OH or CH was found in any of the spectra.

Spectrograms exposed to reach the core of the Ca II
H and K lines of α. Cen A and B have been taken by
Boesgaard to study the chromospheric K 2 emission. The
dispersion is 3.3 A/mm. α Cen B (K1 V) shows a K 2
feature of intensity 2 on O. C. Wilson’s intensity scale
0–5. The emission in α Cen A (G2 V) is present but just
barely detectable on the two spectrograms. Further work
on the chromospheres and ages of these stars is in
progress.

Simon and Cruikshank obtained numerous high-disper-
sion spectra of the eclipsing variable star δ Aurigae during
November eclipse of the primary. Plates taken during
the ingress phase are presently being measured for radial
velocities and equivalent widths of the chromospheric
lines in the vicinity of the Ca II K line. The variability of
the K2 emission features during totality is also under
investigation.

During the report period, T. Simon, N. D. Morrison,
S. C. Wolff, and D. Morrison completed an investigation
of the variable star V1057 Cygni (LkHα 190). Four
color (uvby) photometry and broadband observations
at Sp, 11µ and 20µ reveal a large infrared flux excess
originating in a circumstellar gas and dust shell. The
uvby photometry indicates that the optical birth
of V1057 Cyg decreased monotonically from July 1971
to November 1971. The infrared flux at 11 µm and 20µ
has also steadily decreased from July 1971 to August
1972, while the 5µ brightness has remained constant
during this period. The results of this study are in press
in Astronomy and Astrophysics.

Simon, D. Morrison, and Cruikshank pursued a pro-
gram begun last year to establish calibration standards
for 20µ photometry. Because of high transparency and
stable observing conditions in the 17 to 28 µ spectral
region, Mauna Kea is an ideal site from which to make
the necessary observations. An absolute calibration based
on a 20µ flux for α Boo of 1.54 X 10^-16 W cm^-2 µ^-1
has been established, and the fluxes of four standards (α Ori,
α Tau, β Gem, β Peg) and eight other bright stars mea-
ured relative to α Boo to a precision of 5% have been
published (Astrophysics, J. 177, L17). Together with the
absolute calibration (estimated uncertainty 15%), these
observations provide a set of photometric standards for
the 20 µ spectral region of accuracy comparable to that
achieved previously in the near infrared.

D. Morrison and Simon are now extending the 20µ
photometry to approximately a hundred stars of varied
types. The absolute calibration adopted for α Boo has
been checked by observations of α Lyrae and α CMa.
Publication of the photometry for the nonvariable stars
is planned for next year, while observing programs
directed at objects that show 20µ variability as well as a
number of peculiar classes of objects will be continued.

Using the IR radiometer, Simon has observed 5Scorpio
and 5Sco, two stars in the Upper Scorpius complex for
which Kemp has detected circular polarization. A
preliminary analysis of the data indicates that neither
star has an infrared excess, suggesting that the polarization
arises in the interstellar medium rather than a circum-
stellar shell.

Using a highly sensitive polarization analyzer at the
88-inch telescope, Kemp and Wolstencroft have made
extensive series of observations of stellar sources. Im-
portant null results for circular polarization, generally
down to the 0.01% level, were obtained for a series of
peculiar objects, including 3C273; the nuclei of NGC
1068, M87, and NGC 2261; the central stars of two
planetary nebulae; and the supernova in NGC 5253.
Along with null results by Gehrels, these data effectively
disproved a recent claim by Severny, Nikulin, and
Kvushinov to have found large circular polarizations in
several of these objects.

They also discovered a circularly polarized component
in light from six reddened early-type stars, indicating
a twist in the interstellar grain alignment along the line
of sight. A program was begun to study the so-called
helical structure in the local galactic arm using this new
effect; such structure was earlier postulated by Mathewson.
Linear polarization of several percent has been detected
in the integrated light from the Milky Way at several
longitudes including l = 90°, 180° and 270°. A polar-
ization "hot spot" found close to the galactic center
may be produced by scattering of starlight in the vicinity
of a large nearby dust cloud. It is uncertain whether
either the integrated starlight or the diffuse galactic
light dominates in producing the polarization found in
the Milky Way away from hot spots.