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Planetary Research Center
Lowell Observatory
Flagstaff, Arizona 86001

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SEMI-ANNUAL STATUS REPORT NO. 25
1 July 1975 through 31 December 1975

Submitted: 22 March 1976

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I. PERSONNEL

Dr. W. A. Baum, Director of the Planetary Research Center and Principal Investigator, seven-tenths time
Dr. R. L. Millis, astronomer and co-investigator, four-fifths time
Dr. E. L. G. Bowell, astronomer and co-investigator
Dr. L. H. Wasserman, post-doctoral fellow and co-investigator
Ms. L. A. Riley, research associate, half time
Mr. L. J. Martin, observer and film editor
Mr. C. F. Capen, observer and film analyst
Mr. D. T. Thompson, observer and data analyst, half time
Mr. S. E. Jones, chief technician
Ms. H. S. Horstman, research assistant and secretary
Ms. H. M. Ferguson, research assistant
Mr. J. H. Chastain, electronics and computer technician
Mr. N. C. Crowfoot, computer programmer, half time
Mr. H. W. Culp, instrument maker
Mr. F. Macias, maintenance man, half time
Ms. H. J. Scheele, bookkeeper, half time

Except as otherwise indicated, the personnel listed above were full-time under this grant. Temporary darkroom assistance was provided by Ms. S. D. Pratt during November and December. Other Observatory employees not paid under this grant, such as Dr. J. S. Hall, Dr. O. G. Franz, Dr. G. W. Lockwood, Mr. H. L. Giclas, Ms. M. L. Kantz, and Mr. K. L. Williams, have participated in or have carried out some of the observations or analyses mentioned in this report.

II. OVERVIEW AND SUMMARY

UBV observations have been obtained for 135 asteroids and used to investigate statistically the physical characteristics of these objects. Results of an extensive photometric study of Eros have been accepted for publication. Positional measurements of asteroids were continued. Results of a photometric study of the Galilean satellites appeared in Icarus. The darkening of the leading hemisphere of Iapetus mentioned in previous status reports was observed to continue. Area-scanning photometry of the inner satellites of Saturn, Saturn's rings, and Uranus was conducted. These observations revealed limb brightening in methane bands on Uranus and brightness asymmetries in the rings.

Electronographic films of the satellites of Uranus and Neptune were scanned with the PDS microdensitometer, and programs were developed to derive magnitudes and colors from this material.

Programs for scanning Jupiter images with the PDS microdensitometer and rectifying them to a standard coordinate system and viewing geometry were developed. Several investigations of Mars were pursued: Papers on the seasonal dependence of albedo variations, on the interaction between dust storms and polar hoods, and on the hourly development of the 1973 major dust storm were completed or appeared in print. An albedo map of Mars showing its appearance in 1967 was prepared and distributed to Viking scientists. Three-color polarization measurements of Mars were made in order to monitor the dust content of its atmosphere as Viking approaches. Observations of photon energy as a function of photon age were analyzed in terms of their implications concerning the constancy of solar system dimensions over cosmic time.

Patrol photography of Mars and Jupiter was conducted at Lowell, Mauna Kea, Perth, and Cerro Tololo. Images of Venus were also obtained at Perth. Osservatorio S. Vittore in Bologna, Italy, and the National Observatory of Athens, Greece, participated in the photographic campaign on a voluntary basis.

Instrumentation development during this report period was confined to minor modification of the photoelectric polarimeter and addition of two peripherals to the PDP-11 computing system.

Guest investigators and visiting scientists have been received as usual, and photographs and other data have been supplied to outside investigators. Two of our staff served on teams and committees in support of NASA's space program. Four full research papers and three shorter publications appeared in print during this six-month period; seven more were in press as of December 31; four papers were presented at scientific meetings by members of the staff.

III. RESEARCH PROGRAM

Photometry of Asteroids. The survey program of UBV photoelectric photometry of asteroids by Bowell has progressed very rapidly during this report period. The rationale for this survey was spelled out in considerable detail in our very recent FY 77 proposal, and first results were published during this report period in a paper by Zellner, Wisniewski, Andersson, and Bowell. UBV colors are found to be indicative of compositional class as determined by infrared radiometry, spectrophotometry, and polarimetry. Therefore, a survey program of UBV photometry provides an efficient method of classifying a large number of asteroids and investigating their physical characteristics statistically.

At the end of this report period, Bowell had UBV data for 135 asteroids, most of them observed twice and many observed three or more times. This provides enough material for examining the correlation between physical and orbital parameters in a statistical manner in order to evaluate the compositional distribution within the asteroid belt. Preliminary results in Figure 1 show that the frequency distribution of semi-major axes for carbonaceous (C) asteroids is different from that for silicaceous (S). Their actual distributions must differ even more, because selection bias dilutes the difference. These two classes, which make up a majority of all asteroids, also seem to differ from one another in regard to the frequency distribution of their diameters, C objects having a larger mean size.

This work has been able to move forward so rapidly because of the efficient method developed by Bowell for finding asteroids at the telescope, as described in the previous status report. Quasi-osculating elements are derived, and finding charts are generated on the computer.

The analysis of last spring's Eros photometry was completed by Millis, Bowell, and Thompson; the results are in press in Icarus. The data comprised UBV observations obtained on 17 nights. The peak-to-peak amplitude of the light curve varied from about 0.3 mag to nearly 1.4 mag. The absolute V magnitude at maximum light, extrapolated to zero phase, was found to be 10.85. The zero-phase color of Eros (B-V = 0.88, U-B = 0.50) is representative of an S compositional type asteroid. The photometric behavior of Eros can be modeled by a cylinder with rounded ends, having a length about 2.3 times its diameter and rotating about a short axis with the north pole at $\lambda_o = 15°$, $\beta_o = 9°$.

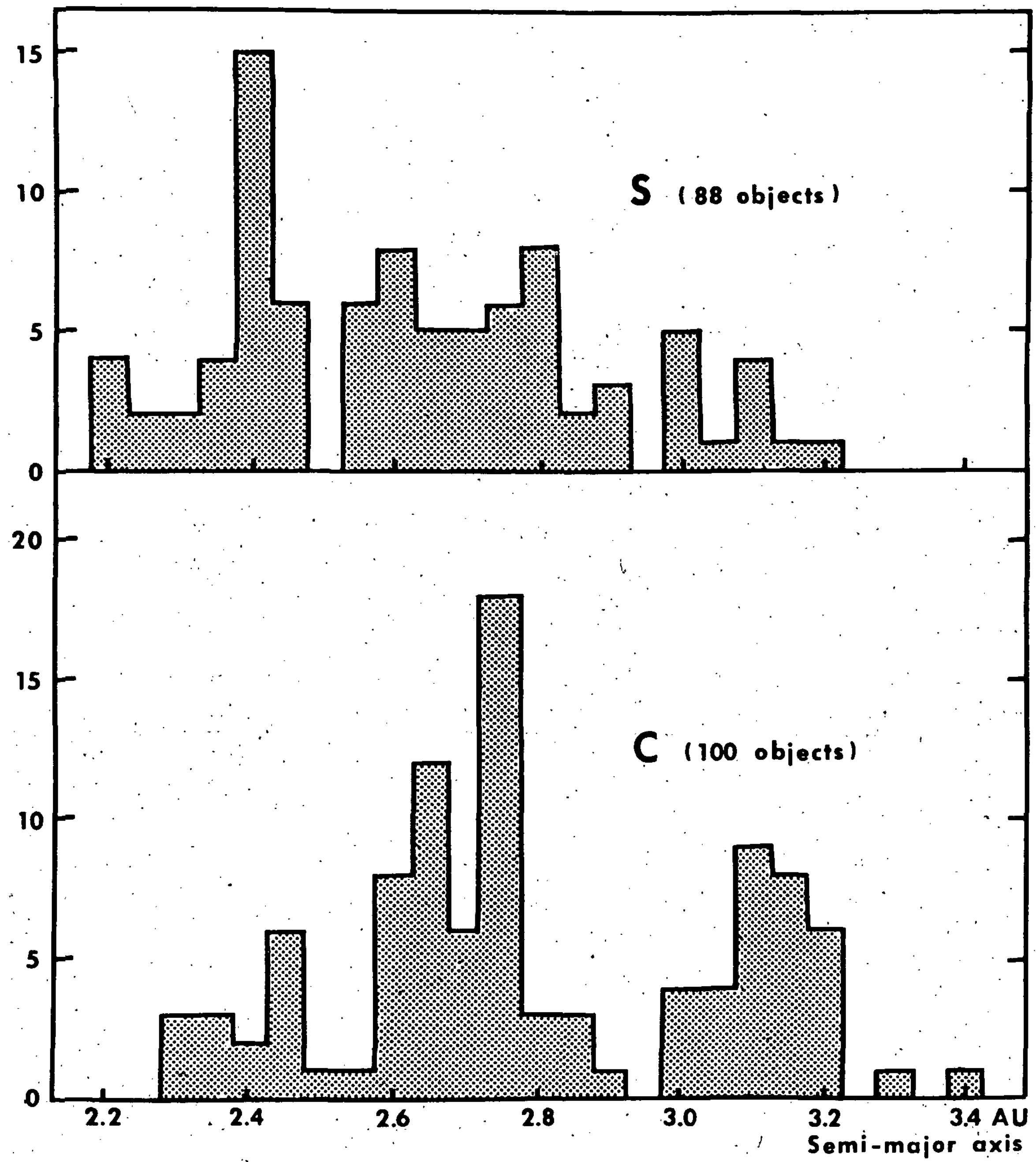

Figure 1. Frequency distribution of asteroid semi-major axes. Silicaceous (S) and carbonaceous (C) asteroids have been classified according to their UBV colors. C asteroids appear to be much more numerous in the outer part of the belt (a > 3 AU). Note the Kirkwood gaps at 2.50 and 2.96 AU and the apparent avoidance by the C asteroids only of the 3/8 commensurability point with Jupiter at 2.71 AU.

The positional measurements of asteroids have been continued by Giclas and Kantz. Typically, about 200 positions per year are transmitted to the IAU Minor Planets Center in Cincinnati, based on measurements of plates obtained with the 13-inch refractor.

Photometry of Outer Planet Satellites. The photometric investigation of Galilean satellites by Millis and Thompson was completed during this report period, and the results have been published in Icarus. They determined brightness and color variations as a function of orbital position and solar phase angle (Figure 2). Different faces of the Galilean satellites were found to have different phase coefficients, indicating the faces to be unequal in surface texture. They also discovered an apparent brightening of the Galilean satellites amounting to about 0.04 mag between 1973 and 1974.

UBV observations of Iapetus by Millis show a 0.1-mag darkening of its darker hemisphere during the past four years, but no change was found for the brighter hemisphere. Lockwood has observed secular changes in the brightness of Titan, Uranus, and Neptune. Since the causes of these changes are unknown, we plan to continue monitoring these objects from time to time.

Area-scanning photometry of Saturn's satellites has been continued by Franz. Dione and Tethys were found to have brighter leading hemispheres, whereas Mimas and Enceladus are brighter on their trailing hemispheres. Tethys is also suspected of small sporadic variations in brightness, but further observations are needed.

In the previous status report we described experimental observations of Uranus and Neptune satellites with an electronic camera. An imaging detector of that kind has linear photometric response, so it provides a complete two-dimensional photometric map of the mound of scattered and diffracted light surrounding a planet's image. A Spectracon belonging to Imperial College London was used by Baum at the Cassegrain focus of the 72-inch reflector with the help of Brian Morgan and David Youll (ICL). The Spectracon films were scanned by Wasserman with our PDS microdensitometer, and the taped images were processed with a PDP-11 computer. A lot of experimenting and computer programming were required in order to find the best method for subtracting the mound of background light surrounding the planets and for making the best fit of a point-spread function to the images of the satellites. The derivation of satellite magnitudes and color indices is continuing. A sample PDS scan of a Neptune-Triton image is shown in Figure 3.

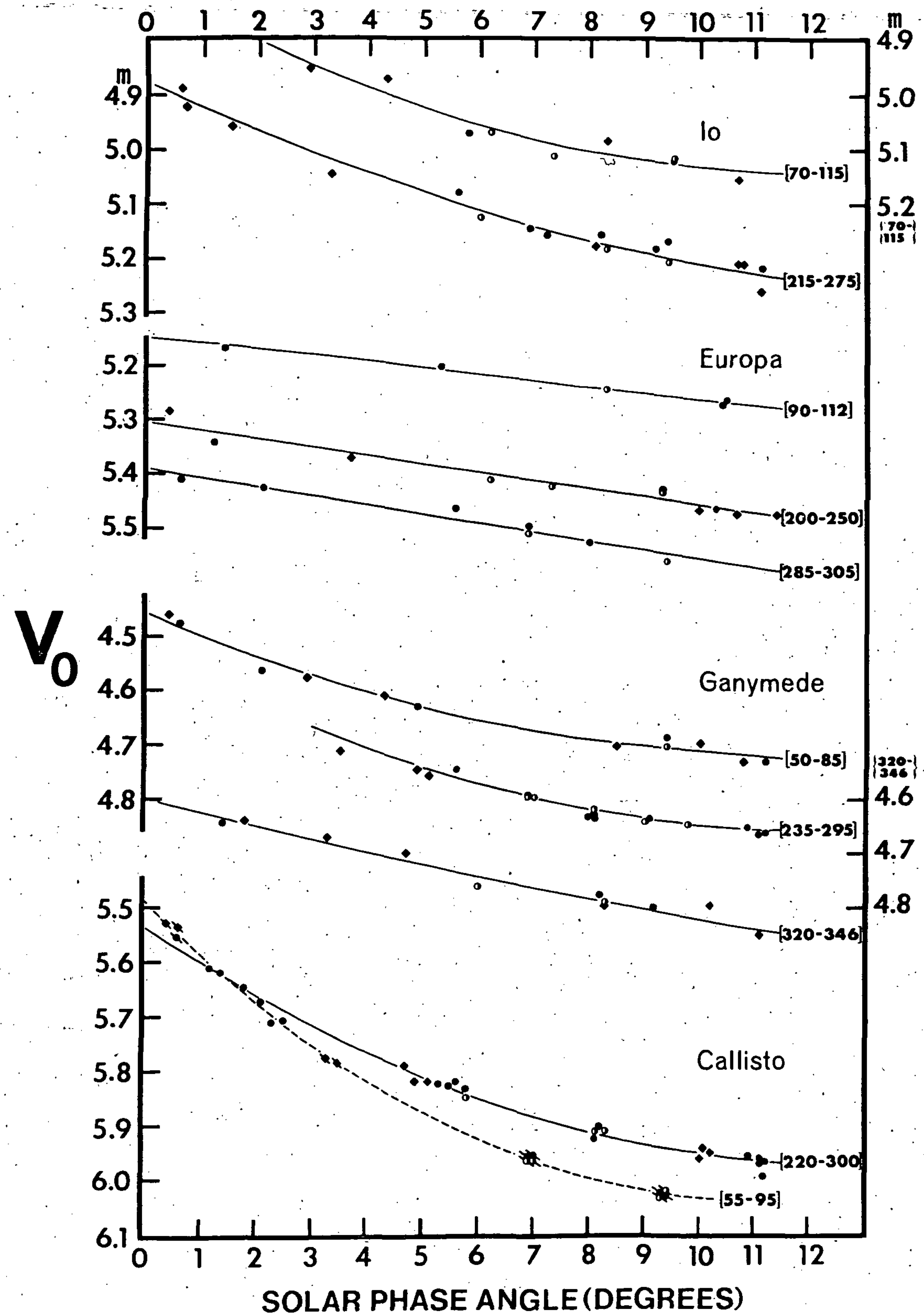

Figure 2. Brightness of various faces of the Galilean satellites plotted against solar phase angle. The numbers in brackets denote the range in orbital phase angle corresponding to each curve. The filled and half-filled curves are observations in 1973 from Lowell and Cerro Tololo, respectively. Observations from Lowell in 1974 are plotted as diamonds.

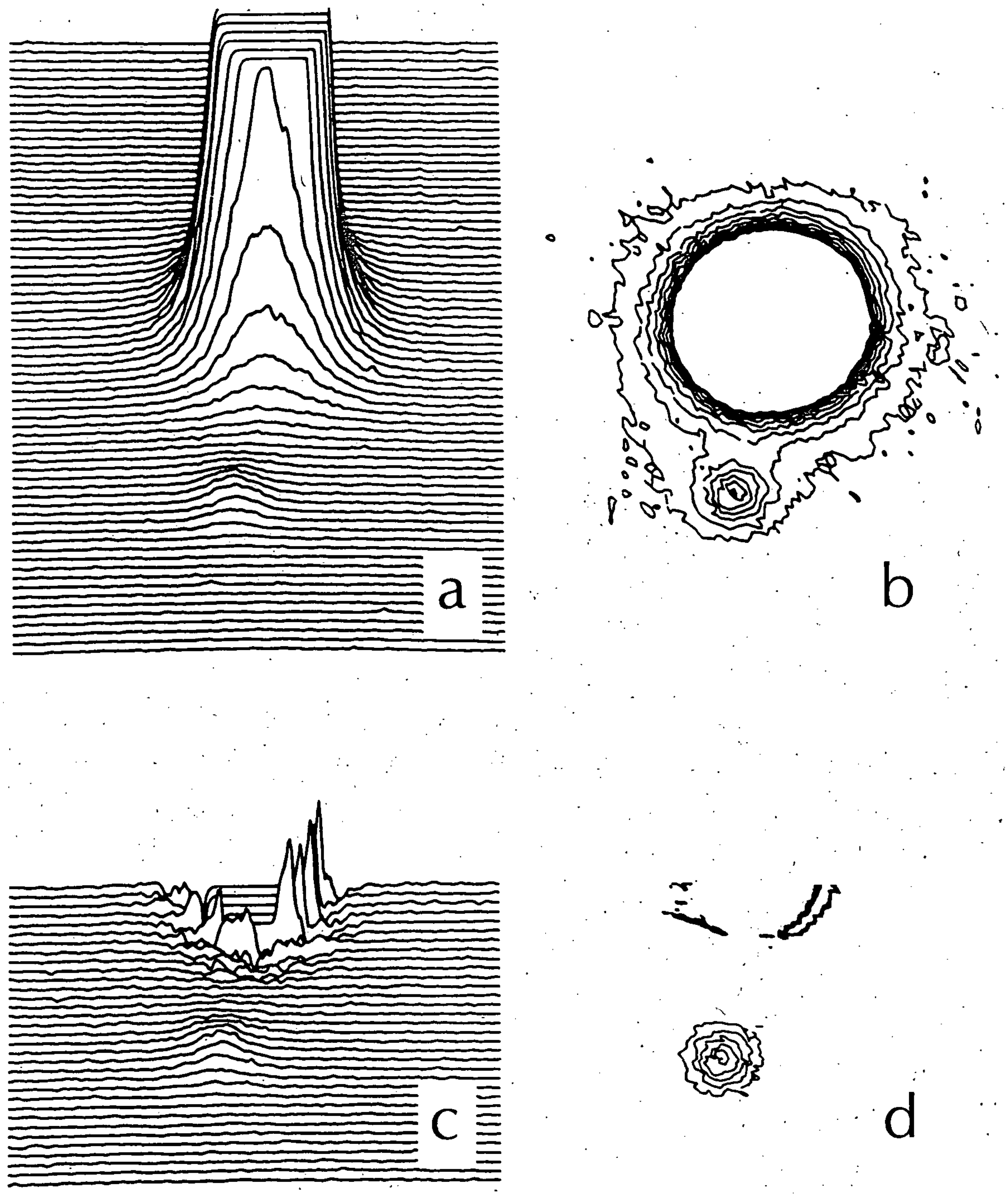

Figure 3. Neptune and Triton. Intensity profiles and isophotal contours derived from a Spectracon image by means of a PDS image-digitizing microdensitometer and a PDP-11 computer. Parts (a) and (b) represent the original image, while (c) and (d) show Triton with a flattened background after the upper half of the original has been subtracted from the lower half.

Cloud Motions in the Jovian Atmosphere. As outlined previously, selected Patrol photographs of Jupiter are being analyzed by Wasserman and Baum in an effort to detect circulation cells in the velocity flow field. The hope is to distinguish between alternative dynamical modes that are theoretically possible in the Jovian atmosphere, as outlined in our recent FY 77 proposal.

During this report period, a lot of attention was given by Chastain, Wasserman, Jones, and Crowfoot to the curing of technical problems with the PDS microdensitometer and the associated PDP-11 computer. Meanwhile, Wasserman developed computer programs and subroutines for scanning Jupiter images and rectifying them to a rectangular longitude-latitude coordinate system. Some samples of rectified images were shown in our FY 77 proposal, and some alternative methods for extracting cloud motions are being explored.

Area Scanning of Outer Planets. UBV area scans of Saturn's rings were obtained at the 72-inch reflector by Franz in collaboration with Michael Price of the Planetary Science Institute. Preliminary results on Saturn's rings confirm the east-west and front-back asymmetry in the brightness of Saturn's rings recently reported by Ferrin from earlier photographic analysis made here at the Center. The new area scans, which preceded this winter's opposition, showed the front of the east ansa to be brighter than the back, while the back of the west ansa was brighter than the front. The same effect was also checked again photographically by scanning some Patrol photographs of Saturn with the PDS microdensitometer.

Last spring's area-scanning observations of Uranus by Franz and Price were analyzed during this report period. The scans had been made at eight wavelengths with interference filters of 100-Angstrom bandwidth, some centered on methane bands, and some in the continuum. Limb brightening was inferred from systematic broadening of image profiles in the light of methane bands, particularly those centered on 6190 Å and 7300 Å, and results have been accepted for publication in Icarus.

Analyses of Mars Photographs. Analyses of Planetary Patrol photographs of Mars that were completed or appeared in print during this report period included papers by Capen on the seasonal dependence of albedo variations, by Martin on the interaction between dust storms and polar hoods, and by Martin on the hourly development of the 1973 major dust storm. Martin and McKinney (University of Wisconsin) also worked on the 1969 distribution of polar hood clouds and on the 1969 hourly mapping of clouds. To a large degree, these studies involved the transferring of photographic information to Mercator maps with the aid of our projection image readers. Some use was also made of the Joyce-Loebl microdensitometer to measure regional contrasts and their fluctuations.

The Martian apparitions of 1971 and 1973 provided Capen with a sampling of two seasons when the solar phase angle and viewing geometry were very similar. By microphotometry, he found higher contrasts between light and dark areas in southern spring than in southern summer on Mars. As shown in Figure 4, he also found that the day-to-day fluctuations (σ) were greater in spring, especially so for light areas.

Martin's maps of the 1973 Martian dust storm show the development of brightened areas at two-hour intervals throughout the first 20 days of the storm. Comparisons were made with the 1971 dust storm, which he had mapped by similar methods but in less detail. Figure 5 summarizes the relative degree of dust activity found in various regions during the 1973 interval that was studied.

Since at least some of the variations of albedo features on Mars tend to be seasonal, there is considerable current interest in what Mars will look like at the time of the forthcoming Viking encounter. With the artistic aid of our former colleague Jay Inge (now with USGS), we prepared a 1967 albedo map, similar to our earlier maps for 1969, 1971, and 1973. It is a Mercator projection with an equatorial scale of 1:25,000,000. The new 1967 map was lithographed by Northland Press and has been distributed to 98 Viking scientists and staffers. Just at the end of this report period, we began making preparations for the production of a similar 1975-76 albedo map of Mars.

Polarization Measurements of Mars. Three-color photoelectric measurements of the polarization of Mars were initiated by Bowell and Thompson during this report period. Although these observations were undertaken to provide information of direct interest to the Viking mission, they are of scientific interest in themselves. Multicolor polarimetry can be used to monitor the dust or aerosol content of the Martian atmosphere, because the scattering of light by particles depresses the degree of polarization below the value that the surface alone would normally produce at various solar phase angles. These observations are planned to continue up to about the time of arrival of the first Viking spacecraft at Mars.

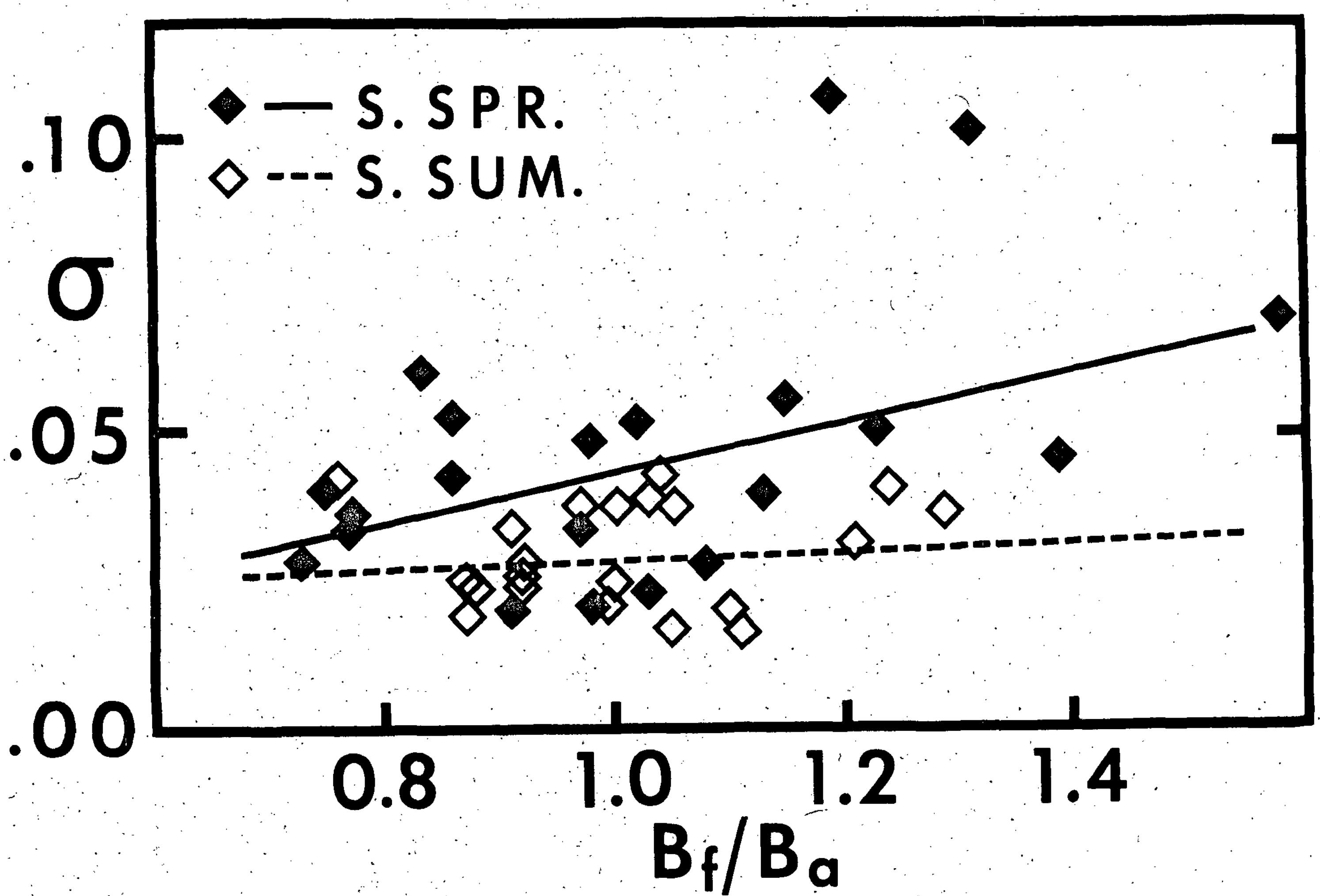

Figure 4. Brightness fluctuations of individual Martian areas in relation to the mean brightness of selected areas in a region, expressed as a standard deviation of day-to-day values. Greater fluctuations occurred in southern hemisphere spring than in summer, and light areas ($B_f/B_a > 1$) were more active than dark areas.

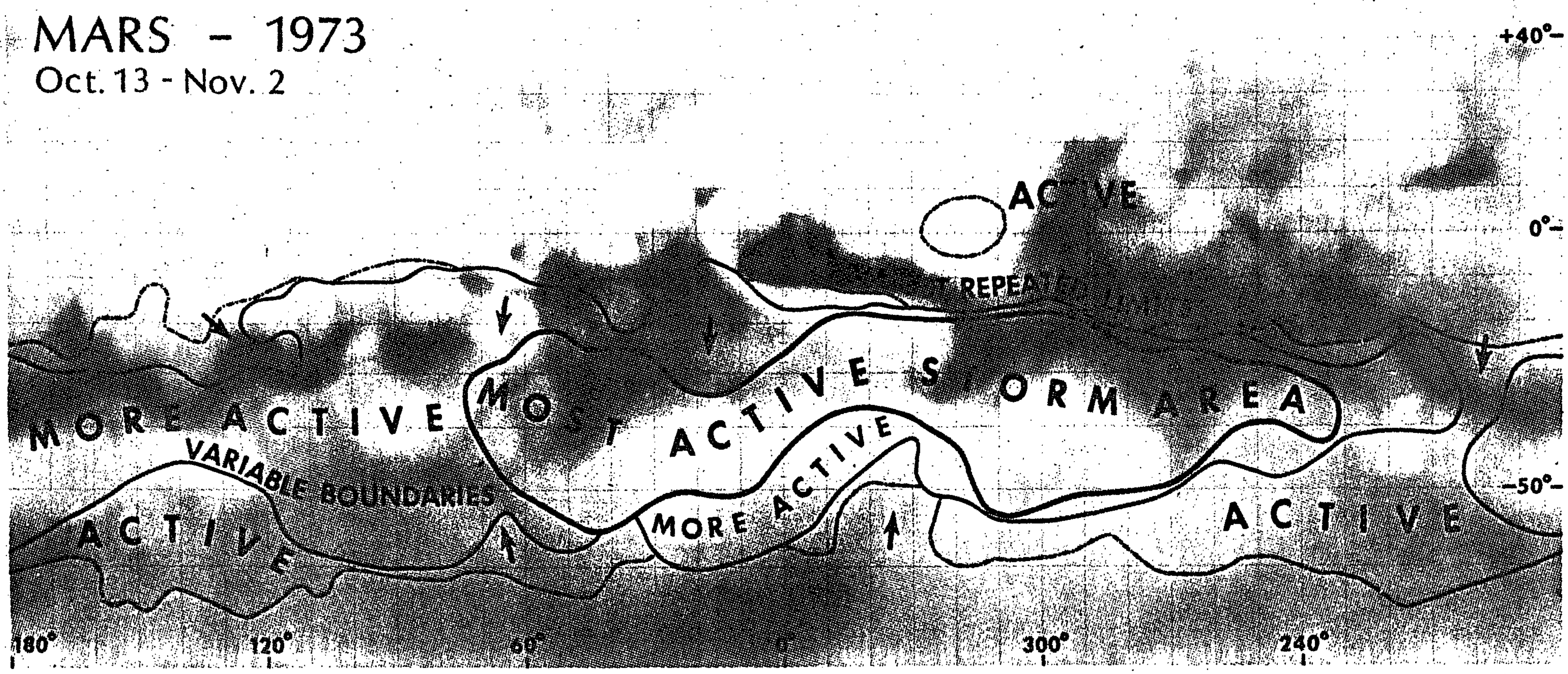

Figure 5. Relative degree of dust storm activity in various regions of Mars during the first 20 days of the major storm of 1973. This summarizes red-light brightenings charted at two-hour intervals on 20 daily maps.

The Constancy of Solar System Dimensions over Cosmic Time. In our previous status report we described observations by Baum in collaboration with Florentin-Nielsen of the Copenhagen University Observatory, concerning the energy of old photons and bearing on the constancy of various physical constants. It was pointed out that these observations appeared to argue against a fundamental ambiguity concerning the possible secular decrease of the universal gravitational constant claimed by van Flandern on the basis of lunar occultation timings. During this report period Baum and Nielsen carried through their analysis of the observations and presented a paper at the American Geophysical Union meeting in December concerning the implied constancy (or non-constancy) of solar system dimensions. If van Flandern's data are correct, the solar system would have to have expanded adiabatically about 40 percent since its formation. The lunar occultation timing data are somewhat open to question, however; and it probably remains for an analysis of lunar ranging data to determine whether the claimed effect can be confirmed. Since both the occultation timings and the laser ranging merely determine the constancy of the ratio of G to the Rydberg frequency, our work supporting the constancy of the Rydberg frequency narrows the possibility of secular change to G alone.

International Planetary Patrol. Owing to the fact that the 1975 oppositions of Mars and Jupiter occurred somewhat closer together than in previous years, it was possible to schedule Patrol photography for an interval throughout which both planets were accessible. Jupiter had a declination of +6° and a diameter of 50 arcseconds at opposition on October 13th, whereas Mars at opposition on December 15th had a declination of +26° and a diameter of 16 arcseconds, which was only two-thirds as large as its diameter at the time of the very favorable opposition in 1971. Uninterrupted Patrol photography of both planets commenced at Perth, Mauna Kea, and Lowell on September 9th. Local observers were on regular duty at those three places; but we had to send a Lowell observer, Holly Ferguson, to Cerro Tololo, where observations were limited to a ten-week period beginning November 11th. In addition, continuous Mars observations were made at Osservatorio S. Vittore in Bologna, Italy, on a voluntary basis through the same period as that covered by the regular Patrol stations. The National Observatory of Athens, Greece, also participated as a volunteer station, scheduling Mars observations three nights per week. Neither of these stations used Patrol equipment, although they were provided film and filters. Venus, which was in the southern sky, was observed mainly from Perth during the interval between October 21st and December 15th. At the end of this report period, work was in full swing on processing Patrol films, editing them, making master positives, and cataloguing.

Instrumentation. During this report period, a few changes were made in the photoelectric polarimeter. These included the addition of filter slides for accommodating more color filters and for simultaneously inserting neutral filters to permit calibration on relatively bright stars.

Two new peripherals, both acquired at the expense of the U. S. Naval Observatory, have been added to our PDP-11 computer, thus increasing the capability of our PDS/PDP-11 image processing system. These two items include a Versatec Model D1200A electrostatic printer/plotter, which was installed in September, and an Infoton Vistar/GT CRT terminal, installed in August.

IV. PLANNED OBSERVING RUNS

Most observing with our own telescopes at Lowell Observatory is scheduled on specific dates a relatively short time ahead of the actual observing. Asteroid photometry will be continued by Bowell with the 42-inch telescope, with at least some observing nearly every month. Area-scanning photometry of Saturn's rings and satellites and of Uranus will be continued by Franz. Millis is finishing up this year's photometry of the Galilean satellites and is continuing the monitoring of the Saturn satellite Iapetus. In line with the comet program plans outlined in our FY 77 proposal, several of our staff are to be involved in experimental observations of Comet West, including narrow-band photometry of the head by Millis, high-resolution photography with the 13-inch refractor by Giclas, and tail photography with a 12-inch, f/2.5 Aero-Ektar lens by Jones, Baum, Martin, and Ferguson. Narrow-band photometry will yield data on the time variation of selected emissions. The Aero-Ektar observations will be aimed at checking the feasibility of operating a distributed network of Aero-Ektars for obtaining improved data on the motions of filaments in ion tails. Polarimetry of Mars will be continued by Bowell and Thompson with the 42-inch telescope in order to check the dustiness of the Martian atmosphere up until the time of Viking arrival. They also plan polarimetric observations with the 72-inch telescope of the brighter satellites of Saturn and of a small number of asteroids. The Planetary Patrol cameras are scheduled to run through February 15th at Perth, Mauna Kea, and Lowell. The Lowell Patrol observers include Martin, Capen, and Thompson; the expeditionary observations by Ferguson in Chile are scheduled through the first three weeks of January.

Observations at Bologna and Athens will also continue during the first few weeks of the year. Wasserman and Millis are continuing to prepare for photometrically observing the occultation of the third-magnitude star ε Geminorum on April 7th (1976) with telescopes at Goddard Space Flight Center and at Fernbank Science Center in Atlanta. In preparation for the early 1977 occultation of SAO 158687 by Uranus, Millis will be making and analyzing spectrum scans of Uranus and the star in order to choose an optimum passband for the occultation observations.

V. DISTRIBUTION OF PHOTOGRAPHS AND DATA

During this report period, photographic products were supplied by the Center in response to 16 requests from publishers, institutions, and individuals. In addition, 63 negatives and 63 prints of selected Mariner frames were prepared for Dr. Frank A. Gifford of Oak Ridge, Tennessee, for his analysis of crater tails which he commenced as a guest investigator here at the Center. Three mural prints and two large negatives of our "Martian Albedo Features and Topography Map" were furnished to Dr. George Sands of the Langley Research Center. The Viking Project plans to cover these with transparent plastic overlays and use them as grease-pencil planning charts. Some of our photographic products are being made available for future public distribution through the Public Information Office at the Kitt Peak National Observatory, and a substantial amount of reproducible material has been made available to Mr. Warren Hill of that office. Color transparencies from five apparitions of Mars (1963, 1965, 1969, 1971, and 1973) were furnished Dr. Loyal Goff, NASA Headquarters. These images covered a sampling of seasons while simultaneously illustrating clouds, polar caps, polar hoods, dust storms, and surface features and were to be used in a Congressional presentation. Four composite positives of September 22, 1975, Jupiter observations were prepared for Dr. Don Davies of the Jet Propulsion Laboratory. Brightness in optical wavelengths of the images was to be compared with the brightness in infrared scans made on the same night. At the request of Dr. Pierre Connes of the Laboratoire du C.N.R.S., an attempt was made on two occasions in December to detect "ashen light" on Venus. These observations were in support of simultaneous spectroscopic observations by Dr. Connes at Mount Palomar.

Computer-printed catalogues of various parts of our planetary collection were made available to Dr. Bruce Hapke of the University of Pittsburgh, Dr. Raymond Hide of the Meteorological Office in England, the Lunar and Planetary Laboratory in Tucson, the Planetary Data Center at Meudon, the Smithsonian Astrophysical Observatory in Cambridge, the Astronomy Department of New Mexico State University, the Center for Radiophysics and Space Research at Cornell University, the Institute for Astronomy in Hawaii, and the Department of Astronomy at the University of Texas in Austin. Dr. R. Servajean of the Planetary Data Center at Meudon was supplied with 16 subroutines for use with Mars and Jupiter ephemeris programs previously furnished.

Incoming material included IBM cards for 448 observations of Mars, Jupiter, Venus, Saturn, Neptune, Uranus, and Pluto (1973/74) from the Planetary Data Center at Meudon; 20 positive composite transparencies of selected 1973 Mars observations from Pic du Midi supplied by Meudon, and a copy of the 1974/75 LPL Jupiter observing log for inclusion in our general catalogue of planetary photographs. At the end of this report period, we had received approximately 7300 usable Mars image sequences and 6000 Jupiter sequences from our own Patrol stations, including Mauna Kea, Perth, Cerro Tololo, and Lowell, as well as from the new voluntary stations at Athens and Bologna.

VI. GUEST INVESTIGATORS AND VISITORS

Listed chronologically according to arrival, scientific visitors to the Planetary Research Center during this report period included Professor William McCrea of the University of Sussex in England, Dr. William McKinney of the University of Wisconsin at Stevens Point, Dr. William Hartmann of the Planetary Science Institute in Tucson, Dr. Frank Gifford of the National Oceanic and Atmospheric Administration in Oak Ridge, Dr. Gerard Coupinot of the Pic-du-Midi Observatory, Dr. Josette Hecquet of the University of Lille in France, Dr. Jan-Eric Solheim of the University of Tromsø in Norway, Dr. Ernest Both of the Buffalo Museum of Science, Mr. Eric Burgess (who assists NASA in the preparation of special publications and public release material), Mr. Richard Hoagland (who is also a science writer connected with projects at the Goddard Space Flight Center), Dr. James Elliott of Cornell University, Mr. Peter Woiseshyn of the Jet Propulsion Laboratory, and Dr. Joseph Veverka of Cornell University. Those who made extended working stays included McKinney, Hartmann, and Gifford.

VII. NASA TEAMS AND COMMITTEES

Baum has continued to serve on the Viking Orbiter Imaging Science Team. Baum and Thompson are both on the Viking Flight Team. Baum is also a member of the Viking Landing Site Staff. Planetary Center activities that may prove helpful to Viking include the preparation of the 1967 and 1975 Martian albedo maps by Inge and our staff, and the photoelectric measurement of Martian polarization by Bowell and Thompson for monitoring Martian atmospheric dust content.

Baum also served as a member of the LST Detector Working Group and as a consultant to the LST High-Resolution Camera Team. Committee and team participations have been funded separately from this grant.

VIII. FINANCIAL STATUS

Routine monthly expenditures have been running close to the budgeted level. No unusual expenses occurred during the six months covered by this report, nor do we anticipate any during the remainder of this fiscal year. The only foreign travel charged to this grant during the current report period pertained to the sending of one Patrol observer (Ferguson) to Cerro Tololo for ten weeks beginning in November.

IX. PUBLICATIONS AND PRESENTATIONS

The following is a list of papers that appeared in print or that were in press (accepted for publication) during the twelve months ending 31 December 1975. Papers which appeared in the present six-month reporting period are indicated by asterisks, while those newly in press during the same period are indicated by daggers.

*Baum, W. A., and Florentin-Nielsen, R. (1975). The constancy of Planck's constant. Bull. Amer. Astron. Soc. 7, 412.

*Baum, W. A., and Nielsen, R. F. (1975). Is the Solar System expanding? EOS, Trans. Amer. Geophys. Union 56, 1014 (December).

Bowell, E. L. G. (1975). Short-term periodic variations in the polarization [of Venus]. In The Atmosphere of Venus (J. Hansen, Ed.), NASA SP-382, pp. 36-39, STIO, NASA, Washington, D. C.

Boyce, P. B. (1975). Mars 1971: Photometric behavior of the Martian dust. Icarus, submitted for publication.

†Capen, C. F. (1975). Martian albedo feature variations with season: Data of 1971 and 1973. Icarus 27, in press.

*Dollfus, A., Camichel, H., Boyer, C., Aurière, M., Bowell, E., and Nikander, J. (1975). Photometry of Venus: I. Observation of the brightness distribution over the disk. Icarus 26, 53-72.

Franz, O. G. (1975). A photoelectric color and magnitude of Mimas. Bull. Amer. Astron. Soc. 7, 388.

Franz, O. G., and Millis, R. L. (1975). Photometry of Dione, Tethys, and Enceladus on the UBV system. Icarus 24, 433-442.

†Hall, J. S., and Riley, L. A. (1976). A polarimetric search for fine structure on Jupiter's disk. Icarus, in press.

*Inge, J. L. (1975). Mars 1967 (Albedo map, 1:25,000,000). Lowell Obs. Map Series.

†Jones, S. E. (1976). Methods, advantages, and limitations of compositing photographic images. A.A.S. Photobulletin, in press.

Martin, L. J. (1975a). Apparent changes in the north polar hood of Mars during dust storms. Bull. Amer. Astron. Soc. 7, 369.

*Martin, L. J. (1975b). North polar hood observations during Martian dust storms. Icarus 26, 341-352.

*Martin, L. J. (1975c). 1973 dust storm on Mars: Maps from hourly photographs. Program, 1975 Fall Annual Meeting Amer. Geophys. Union, p. 37.

†Martin, L. J. (1976). 1973 dust storm on Mars: Maps from hourly photographs. Icarus, in press.

†Millis, R. L., Bowell, E., and Thompson, D. T. (1976). UBV photometry of Asteroid 433 Eros. Icarus, submitted for publication.

*Millis, R. L., and Thompson, D. T. (1975a). UBV photometry of the Galilean satellites. Icarus 26, 408-419.

Millis, R. L., and Thompson, D. T. (1975b). Recent UBV photometry of the Galilean satellites. Bull. Amer. Astron. Soc. 7, 237-238.

†Price, M. J., and Franz, O. G. (1976). Limb-brightening on Uranus: The visible spectrum. Icarus, in press.

Wasserman, L. H., and Baum, W. A. (1975). Analysis of Earth-based planetary images thru digitization. Bull. Amer. Astron. Soc. 7, 389.

†Wasserman, L. H., Elliot, J. L., and Veverka, J. (1976). Galilean satellites: Observations of mutual occultations and eclipses in 1973. Icarus 27, in press.

*Zellner, B., Wisniewski, W., Andersson, L., and Bowell, E. (1975). Minor planets and related objects. XVIII. UBV photometry and surface composition. Astron. J. 80, 968-995.

Papers presented at society meetings during this six-month report period included the following:

At the 146th annual meeting of the American Astronomical Society at San Diego (California) in August:

W. A. Baum and R. Florentin-Nielsen, "The Constancy of Planck's Constant"

At the meeting of the AAS Working Group on Photographic Materials at San Diego (California) in August:

S. E. Jones, "Methods, Advantages, and Limitations of Compositing Photographic Images"

At the Fall Annual Meeting of the American Geophysical Union at San Francisco (California) in December:

W. A. Baum and R. F. Nielsen, "Is the Solar System Expanding?"

L. J. Martin, "1973 Dust Storm on Mars: Maps from Hourly Photographs"