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FURTHER REPORTS OF OBSERVATORIES, 1965–1966

Dearborn Observatory and Lindheimer Astronomical Research Center, Northwestern University, Evanston, Illinois

Staff. Professors Karl G. Henize, Su-Shu Huang, and J. Allen Hynek (Chairman); Associate Professors John D. Bahng, Jay Burns; Instructor Miss Laura P. Bautz; Administrator, Raymond K. Woo; in charge, Organ Mountain and Corralitos Observatories, Justus R. Dunlap; space research project astronomer, Lloyd R. Wackerling; engineers and technologists: Bert C. McKenna, Frederick G. O'Callaghan, Edward J. Pekol, Robert J. Pernic, William T. Powers, Edward Yelke; observers, Corralitos Observatory; Randal F. Cooper, James R. Gallivan, Chalmer H. Hartman, and William Ohlhausen. Staff photographer, Raymond V. Lazenby; instrument maker, Egon R. Jaeggin; librarian, Mrs. Ellen B. Miskall; secretaries: Mrs. LaVerne Parrott (Departmental Secretary), Mrs. Donna L. Zimmerman (Space Research Projects), Mary M. Parent, and Mrs. Mary Jo Simon.

Facilities. The completion of the observatory building and superstructure enclosing two 70-ft-high telescope towers represents the major facility addition. The two domes are 24 and 36 ft in diameter, respectively, and will house Boller and Chivens 16- and 40-in telescopes. The 16-in reflector, made possible largely through a gift from Mr. Hans D. Isenberg and an NSF grant, has already been installed. The 40-in reflector is being furnished entirely by private funds, largely through a gift from the Montgomery Ward Foundation, and is scheduled for installation in the late autumn of 1966. The facility is located on the new lake campus of Northwestern University in Evanston. The Lindheimer Astronomical Research Center building has yet to be constructed; the observatory bulding represents about one-half of the complete Lindheimer Astronomical Research Center.

The new Corralitos Observatory of Northwestern University, built and made possible by a grant from NASA in support of a lunar surface surveillance program, has been in full operation during the past year. The Corralitos Observatory houses a 24-in Ferson Optics Inc. reflector. The telescopic facilities of the astronomy department will shortly comprise five telescopes, ranging from 40 to 12 in. in aperture, three of which are located in Evanston, and two near Las Cruces, New Mexico. The old facilities of the Dearborn Observatory continue to be fully occupied.

Ground-Based Research. Su-Shu Huang has continued his studies of rotating stars, binaries and planetary systems, as well as on mass–luminosity relations in spiral galaxies.

Miss Bautz continued her investigation of the interiors of gravitationally contracting, partially degenerate stars of one solar mass. She is using the Henyey method of approach with a code developed by Schwarzschild and Vila.

Hynek completed a study in which he showed that the differences in magnitude, the space motions, and the relative frequency of binary stars in different spectral classes furnish a strong observational support for the theory of stellar evolution.

Bahng spent two months at Kitt Peak National Observatory to carry out infrared spectrophotometric observations of late-type stars. Preliminary results were presented at the IAU Colloquium on Late-Type Stars held in Trieste, Italy, June 1966. Observations were made with the Kitt Peak 36-in. telescope in three bands at 1.2, 1.6, and 2.2 μ. The infrared colors show that G, K, and M stars have a continuous energy distribution deviating considerably from that of a blackbody. The deviation may be explained as a result of excess continuum emission near 1.6 μ due to the H^- opacity window in the atmospheres of these stars. The infrared colors of seven carbon stars show a poor correlation with the Morgan–Keenan temperature class. Either the molecular absorption feature in the spectra affect the colors very strongly, or some mechanism of continuous opacity such as the one proposed by Hoyle and Wickremasinghe redistributes the radi-

ation from the photosphere. Whatever the mechanism, the carbon stars appear to radiate more nearly as blackbodies than do the M stars.

The astrophysics laboratory of the Lindheimer Astronomical Research Center, of which Burns is in charge, was concerned with five programs. One of these is a basic research program into the physical mechanisms of photoemission from compound semiconductor photosurfaces of various types that have technical importance in photoelectric devices. Present effort is concentrated upon the Ag–O–Cs or S-1 type, infrared-sensitive photosurface. This project is supported by the U. S. Army Engineer Research and Development Laboratories, Ft. Belvoir, Virginia.

Another program under Burns' direction seeks to determine experimentally the electronic band structure of the states from which electron emission takes place in certain metallic elements and semiconductors through precise measurements of fine structure in the angular distribution of secondary electron emission from single crystals of these materials. This work is supported by a grant from the Air Force Office of Scientific Research.

A third program in the astrophysics laboratory, supported by the Goddard Space Flight Center, seeks to evaluate certain characteristics of television systems in current use in astronomy with emphasis upon distortion, photometric accuracy, and stability of image orthicon camera tubes. The work also seeks to evaluate the use of strong axial magnetic fields produced by a telescope-mounted superconducting magnet for focusing electron images in astronomical image tubes.

A fourth program in the laboratory concerns the development of an image orthicon system to gather astrographic data, and is supported by the Aeronautical Systems Division, Wright-Patterson Air Force Base. Two advanced image orthicon systems have been built and tested for use in precise tracking of meteors, re-entry objects, asteroids, etc. One of the systems has been extensively field tested at the Corralitos Observatory.

A fifth project in the astrophysics laboratory seeks to develop practical instrumentation capable of determining spectroscopic temperatures in hot turbulent gases without the averaging errors that are introduced by effects of turbulence into results obtained by methods of measurement in current use. This work is supported by the Air Force Materials Laboratory, Wright Patterson Air Force Base.

Corralitos Observatory Activities. The lunar surveillance program became fully operational in November 1965, and has remained so since. The moon has been observed in a continous manner for over 800 h whenever it has been above the horizon in Las Cruces, New Mexico, during clear nighttime hours. During this time, no transient surface phenomena within the detection capability of the Co ralitos electro-optical system have occurred the moon. The method of observation consists linking the 24-in. reflector to an image orthic system which incorporates rotating color filte The "red" and "blue" images of the moon a viewed in quick succession on the TV monit in the observing room. Compensating neutr density filters are used so that virtually ide tical intensity levels are presented to the monit thus eliminating change of brightness during t "blinking" process. Visual observers, seated the console, spell each other at 20-min interva throughout the course of the night. Occasion photographs of the TV monitor are taken for reco purposes.

Throughout the course of observation, the o servers monitor the Argus shortwave "astro-ne employed by several interested amateur grou These groups have frequently reported brig flashes, rays of luminescence, large areas brighte ing for a few seconds at a time, etc., particular near or in Aristarchus, Copernicus, Grimaldi, A phonsus, and Plato. In view of the large amount surface activity reported by the astro-net, a r gular program of infrared observations of the lun surface was initiated. In addition to the regular o servation of the sunlit portions of the moon, t program of infrared observations of the lunar su face was undertaken as a promising approach for d tecting highly localized thermal changes on t moon which might not have a corresponding visu change. These observations are accomplished by t use of a second television camera with an S-1 phot cathode image orthicon and a separate optical sy tem using an interference filter cutting off at 6500 Laboratory tests have shown that this auxilia electro-optical system, covering a spectral range 6500–11 000Å, is capable of detecting radiation the near infrared from the lunar surface.

Because the majority of the most recent astr net observations pertain to activity on the eart lit portion of the moon, particular emphasis h been placed on attempts to confirm such repor While a high-resolution S-20 photocathode tube primarily used in the lunar patrol, a high-sensitivi tube has been used over a seven-day period, wi observations centered on the new moon, to perm observing and photographing the earthlit porti of the moon. Despite the faintness of this part the moon, photographs of a 6×6 min of arc ar of lunar surface in yellow light can be made wi exposure times as short as 1/30th of a second. T lunar patrol was further expanded in March to i clude visual observations of the earthlit portion four or five nights after new moon with a 12- Cassegrain reflector located at the Organ Mt. C servatory. On 26 April the visual observer report

a small area near Aristarchus that had the appearance of brightening slightly for a few seconds and then fading out. This effect was detected with the Corralitos electro-optical system and was found to arise from a small, bright crater which because of image excursion blended into the surrounding area most of the time. Occasionally, however, the seeing stabilized for a few seconds at a time, thus permitting the crater to be resolved. This incident suggests that most astro-net reports of lunar surface brightening are probably effects of atmospheric seeing. Hynek is the principal investigator in this project supported entirely by the National Aeronautics and Space Administration at the Corralitos Observatory, but the major portion of the observations are carried out by Justus Dunlap and his staff of observers in New Mexico.

Space-Based Observations. Henize and his group have worked with the NASA Manned Spacecraft Center to obtain ultraviolet stellar spectra from both Gemini and Apollo spacecraft, The Gemini experiment was flown successfully in Gemini 10 and is expected to be operated by astronauts again during Gemini flights 11 and 12. The equipment used is the 70-mm Maurer camera equipped with a 22-mm-aperture ultraviolet lens and a diffraction grating giving a dispersion of 180 Å/mm or a 10-degree quartz prism giving a dispersion of 1500 Å/mm at 2500 Å. Wavelengths covered range from 2200 Å to 3500 Å. During the first flight of this equipment on GT-10 in July 1966 27 exposures were made in the regions of Crux, Carina, and Vela.

In the Apollo experiment a 6-in. aperture objective-prism spectrograph with a 5-deg field will be used to obtain stellar spectra in the wavelength region from 1300 to 3000 Å. This instrument, now under manufacture by Cook Electric Company of Morton Grove, Illinois, will be attached to the airlock on the Apollo command module and is scheduled to fly on Apollo flight 207. It is hoped that this instrument will also be flown on later Apollo flights in order that a sizable region of the Milky Way may be surveyed.

As a part of this program a vacuum facility has been established at the Observatory for the purpose of performing optical tests and the fabrication of high-reflectance aluminum coatings and interference filters.

Publications.

Bahng, J. 1966, "Infrared Photometry of Late-Type Stars," *Proceedings of IAU Colloquium on Late-Type Stars* (to be published).

Bautz, L. P. "Supernovae," *Space Frontiers* (to be published).

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——. 1965, "Cesium Partial Pressure over a Cs_3Sb Photocathode," *J. Appl. Phys.* **36**, 856.

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——. 1965, "Noise Spectrum of Arc Plasma Generators" (co-authored with H. Halle), *J. Opt. Soc. Am.* **55**, 574.

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Henize, K. G. "Observations of Southern Planetary Nebulae" *Astrophys. J. Suppl.* (to be published).

——. "Dimensions of Southern Planetary Nebulae" (co-authored with Dr. Bengt Westerlund), *Astrophys. J. Suppl.* (to be published).

Huang, S. "Mass–Luminosity Relation for Spiral Galaxies" *Astrophys. J.* (to be published).

——. "A Theory of Origin and Evolution of Contact Binaries" *Ann. Astrophys.* **29**, (4).

——. "Nature of Non-Synchronous Binary Stars," presented at AAS meeting.

——. "Problems of Close Binary Systems that Involve Transfer of Angular Momentum," *Ann. Rev. Astron. Astrophys.* (to be published).

——. "Hypothetical Four-Body Problem and its Applications," *Vistas* **5** (to be published).

——. 1966, Book Review of Aller and McLaughlin's *Stellar Structure*, *Sky and Telescope* **31**, 290.

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Hynek, J. A. "Recent Advances in the Application of the Orthicon to Astronomical Problems," *Proceedings of the Fourth International Symposium on Photoelectric Image Devices* (London, 1965).

——. "Stellar Multiplicity: An Aspect of the Observational Approach to Stellar Evolution," Otto Struve Memorial Volume, *Astrophysics*, Trieste, Italy (to be published).

——. "An Automatic Question-Answering System for Stellar Astronomy" (with Jacques Vallee), *Publ. Astron. Soc. Pacific* (to be published).

——. "Some Systematic Effects in the Catalog of Space Vectors for 3483 Stars by O. J. Eggen," letter to *Astrophys. J.* with Weller and Crull (to be published).

Instruction. Three Ph.D.'s and two Master's degrees were granted during this period, and all staff members participated in the instructional program from basic astronomy to graduate seminars. During the year there were 10 undergraduate majors and 12 graduate students.

Miscellaneous. The Department of Astronomy directs the Astro-Science Workshop, a cooperative venture of the University of Chicago, Univer-

sity of Illinois, Indiana University, University of Michigan, Northwestern University, Ohio State University, and the University of Wisconsin. Fifty highly selected high school students drawn from the greater Chicago area gather each Saturday morning during the academic year at the Adler Planetarium and Astronomical Museum for a course of lectures given by visiting astronomers from the cooperating universities. The project, now in its fourth year, is supported by the National Science Foundation and sponsored by the Chicago Planetarium Society, and is directed by Hynek. Laboratory sections are supervised by Dr. Harry Rymer. This venture is an interesting experiment in tapping and developing unusual talent.

Hynek participated in the Earth Science Curriculum Project at Boulder, Colorado, sponsored by the National Science Foundation.

Hynek continued to serve as Scientific Consultant to the Air Force on the matter of unidentified flying objects with the particular view to establishing patterns in sightings reported from this and a score of other countries.

The entire staff participated in numerous public service functions.

During the academic year, library acquisitions totaled 540 bringing the number of volumes in the astronomical library to 9744.

J. ALLEN HYNEK, *Chairman*

Flower and Cook Observatory, Philadelphia, Pennsylvania

Personnel. Dr. Benjamin S. P. Shen was appointed Associate Professor of Astronomy and Astrophysics, effective 1 July 1966. Dr. Igor Jurkevich was appointed lecturer for the spring term in 1966, and reappointed for the academic year 1966-67. Dr. L. Binnendijk spent a sabbatical leave during the spring term at the Dominion Astrophysical Observatory. Dr. William M. Protheroe received a Guggenheim award to permit him to spend the coming academic year at the Mount John Observatory in New Zealand. Dr. Charles P. Olivier continued as President of the American Meteor Society. Dr. F. B. Wood continued to serve as Secretary of Section D (Astronomy) of the American Association for the Advancement of Science and as Chairman of the Committee on Coordinated Observing Programs of Commission 42 of the International Astronomical Union. Allen Joel Harris held the Jesse and Ella Pawling Fellowship and received the Ph.D. degree in May 1966. His dissertation subject was "Photometric Studies of the Eclipsing Binary Systems BV 412, BV 332, and V 836 Cygni." Carlson R. Chambliss held a Special Harrison Fellowship. For 1966-67, Chambliss has been awarded a Fu bright grant to permit him to carry out spectr graphic investigations at the Mount Strom Observatory.

After nine years of service, Mrs. Claire F. Weav retired as Secretary. Miss Joanne Di Francesc was appointed as Secretary of the Astronomy D partment. Robert E. Smith was appointed Ele tronics Technician.

Kam-Ching Leung attended the symposium c peculiar A stars held in Washington in Novemb 1965, and presented an invited paper. Leung h been awarded a Zaccheus Daniel Fellowship f 1966-67.

In September 1965, Chambliss went to t Mount John Observatory operated jointly by t University of Pennsylvania and the University Canterbury. Chambliss spent a year gatheri observational material for a doctoral dissertatio In January 1966, Leung went to the Mount Jo Observatory for the same purpose.

Professor C. D. Shane spent three months at th observatory in order to initiate an extension of t Lick Photographic Atlas to the southern hem sphere. A. J. Thomas was appointed observe photographer for this program and D. B. Mab continued as technician for general observato programs. F. M. Bateson was elected as chairm of the National Committee for Astronomy in Ne Zealand and president of the Royal Astronomic Society of New Zealand. He was also appoint one of the government repersentatives on the Cart Observatory Board.

Instrumentation. A number of instrumental studi were carried out under the direction of Dr. Willia Blitzstein with the goal of making dual automa cally recording photometry operational by July 196 George W. Wolf made resolving time studies of t new equipment as well as dual photometry tes to guard against systematic errors being introduc by simultaneous observation of variable and co parison star. Edward F. Guinan made color obse vations with the Pierce-Blitzstein photometer permit the natural system of the photometer to calibrated with standard systems. Robert Smi completed the construction of instrumentati which will permit the output of the photometer be recorded directly on an IBM punch in form su able for computer reduction.

Alan F. Petty and his associates have near completed a rapidly scanning spectrophotomet for use in the infrared. The work is being done und the auspices of the Association for Astronomic Research — a joint working arrangement betwe the University of Pennsylvania and the Space S ences Center of the General Electric Company.

Dr. Protheroe and Edward J. Devinney, assist by James K. Thorpe and Smith continued constru

tion of equipment to be used at the November 1966 total solar eclipse.

In New Zealand, design and specifications for a mounting for the four cameras supplied by Dr. W. Strohmeier, director of the Bamberg Observatory were prepared by the consulting engineers, Ian Macallan and Company of Wellington. Work has been started and completion of the mounting is expected by October 1966. Completion of the building for housing the telescopes (including darkroom) is scheduled for September 1966. The telescopes are to be used in collaboration with the Bamberg southern station in South Africa in a program for the discovery, classification, and study of southern variable stars. The difference of longitude of the two stations will make the collaboration especially useful for rapidly changing stars or stars with periods of the order of a multiple of one day.

At Christchurch computer facilities have been supplied by the University of Canterbury. The work of testing and adjusting the electronic equipment has been carried out in the Physics Department of Canterbury under the direction of A. W. Black.

Scientific Programs. Dr. Charles P. Olivier, in addition to directing the work of the American Meteor Society, prepared "Meteor Reports" for the American Meteor Society for 1964 (*Flower and Cook Reprint* No. 155) and "Bolide of 1964 July 19, American Meteor Society No. 2384 [*J. Roy. Astron. Soc. Canada* **59** (6), 1965]. He has in preparation a third, and probably final, catalogue of hourly meteor rates.

Dr. William Blitzstein was occupied chiefly with the testing and automatic recording feature developed for use with the Pierce-Blitzstein photommeter and with the supervision of the development of various computer programs for treatment of data obtained.

Dr. William M. Protheroe continued work in preparation for observation of the next solar eclipse. At the Dominion Astrophysical Observatory, Dr. L. Binnendijk made radial velocity observations of 441 Boo, VW Cep, and W UMa. At Flower and Cook Observatory, he continued studies of W UMa systems. A summary appeared in *Kleine Veröffentlichungen Bamberg* **IV** (40), 36, 1965 (*Flower and Cook Reprint* No. 157). A light curve and solution of W UMa was published in *Astron. J.* **71**, 1966.

Dr. Eva Novotny completed reduction of data from flash spectra in the 1963 total solar eclipse, and continued programming for stellar interior models.

Dr. F. B. Wood began work on a discussion of selected eclipsing systems to be published in a forthcoming Henry Norris Russell memorial volume edited by Dr. Arthur Beer of Cambridge. The work is being done in collaboration with Dr. George E. McCluskey of Lehigh University.

A number of observers participated in the international collaborative observing program of SX Cas, coordinated by Dr. Robert H. Koch of the University of Massachusetts. The 15-in. horizontal telescope and the Pierce-Blitzstein pulse counting photoelectric photometer were used for these observations. Observers included Christopher Fang, Edward Guinan, and George Wolf. Guinan and Anthony Galatola made three-color observations of S Cnc and RS CVn. Guinan also participated in the international patrol of HD 128220 and Galatola started three-color observations of the intrinsic variable R CBr. Devinney used the 28-in. reflecting telescope to make photoelectric observations of selected eclipsing systems.

The orange and infrared (1.6 μ) light curves of Algol observed in previous years by Dr. Ernest L. Reuning (University of Georgia) and Dr. Kwan-Yu Chen (University of Florida were published in *Astron. J.* **71**, 283, 1966 (*Flower and Cook Observatory Reprint* No. 165) together with a discussion of the system based on these and earlier observations.

Dr. Allen J. Harris completed photoelectric light curves and derived orbital elements for BV 332 and BV 412 using the 28-in. reflector, and did the same for V836 Cyg using the 15-in. telescope; photoelectric observations were also made of CW Cep. In addition, Dr. Harris wrote the following computer programs: (1) Calculation of precision of light curves using harmonic analysis of the entire light curve to the 30th harmonic. (2) Normal point program. (3) Relative color curve program. (4) Calculation of theoretical light curves for partial eclipses using the chi functions. (5) Derectification program.

Pasquale Esposito, under the direction of Pieter de Vries has prepared a master's thesis entitled "Application of the Hamilton–Jacobi Theory to the Motion of an Artificial Earth Satellite."

The Card Catalogue of eclipsing variables was maintained by Fang, Leung, and Dr. Harris under the general supervision of Dr. Wood.

At the Mount John University Observatory in New Zealand, plates were taken for an extension to the southern hemisphere of the Lick Observatory Photographic Atlas. This was initiated by Thomas under the direction of Dr. Shane. The Physics Department of the University of Canterbury has done considerable experimental work in determining the best method of reproducing the atlas in final form. Samples obtained by different processes by E. R. Mangin have been submitted to Dr. Shane.

Bateson has continued his program of visual observation of intrinsic variables concentrating on the U Gem and RW Aur type; data on long-period

variables have been distributed to other observatories in advance of publication.

Photoelectric observations chiefly of eclipsing variables have been continued by Kam-Ching Leung and Carlson R. Chambliss. Chambliss has obtained light curves for the following eclipsing variables: AU Pup (550 observations in B and V), BV 430 (1200 observation in B and V), BV 516 (about 500 observation in B and V), and BV 419 (about 300 observation in B and V). He has also obtained some observations for the short-period pulsating variable SX Phe. The period for BV 419 is found to be about 15 h rather than the shorter value given in the literature.

Leung has made photoelectric observations of BV 513, BV 544 (about 600 observations), and V 701 Sco. Leung also has observed peculiar A stars, and made observations as part of the international campaign on W Ser. The period of BV 513 was found to be about 0.739 days. Leung, in collaboration with Dr. W. Wehlau of the University of Western Ontario, has prepared a paper on the variability of the δ Scuti stars and is working on a paper on the β Canis Majoris stars.

General. A series of 10 lectures was given by Dr. A.G.W. Cameron under joint sponsorship with the Space Sciences Center of the General Electric Company. Dr. John W. Evans gave a colloquium talk and showed motion pictures of the solar chromosphere.

Acknowledgments. Several of the programs, both at Flower and Cook and in the southern hemisphere, were substantially aided by grants from the National Science Foundation. Preparations for the forthcoming solar eclipse have been aided by a grant from the National Aeronautics and Space Administration. The University of Canterbury in Christchurch has helped in many ways, especially in the granting of computer time and in technical aid with the electronic equipment.

Two fellowships for 1966-67 were awarded under terms of the will of the late Zaccheus Daniel.

FRANK BRADSHAW WOOD, *Director*

Leander McCormick Observatory, University of Virginia, Charlottesville, Virginia

Personnel. Professor Adriaan Blaauw of Groningen University has been appointed University Lecturer in Astronomy and a member of the Center for Advanced Studies in the Sciences. Dr. Abdullah Kizilirmak and Dr. Rumeysa Kizilirmak of Ege University, Izmir, Turkey, were appointed Research Associates beginning June. Robert P. Redick was made full-time Electronics Engineer in September. Roger Heffelfinger, Mrs. Delphine MacDonald, and G. Bartlett Reid were appointe part-time Astronomy Technicians in Septembe Summer appointments have been made to Jame L. Grogan, Phillip A. Ianna, Paul Knappenberge George W. Lockwood, Phillip K. Lü, and Wayn D. Sigel. There were 19 graduate students in res dence for higher degrees during the year. Thre Master's of Arts degrees were awarded: John I Hershey, "Internal Motion of 35 Stars in Prae sepe"; Paul H. Knappenberger, "Astronomica Applications of Wave Front Shearing Interferom eter"; Richard A. Berg, "Spectroscopic and Photo metric Observations of 73 Draconis."

Astrometry. The astrometric program continue with its emphasis on the red dwarfs. Selected whit dwarfs have been added to the program. BI +66°34, Sirius, UV Ceti, VV Cephei, and four re dwarfs are in the active measuring or analysis stag Fifteen stars were measured for parallax and prope motion and completed. All of the plate taking an also marking of reference stars on all of the plate in Osvalds' program on close visual binaries wa completed. Plate measuring will begin in the fal Astrometric observations were carried out on 17 nights with 1385 plates being taken.

Astrophysics. Kumar continues work on the late type stars and suggests that known planetary com panions are black dwarfs from considerations c mass ratios and eccentricities. He is investigatin the suggestion that multiple star formation is quite different process than that which led to th formation of the solar system. Wood is studyin the similarity between the acoustic oscillations c the sun and the rapid Hβ oscillations of magneti stars.

Instrumentation. The new tailpiece has bee mounted on the 26-in. refractor and features simpl plate reversal, automatic timing, and other con veniences for the observer. An automatic guider in the process of being mounted. A small transmi sion grating spectrograph for observing the spec trum of lunar redspots is complete and in use. compact two-channel photometer is under con struction by Wood and Fredrick. Development c an electrometer-tube amplifier using monolithic in tegrated circuits was completed by Redick, Birney and Wood.

Photometry. Wood, Lockwood, and Kizilirma have α^2 CVn and 73 Dra under observation an Wood has completed a paper on HD 21544 Birney continues to observe SX Cas and six othe eclipsing binaries.

Spectroscopy. Infrared spectra of the brighte late-type long-period variables have been obtaine by Lockwood, Fäy, Londak, and Fredrick. Woo continues studies of 17 Lep. A study of 73 Dra b Berg, soon to be published, indicates a constan

period and suggests that it is an α-type magnetic variable.

Radio Astronomy. Goldstein and Kumar assisted by Knappenberger are measuring linear polarization and Faraday rotation at 138 MHz. Goldstein is looking for coincidences between interstellar hydrogen and calcium lines. From 17 coincident H and Ca lines he has obtained a Z distribution function for the interstellar gas. Using the twin 85-ft NRAO interferometer, Frank Bash is studying the brightness distributions at five baseline lengths of 238 extragalactic radio sources.

Miscellaneous. Robert McCormick Ayer, of Beverly Farms, Massachusetts, was named family representative to the Observatory Council by the Estate of Leander J. McCormick. Thirty-five joint colloquia with the NRAO were held. Joint colloquia began in January 1966. Visitors nights were held on the first and third Friday of each month with a total of slightly more than 1800 visitors attending. Fredrick presented an invited paper at the third Image Tube Symposium in London, served on the Visting Professor's program of the Society, and was elected to represent the Society on the National Research Council. Goldstein was elected Secretary of the Radio Astronomy Section of the International Scientific Radio Union. Wood presented an invited paper at the AAS–NASA "Symposium on the Magnetic and Other Peculiar and Metallic-Line A Stars." Kumar presented an invited paper at the Trieste "Symposium on Late-Type Stars" and a joint paper with Gingerich, Latham, and Linsky at the same symposium. A Moonblink instrument is being manned on a volunteer basis by undergraduates.

Acknowledgments. Our work is supported by the University, Office of Naval Research, National Science Foundation, National Aeronautics and Space Administration, Army Signal Corps, the Estate of Leander J. McCormick and the McCormick family.

LAURENCE W. FREDRICK, *Director*

New Mexico State University Observatory, Las Cruces, New Mexico

Personnel. The present staff consists of the following: Dr. Clyde W. Tombaugh, Astronomer and Supervisor; Bradford A. Smith, Associate Astronomer and Director of the Observatory; J. C. Robinson, Associate Astronomer; Charles F. Mozer, Assistant Physicist; Thomas B. Kirby, Junior Physicist; Elmer J. Reese and Thomas C. Bruce, Data Analysts; Robert L. Fritz and R. B. Minton, Photographic Technicians; A. Scott Murrell, Chief Observer; Thomas P. Pope, Observer; Judith Putney, who worked during the summer making a card catalogue of all the plates. Part-time students assisting with the work over the past year were Charles A. Richey, graduate student in physics; Walter E. Bains and H. Gordon Solberg, undergraduate students in physics.

Equipment and Use. The observatory on Tortugas Mountain is at an altitude of 4760 ft above sea level. The two principal instruments are a 12-in. Fecker Newtonian–Cassegrainian (2, 6, 20, and with a negative amplifier, 30-m focal length), and a 16-in. Gregorian (14-m focal length).

Considerable planning for the new 24-in. Newtonian–Cassegrainian reflector, dome and building was carried on by various members of the staff. This instrument is scheduled to go into operation near the end of 1966.

Several accessories and operation devices for the various telescopes are in preparation by Mozer. A new photoelectric photometer is being built for the 16-in. telescope. This instrument will employ a photomultiplier with S-20 spectral response and an expanded filter array to extend photoelectric studies into the near infrared and near ultraviolet. Similar instruments are being built for the new 24-in. telescope and for a portable 8-in. Cassegrainian telescope to be used in field work. The electronic shutter control on the 12-in. telescope is being modified to provide improved accuracy and more versatile operation. Also, an electric clock drive is being built for the 12-in. Fecker telescope. A planetary camera for the 24-in. telescope is being designed.

An additional 12-in. reflector for student use was planned to be fabricated partly from other pieces of equipment.

A new photographic darkroom was planned and completed with added equipment and facilities for copying planetary images.

RESEARCH

The main part of the planetary research program consists of photographic and photoelectric observations and the reduction and studies of these observations directed by B. A. Smith.

Photographic Observations. A total of 1879 plates of the planets was taken with the Fecker telescope at the 20- and 30-m Cassegrainian foci during the past year of this report, mainly by Murrell and Pope. Nearly all photographs were taken on Eastman spectroscopic plates through Schott filters where applicable. The planetary patrol consists of taking photographs in ultraviolet, blue, green, orange-red, and infrared wavelenghts in rapid succession.

Mercury was placed on our regular patrol program, as a result of renewed interest in its rotation period. Photographs were taken in brief periods

around greatest elongation from the sun in daytime. A total of 56 plates was obtained on 30 days. Mercury's proximity to the sun and its small disk make such observations very difficult. Results were encouraging since surface marking were recorded on many of the photographs.

Venus. A total of 363 plates was taken on 139 days in various wavelengths, but mainly in ultraviolet.

Mars was well past opposition, but because of interest in the Mariner IV sweep-by, 39 plates of Mars were taken on 11 nights in July 1965. Mars was in conjunction with the sun on 29 April 1966, and consequently unfavorably placed for photographic observations during the period of this report.

Composite copies were made of 277 plates of the 1965 Mars apparition by Fritz and Minton.

Although considerable work remains to be done with the plates of previous Mars apparitions, reduction of the 1965 data was given priority.

Measurements of areocentric positions of various features of immediate interest were made by Robinson. Longitude measurements of features rotating through the sub-earth point revealed a strong correlation between published radar data and the distribution of light and dark areas on Mars. The implications of these results tend to support the hypothesis that all dark regions (maria, oases, and canals) are situated at lower topographic altitudes than the bright desert areas.

Jupiter. A total of 1289 plates was taken of Jupiter on 260 nights. A large number are of outstanding quality. Reese and Solberg measured and reduced a large number of Jupiter images for size of various markings, their zenographic coordinates and rotation periods.

Saturn. Sixty-three plates were taken of Saturn on 37 nights.

Uranus. A total of 19 plates was taken of Uranus on 10 nights.

Moon. Thirty plates were taken of selected portions of the moon on 17 nights.

Comet Ikeya-Seki. About a dozen good photographs were taken of this object with small cameras in October and November 1965. Solberg measured some features for changes.

Composite Work. Composite copies were made from the combination of several images from 15 plates of Mercury, 93 of Venus, 277 of Mars, 376 of Jupiter, two of Saturn, and two of Uranus. A considerable number of copies of these composites have been sent to the International Planetary Plate Depositories at Flagstaff and Meudon.

Photoelectric Observations. Mars. Forty-five sets of *UBVR* photoelectric data on the integrated disk with the 16-in. Gregorian telescope were obtained in the period 1 July through 6 December 1965, by Bains, Bruce, Kirby, Mozer, and Richey.

By 1 July 1966, all of the 1965 Mars photoelectric data had been reduced. This reduction wor was performed by Kirby, Bains, and Bruce.

Jupiter. Approximately 215 sets of *UBVR* photoelectric data of the integrated disk were obtaine in the period 30 October 1965 through 1 April 196 by Bains, Bruce, Mozer, and Richey. Data redu tion was begun by Bruce. Also he has been prepa ing a new program of reduction of photoelectr observations on the University's CDC 33 computer.

Some differential photometry was attemped o the Red Spot of Jupiter. Several sets of *UBVR* da were obtained, as yet not reduced.

Visual Observations. Daytime visual observatio and sketches were made of Mercury by Pope an Reese to supplement the photographic record.

Visual observations of Mars were made by Ton baugh on 25 nights from 2 July through 6 Septen ber 1965 UT dates, with his 16-in. *f*10 reflector wit magnification of 524 diameters. Fortunately, supe seeing was experienced at the time Mariner IV w scheduled to sweep over Mars. Although the dis subtended an angle of only 6.5 sec of arc, a fa amount of detail was seen and recorded on drav ings. Most of the areas covered by the flight pa appeared to be free of Martian haze, but the sou limb beyond Mare Sirenum and Mare Cimmeriu was quite white.

Reese observed Jupiter visually on 114 nigh and recorded the times of 1297 central meridia transits of Jovian markings. He made approx mately two dozen detailed sketches of the R Spot region.

Jupiter has continued to be very active and gre changes occurred.

Saturn was observed visually by Tombaugh c 76 nights. Saturn went through its autumn equinox on 15 June 1966. Other than tilt aspect only gradual and minor intrinsic changes were not and recorded. A small number of visual observatio were made of Uranus.

Publications.

Mozer, C. F. 1965, "Electronic Shutter Contr for Planetary Photography with Automatic Tin Recording Capability," TN-701-66-11, New Mexi State University Observatory.

Reese, E. J., and Solberg, H. G., Jr. 1966, "R cent Measures of the Latitude and Longitude Jupiter's Red Spot," *Icarus* **5**, 266-273.

Reese E. J., and Smith, B. A. 1966, "A Rapid Moving Spot on Jupiter's North Temperate Belt *Icarus* **5**, 248-257.

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Solberg, H. G. 1965, "Terminal Synchrones in the Tail of Comet 1965 (Ikeya-Seki)," TN-701-66-12, New Mexico State University Observatory.

Tombaugh, C. W. 1966, Letter to Editor of *Nature* **209**, No. 5030, refutation to R. A. Well's letter entitled "Evidence that the Dark Areas on Mars are Elevated Mountain Ranges."

Mars Geology Project. A subsidiary project supported by National Aeronautics and Space Administration designated as "Geological Studies Applicable to the Interpretation of Some Features on Mars" was directed by Dr. Clyde W. Tombaugh. Those assisting with the study were members of the Earth Sciences and Astronomy Department at NMSU, namely, Dr. William King and Dr. William R. Seager (geologists) and one-half year assistance of a graduate student, William Danley. Two other geologists are assisting as consultants.

The first year's work has consisted of conferences, perusal of library literature, studies of Gemini and Tiros satellite photographs, maps, field trips, Martian markings, etc.

Teaching. Tombaugh was on half-time teaching status during the fall and spring semesters in astronomy.

Much planning was done to expand the academic astronomy curriculum with courses in graduate astronomy and additional courses in undergraduate astronomy.

The teaching of astronomy is in the Department of Earth Sciences and Astronomy.

Two teachers in astronomy have been added to the New Mexico State University faculty for the fall semester 1966, and one has transferred from another department at NMSU.

Support. The support for the research in planetary studies came from the National Aeronautics and Space Administration and New Mexico State University. NASA has provided the funds for the 24-in. telescope, and New Mexico State University for the dome and building.

CLYDE W. TOMBAUGH, *Professor of Astronomy*

Stanford Radio Astronomy Institute, Stanford University, Stanford, California

Personnel. In addition to the Director, Professor R. N. Bracewell, other members of the group are Dr. R. S. Colvin, Observatory site manager, T. Krishnan and Dr. A. R. Thompson, radio astronomers, and Kent M. Price, who joined the group as Research Associate. Dr. A. S. Vander Vorst spent last year at the institute on leave from the University of Louvain, Belgium, on a NATO postdoctoral fellowship. C. C. Lee, mechanical engineer, J. H. Deuter and J. Rutherford solar observers, Arthur Lutus electronics technician, H. M. Hartmann, D. Skeim, Manuel G. de Souza, and Leonard Young, mechanical technicians, and Secretary Mrs. M. H. Nilsson are the remaining staff members. In addition to G. Downs, recently arrived graduate students E. Conklin, K. Lang, and A. C. Riddle are working towards Ph.D. degrees and R. L. Kaiser is working towards an E. E. degree. Summer students were David Menasian, Kent Perryman, R. Lee Sims, and Brian Wilkin. Professor R. N. Bracewell spent the fall quarter at the University of Sidney in Australia examining technical problems in connection with the construction of large antenna arrays.

Instruments. The first 60-ft diameter, 3-cm wavelength array element was constructed on the site by institute personnel. Surveying and mensuration for a five-element nonredundant array to operate with a 20 sec of arc fan beam has been done. A 10.69-GHz receiver for initial measurements was assembled. The 30-ft interferometer was instrumented for polarization studies and the first *E–W* spacing set up by Downs and a digital magnetic tape system for recording interferometer data was installed by Colvin and Downs. Improvements in the 71-cm occultation observing system were made by Krishnan and Lang. The 9.1-cm compound interferometer was converted to operation with tunnel diode amplifiers by Vander Vorst. Vander Vorst and Colvin (1966) studied the problem of using degenerate parametric amplifiers in interferometers. A book stimulated largely by studies of radio astronomical instruments was published by Bracewell (1965).

Solar Physics. Daily spectroheliograms made at 9.1 cm with the 3-ft pencil beam instrument have been published by ESSA in the CRPL-FB-263 reports, Solar Geophysical Data, with the financial support of the administration, and data on localized bright regions were reported through the AGIWARN Center at Ft. Belvoir, Virginia. The 9.1-cm spectroheliogram for the eclipse day of 20 May 1966 was published (Bracewell and Deuter 1966).

Galactic Studies. Little and Bracewell (1966) reported a sharply different spectrum for the two components of Centaurus A and determined their right ascensions to within $\pm 0^s.2$, from observations at 73 cm in Australia. Previously reported work by Little, Cudaback, and Bracewell (1964) and Thompson and Krishnan (1965) appeared. The compound interferometer was used by Vander Vorst and Conklin (1966) to study the central component of Centaurus A. Thompson, Colvin, and Stanley (1966) observed planetary nebulae at the Owens Valley Radio Observatory measuring flux densities, positions and widths.

Occultations. Krishnan, Cudaback, and Zisk (to be published) analyzed occultations of Taurus A showing its precise position and determined strip brightness distributions at position angles 115° and 241° through restoration. Krishnan and Lang (to be published) continued to observe occultations at 71 cm with the 150-ft antenna of the Stanford Radar Astronomy Center and reported occultations and restorations for 3C444 and MSH 19-23.

Miscellaneous. The major equipment of the Radio Astronomy Institute was constructed and is largely operated with the support of the Air Force Office of Scientific Research.

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Vander Vorst, A., and Colvin, R. S. 1966, "Use c Degenerate Parametric Amplifiers in Interfer ometry," *IEEE Trans. Antennas Propagation* **AP-14**, 667–8.

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R. S. Colvi