Spencer Lecture and spoke to a standing-room-only crowd of over 600 people. His talk to our introductory classes was an exciting opportunity for our students.

Astronomical colloquia were presented by Dr. Frank Edmonds Jr. (University of Texas at Austin) on solar photospheric fluctuations, Dr. W. R. van Schmus (University of Kansas) on meteorites, and Dr. Tom Armstrong (University of Kansas) on the preliminary results of the Pioneer 10.

RECENT PUBLICATIONS


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I. AURA BOARD

The Association of Universities for Research in Astronomy, Inc. (AURA), which operates Kitt Peak National Observatory and Cerro Tololo Inter-American Observatory under contract with the National Science Foundation, consists of 12 universities. Two persons (one scientist and one administrator) are appointed by each member university to serve on the AURA Board. In addition to these scientists and administrators, the AURA Board includes five members-at-large, and the President of the Corporation, ex officio. The officers of the Corporation for FY 74–75 are:

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The AURA Board of Directors sponsors two Chilean graduate students in astronomy. The recipients of these fellowships are Jorge Melnick, studying at California Institute of Technology, and Santiago Tapia, studying at the University of Arizona.

To assist in its role of providing forefront facilities and support to the astronomical community, the AURA Board appoints an outside Visiting Committee that systematically reviews AURA's policy and operating procedures and makes pertinent recommendations to the Board. This Committee met in January 1974, in La Serena, Chile, and in May 1974, in Tucson. The Committee for FY 75 consists of Frank D. Drake, John W. Evans, John Gaustad, Riccardo Giacconi, William T. Golden, George W. Preston, Maarten Schmidt, Martin Schwarzschild, and Charles H. Townes.

II. KITT PEAK NATIONAL OBSERVATORY

A. Personnel Notes

Staff Changes: Dr. F. C. Gillett joined the KPNO staff as

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Astronomer, and Dr. R. A. Chevalier and Dr. J. G. Cohen as Assistant Astronomers. Seven postdoctoral positions were filled by Dr. D. F. Carbon, Dr. G. D. Illingworth, Dr. S. Kumar, Dr. A. Oemler Jr., Dr. S. T. Ridgway, Dr. J. C. Thays, and Dr. D. C. Wells. Dr. H. M. Dyck and Dr. G. W. Lockwood resigned as Assistant Astronomers and Dr. D. F. Strobel was on leave of absence to the Naval Research Laboratory.

Consultants and Visiting Scientists: Dr. M. Schwarzschild of Princeton University spent about half of his sabbatical leave at KPNO. Visiting Resident Scientists were Dr. Christopher Dainty of Imperial College, England; Dr. R. Goody of Harvard University; Prof. F. Hoyle of Cambridge, England; Dr. R. P. Kraft of Lick Observatory; and Dr. M. C. Pande of Uttar Pradesh State Observatory, India. Dr. W. K. Ford is Visiting Resident Scientist at KPNO for his second year, on leave from Carnegie Institution of Washington. Summer Visiting Scientist during FY 74 was Dr. T. E. Margrave Jr. of the University of Montana. Students appointed as Summer Research Assistants included J. S. Fender, P. Hintzen, D. A. Meloy, R. E. Pitts, H. J. Reitsma, W. L. Rice, J. S. Scott, C. P. Stoll, A. M. Waxman, and J. Weisberg.

Short-term scientific consultants and visitors included the following: D. Allen, Royal Greenwich Observatory, England; R. Bates, University of Canterbury, New Zealand; E. Becklin, California Institute of Technology; R. Buchroeder, University of Arizona; E. de la Rosa, Instituto Nacional de Astrofísica, Optica y Electronica, Mexico; C. Fehrenbach, Observatoire de Haute Provence, France; W. Garton, Imperial College, England; R. Gehrz, University of Wyoming; P. Goldreich, California Institute of Technology; T. Gurski, University of Arizona; G. Harrison, Massachusetts Institute of Technology; J. Heasley, High Altitude Observatory; F. Israel, Sterrewacht te Leiden, Netherlands; D. Kleinnmann, Center for Astrophysics; V. Koto, Crimean Astrophysical Observatory, U.S.S.R.; P. Mezaros, Princeton University Observatory; R. Mielbrecht, San Joaquin Delta College; E. Müller, Observatoire de Geneve, Switzerland; P. Mutschlecner, Indiana University; B. Newell, Yale University; G. Nicolson, National Institute for Telecommunications Research, South Africa; K. Nishi, Tokyo Astronomical Observatory, Japan; P. Palmer, University of Chicago; R. Parker, NASA L.B.J. Space Center; A. Penzias, Bell Telephone Laboratories; J. Pilkingston, Royal Greenwich Observatory, England; J. Prasad, Central Scientific Instruments Organization, Chandigarh, India; E. Richardson, Dominion Astrophysical Observatory, Canada; E. Salpeter, Cornell University; A. Sandage, Hale Observatories; K. Strand, U. S. Naval Observatory, Washington, D. C.; J. Stoner Jr., University of Arizona; A. Toomre, Massachusetts Institute of Technology; A. Young, California State University at San Diego.

Kitt Peak was also visited by delegations from several foreign institutions and countries: the President, Prof. J. Speer, and the Vice President for International Affairs, Prof. Pick, of the Deutsche Forschungsgemeinschaft (DFG), the West German counterpart of NSF; a ten-member delegation of laser scientists from the People’s Republic of China, sponsored by the U. S. State Department and the Committee on Scholarly Communication with the People’s Republic of China; and engineering consultants and officers of the Canada–France–Hawaii Telescope Project.

B. Colloquia and Committee Meetings

Users Committee: A representative group of users of the facilities of KPNO and CTIO are selected each year to serve as an advisory committee to the Observatory Director. Those scientists attending the October 1973 meeting of the Users Committee were

- Dr. D. Barry, University of Southern California; Dr. W. Bonsack, University of Hawaii; Dr. E. Burke Jr., King College;
- Dr. P. Conti, Joint Institute for Laboratory Astrophysics; Dr. A. Cowley, University of Michigan; Mr. L. Goad, Center for Astrophysics; Dr. R. Gehrz, University of Wyoming; Dr. S. Heap, NASA/Goddard Space Flight Center;
- Dr. J. Houck, Cornell University; Dr. R. Humphreys, University of Minnesota; Mr. M. Johnson, University of California, Berkeley; Dr. G. Mechler, Case Western Reserve University; Dr. B. Newell, Yale University; Dr. M. Peimbert, Observatorio Astronomico Nacional, Mexico; Dr. J. Pippher, University of Rochester; Dr. J. Snider, Oberlin College; Dr. H. Spinrad, University of California, Berkeley;
- Dr. R. Teske, The Aerospace Corporation; Dr. A. Title, Lockheed Solar Observatory; Dr. D. Wills, University of Texas, Austin; Dr. R. Wing, Ohio State University.

Stellar Telescope Allocation Committee: This committee has been formed to review all visitor telescope requests and was composed of the following persons during FY 74:

- Dr. G. Burbidge, University of California at San Diego; Dr. A. Cowley, University of Michigan; Dr. D. Crawford, Kitt Peak National Observatory; Dr. I. King, University of California, Berkeley; Dr. R. Humphreys, University of Minnesota; Dr. R. Lynds, Kitt Peak National Observatory; Dr. G. Münch, California Institute of Technology; Dr. G. Neugebauer, California Institute of Technology; Dr. P. Strittmatter, University of Arizona; Dr. S. Strom, Kitt Peak National Observatory; Dr. S. van den Bergh, David Dunlap Observatory, Canada; Dr. J. Westphal, California Institute of Technology.

Colloquium Speakers: A number of scientists visited KPNO to present colloquia this year. These speakers are listed in the Joint Colloquium Series reported by Steward Observatory, University of Arizona.

Detector Workshop: KPNO was host to a Workshop on Detectors, held 9–12 October 1973. The subjects discussed were Photographic Techniques and Calibration Methods, with papers by A. G. Millikan, T. Gull, E. B. Newell, H. Ables, I. Furenid, J. Harvey, and R. Lynds; Image Intensifiers: Cascaded and Fiber Optic Tubes, with papers by R. H. Cromwell, R. Lynds, W. Livingston, A. A. Hoag, E. H. Eberhardt, and R. W. Fitts; Panoramic Detectors: T. V. Camera Tubes, with papers by D. M. Hunt, A. Title, J. L. Lowrance, M. Green, and G. A. Robinson; Panoramic Detectors: Solid State Devices, with papers by G. A. H. Walker, R. Tull, M. H. Crowell, L. Broadfoot, W. Livingston, and E. D. Savoye. In addition to the formal papers, there were extensive technical discussions between the representatives from industry and the engineers and astronomers attending the workshop.

As one of the contributions, A. G. Millikan discussed the new photographic emulsions developed by Kodak—in particular, the IIIa-J and type 127-02. He noted that the photographic plate, with its unrestricted area-recording capability, is well suited to the wide-field imaging capabilities of the new generation of large Ritchey-Chrétien telescopes. A
14 × 14-in. plate with minimum image size of 25 × 25 μm contains 2 × 10^9 individual recordable image elements, each of which can record at any one of more than 64 gray levels. Thus the plate contains more than 1.3 × 10^18 bits.

In the case of an optimally nitrogen-baked Kodak Spectroscopic Plate, type III-1, this high-information-recording capacity has been achieved with detectible quantum efficiencies on the order of 4%.

Extraction of numerical information from analogue photographic records has been, in the past, a slow process. The recent availability of high-speed computer-supervised micrometers has radically changed this. A 2000 × 2000 matrix scanned with a 25-μm aperture with eight-bit digitization (256 gray levels) was accomplished in 30 min—the same time required for a typical original exposure at the telescope. Reliable information on the morphology of the image was obtained at densities up to 5.0.

E. H. Eberhardt of ITT discussed the problems of veiling glare and light-induced background in image intensifiers. Typical values for the veiling glare were 4.5%, 5%, and 6%, respectively, for 40-, 25-, and 18-mm electrostatically focused (Gen I) image tubes, and 0.1%–0.2% for proximity-focused microchannel-plate (Gen II) image tubes, excluding "near-field" veiling glare (within a few pixels of the excited image area). The veiling-glare ratio is the ratio between the total flux emitted from the image field outside of the excited image area proper. This ratio cannot be defined exactly, because of the inherent ambiguity as to the precise spatial distribution of the "true" excited image.

Eberhardt noted that most of the evidence available indicates that backscattered image flux transmitted through the photocathode is the primary cause of veiling glare in present tubes, and that this backscatter can be reduced 2–10 times by blackening the internal tube surfaces, including the phosphor screen.

An additional, and serious, cause of veiling glare in tubes with insufficiently thick phosphor alumining coatings is optical feedback from the phosphor screen proper. Additional possible causes of veiling glare are internal optical reflections in the face plates, soft x-ray feedback, elastically scattered photoelectrons, and ion feedback.

Eberhardt also discussed the results of his experiments with several different types of image tubes as preamplifiers for an image dissector. Tubes tested included a proximity-focused microchannel-plate (Gen II) intensifier tube, as well as one- and two-stage electrostatically focused tubes. Single line scans across the image of a Westinghouse ET-1332 test chart were recorded directly from a monitoring oscilloscope display of the image dissector output current. Quantum detections were improved about 30 times for the single-stage tube and 600 times for the two-stage tube. Results on the channel-plate tube were not complete, but showed reasonably well-behaved characteristics with respect to linearity and S/N ratio as a function of incident flux level. It was also apparent that the time dispersion (smoothing) properties of the phosphor screen in the channel-plate tube were effectively improving the magnitude of the S/N ratio, and could therefore be expected to increase the quantum detection efficiency in the scanned mode.

R. W. Fitts of RCA reviewed the factors contributing to image quality in image intensifiers. He discussed the factors contributing to spatial distortion, such as fiber optic shear, linear (pincushion) distortion, "S" distortion, and image rotation. The latter two effects are common properties of magnetically focused tubes and are correctable by uniform fields or are not seriously objectionable. The linear distortion, a common property of electrostatically focused tubes, is correctable by greater fiber optic curvature, which reduces the brightness uniformity, or by the addition of field-forming electrodes, which increases the cost of the tube. Fitts discussed fixed filter noise such as the fiber optics "chicken wire" of spots and blemishes. He also reported on the uniformity of the tubes, noting a variation in the photocathode response at long wavelengths, and he stressed the fact that the phosphor efficiency is low at low current densities, making the tube nonlinear at low light levels.

Martin Green of Westinghouse discussed the SEC Vidicons and EBS Camera tubes. He noted that within a very short period of time the silicon-diode-array camera tube has become the dominant low-light-level television sensor for many applications. The excellent sensitivity of the silicon tube, its ruggedness, and the simplicity of its direct beam readout mechanism have been major factors in its success. However, silicon tubes do have a variety of shortcomings such as operating limitations imposed by x-ray damage and excessive blooming under overload light conditions. Improvements in lag and resolution are also being sought by camera manufacturers.

Green reported that during the past two years a new type of silicon-diode target has been developed which offers many of the desired improvements in these and other performance characteristics. When incorporated in Electron Bombarded Silicon (EBS/SIT) tubes, the Westinghouse Deep-Etch Metal-Cap Target offers the following advantages: (1) reduced blooming without sacrifice in resolution; (2) excellent beam acceptance giving lower lag; (3) superior resistance to x-ray damage, permitting longer life and higher gun voltages for improved resolution; and (4) low dark current.

The Deep-Etch Metal-Cap Target has been used to upgrade the performance of existing EBS tube types. In addition, its unique characteristics have been incorporated into the design of an advanced EBS tube type with a 1 1/2-in. gun which offers high center and edge resolution, reduced blooming and very low microphonic levels.

George Robinson of RCA showed SIT camera tubes with photocathode diagonals of 16, 25, 40, and 80 mm and two target diameters of 18 and 27 mm. Two tube types, 4804 and 4826, are made in sufficient quantity that a range of cosmetic quality versus price is offered.

The basic S-20 photocathode was described by Robinson with respect to peak responsivity and the cutoff values at both the UV and red ends.

Items that were previously mentioned as being of specific interest to astronomical applications were mentioned: broadcast-type use with inherent 2% geometric distortion in the image section, fiber optic quality specification, and heater light shield use.

Recent work at RCA was mentioned, including the investigation of potential tube damage to either target or photocathode by overexposure, and test results of nonblooming targets having slightly reduced resolution performance with respect to standard targets.

Data were presented on results of first-field readout of information showing dependence upon dark current and signal current. Results were reviewed from a report of storage tests made on SIT tubes integrating for an hour or more at tem-
The physics of solid-state devices was discussed by M. H. Crowell of North American Philips. He discussed first the single-crystal devices and then how the device is incorporated by planar technology into an array. The problems of reading such devices were discussed, with special emphasis on the need of obtaining a proper amplifier. Crowell explained in detail some of the difficulties encountered when such devices are used for astronomical problems, emphasizing the difficulties of the degradation of the target.

E. D. Savoye of RCA reported in detail on the configurations of the CCDs being developed by RCA. He explained the physical processes giving rise to noise and the development steps that industry was taking to improve the systems, primarily in attempting to improve the transfer efficiency. Savoye noted that the interface state is one of the main sources of electron noise, and current research is going into the development of a buried-channel mode of readout. It was noted, however, that these devices, when read slowly and when cooled, would perform quite well at the low light levels associated with astronomical problems.

C. KPNO Programs

Stellar: FY 1974 can be regarded in many ways as the "year of the 4-m." Under the direction of A. A. Hoag, much of the program effort has gone into making the Mayall telescope operational and completing the basic complement of instrumentation for both KPNO and CTIO. Considerable effort was also devoted to optimizing smaller telescopes for infrared and to developing intensified image systems.

Following the June 1973 dedication of the Mayall telescope, the first major goal was to make the Ritchey-Chrétien (R-C) focal reducer operational. The instrument was installed and equipped with a TV field-viewing system at the small auxiliary focus position. Comparison light sources for the rotator have been designed and are being fabricated. A prototype automatic guider, incorporating one guiding probe, was installed below the instrument rotator, and the electronic controls and computer interfacing of the automatic guider were then developed. Installation of a two-probe guider and completion of the permanent electronic gear are now scheduled. The one-probe guider will be equipped with a second probe and shipped to CTIO.

The R-C position camera and R-C grating spectrograph have been completed and tested, with some modifications being made. A TV field-viewing system was adapted to view the front side of the spectrograph slit. A Carnegie image tube was tested at the spectrograph camera port with good results, and a complete Carnegie image-tube system is being planned.

The 4-m telescope echelle spectrograph design and much of the fabrication has been completed under the direction of T. Gull. A test of the mechanical-optical portion of the instrument showed good results. Work continues on mechanical completion and electronic work, with a similar instrument being planned for CTIO.

The main computer for the 4-m telescope was installed. Development of software for position readouts was the first undertaking, followed by programming for routine "housekeeping" functions, automatic guider control, and instrumentation control, especially for the R-C spectrograph. Programming is continuing for other instruments, for more refined pointing and tracking, and for increased remote operating capability.

Design work was completed for a "narrow-beam" (f/163) optical system to extend the light beam into the Coudé laboratories. Other Coudé projects include a second computer system to operate the No. 5 mirror mount (altazimuth style) and for instrument usage; a 10μ FTS instrument; and a 3.34-m scanning spectrometer.

Special racks incorporating a handrail were mounted in the R-C cage of the 4-m, enabling standard electronic drawers to be installed. A "clam-shell" cage bottom is being designed to reduce instrument changeover time. A power-operated, rotating observer's chair and equipment storage facilities will be installed in the prime-focus cage.

The 2.1-m telescope also received considerable attention. A newly installed secondary mirror support structure, optimized for the infrared, enables a "low-background" chopping secondary system to be installed in place of the f/7.5-f/30 mirror assembly, reducing interchange time to less than two hours. The "low-background" feature is such that the infrared detector "sees" essentially only the coated mirror surfaces; the secondary, support housing is all behind the secondary mirror.

To improve position control of the 2.1-m telescope for infrared usage—chopping, blind offsets, and faster scanning—a high-resolution encoding system has been installed. Seventeen-bit incremental encoders, friction driven by the main bull gears, deliver pulses to a Varian computer as the telescope moves in right ascension or declaration. Along with the normal computer controls now available on this telescope, allowances can now be computed for telescope mechanical windup and flexure.

To further improve mechanical accuracy of the 2.1-m telescope, a newly designed declination bearing system will be installed. This will eliminate the present spherical rolling bearings that produce variable friction resistance depending upon telescope position.

The auxiliary Coudé feed telescope for the 2.1-m Coudé spectrograph is now operational. This 92-cm telescope is described in the KPNO Quarterly Bulletin, July–September 1973. A new image-tube camera system and a new wide-field finder telescope will be built for use with this telescope.

The 1.3-m telescope, which is used 60% of the time for infrared observations in the 2-30μ range, has been fitted with a chopping secondary, an infrared photometer, and an optimized low-background secondary assembly. During the past two years, a Varian-CAMAC computer system has been integrated with the telescope system to provide control for precise offsetting and scanning, for secondary mirror control, and for data handling.

Telescope drives continue to receive attention. Over the past five years, digital electronic drives have been installed on all but the No. 1 92-cm and the 41-cm telescopes. Conversion of the No. 1 92-cm telescope to electronic drives is in progress. Two spare telescope-drive assemblies have been completed for KPNO, relieving the critical "no-spare" condition that had prevailed. Two horseshoe damper drives (one for spare) were built for the CTIO 4-m telescope.

Under the direction of C. R. Lynds and W. K. Ford, Carnegie image-tube systems have been designed for the 4-m spectrographs, the 2.1-m spectrograph, and direct cameras at the 0.9-, 2.1-, and 4-m telescopes. Much of the design work on a 144-mm ITT image-tube system has been done, and a three-stage image-tube system utilizing a new spectrographic

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camera designed for KPNO by C. G. Wynne (Imperial College) has been completed. The Kron electronographic cameras have been rebuilt to make two of the cameras available for scheduled telescope usage. The second camera ensures that observing time is not lost because of failure of the first.

Solar: The item of major interest is the new Solar Vacuum telescope. This instrument consists of a coelostat mount feeding a 61-cm aperture, 36.6-m focal length optical system contained in a vacuum tank. A 10.7-m focal length Littrow spectrograph feeds a 512-element silicon-diode array incorporated into a magnetograph. The telescope and magnetograph, designed and built under the direction of scientists A. K. Pierce, W. Livingston, and J. Harvey, have been providing daily full-disc high-resolution magnetograms of the Sun and occasional He λ10830 spectroheliograms to the scientific community. These were of particular interest to NASA during the Skylab program. The daily magnetograms are currently being sent to the National Oceanic and Atmospheric Administration for correlation with atmospheric phenomena; NOAA has provided an observer, J. Busman, to assist in acquisition of the data.

A two-axis dynamic guider for the Vacuum telescope has been designed. After its installation, the guider, telescope drives, and magnetograph will be linked together through the telescope computer system. This arrangement will provide precise scanning of the solar image in heliographic coordinates.

The major effort for the McMath telescope has been the installation of Cer-vit optics in the main optical path. A new 2.1-m diameter Cer-vit heliostat and cell has been installed, along with a Cer-vit image-forming mirror of 1.6-m diameter and 85.0-m focal length. The No. 3 folding flat was replaced with a 1.6-m diameter Cer-vit mirror. The mirror carriage and mount were rebuilt to provide light beams into the new Fourier transform spectrometer—Coudé observing room. The new optical system has greatly reduced focal changes and astigmatism due to heating of the mirrors.

A new tangent arm system has been installed on the declination axis of the heliostat, increasing significantly the stiffness of the drive system.

A new Vax computer system has been installed in the observing room to replace the obsolete XDS 912 system.

Work on the Fourier transform spectrometer has continued under the direction of J. Brault. The instrument is now under closed-loop control via a laser interferometer system. The path differences are controlled to within 0.005 fringe, the eventual goal being 0.001 fringe. This instrument will be contained in a vacuum system, for which a subcontract has been let.

Construction of the FTS—Coudé addition began in April; this building will provide three observing stations fed by the main optical beam of the McMath telescope. One of the observing stations will be reserved for visitors with long observing programs. The other two stations are for the Solar FTS and a 3.4-m spectrometer provided by the Planetary Sciences Program.

Planetary Sciences: A silicon vidicon detector has been installed in the 2-m McPherson spectrograph, and laboratory tests are encouraging; for example, the A band of O₂ is readily detected in the 8-m path inside the instrument.

During November 1973 the 31-cm Schmidt telescope was mounted temporarily in the 12-ft dome at the Airglow Laboratory site, in time for observations of Comet Kohoutek (1973f). Tests performed in collaboration with H. Spinrad (Berkeley) indicate that the Schmidt camera is also suitable for recording the faint outer extensions of galaxies. The camera is now being moved into a 16-ft dome, to escape problems of vignetting in the smaller dome.

Several observing aids and instruments in Planetary Sciences have been improved to facilitate general visitor and staff use. T. Parkinson put the guiding and finding system for planetary and stellar objects into a standard configuration; these systems include standard TV and low-scan TV guides and an image stabilizer. The stabilizer was configured to operate both at night and, on bright objects, during the day. M. Belton modified the pulse-counting scanner system on the 13.4-m spectrograph into a form suitable for general use, by providing more flexible software and new control interface between hardware and computer. All photomultipliers were converted to LN₂ coding systems.

These developments laid the basis for the Solar Telescope Nighttime Operation program, instituted in mid-1974. To date, this program has been used by four visiting observers; further proposals are presently under consideration.

Computer Applications: Computer systems have been installed for the McMath main telescope and the No. 2 92-cm telescope. Throughout the year, a considerable effort was made to standardize the systems, to add plugboards for the user and to add many peripherals. The computer system and spare data cables were also installed at the 4-m telescope.

The maintenance group was augmented and this has led to improved response time (on a 24-h basis) for emergency repairs. Preventive maintenance is now done on a routine basis wherever possible.

Several CAMAC modules were redesigned: the DDO Mark II, the Timer Mark II, and the Pulse Generator Mark II. These newer modules contain hardware improvements which were dictated both by software and system needs as well as reliability features.

Photomultiplier: In the past year a facility has been established in which the characteristics of photomultiplier tubes can be examined. Parameters of interest are the quantum efficiency, spatial sensitivity, dark current as a function of temperature and voltage, the pulse height distribution, and others that are required by their application. Data were logged on 26 photomultiplier tubes which are being used in the observing equipment at KPNO and CTIO. In some cases substantial improvement in the quality of observational data was reported as a result of the observer's ability to select the best detector.

The photomultiplier laboratory is available for requested evaluations. Standard tubes can be examined in a reasonably short time; delays occur for devices requiring special fixtures.

Grating Laboratory: The "Harrison-C" ruling engine has been relocated at KPNO. The engine has now been reassembled and is installed on a vibration isolation pier in a temperature-controlled enclosure at the KPNO facility. Under the direction of D. Hall, KPNO is making an effort to restore the "C" engine to its full ruling capability and to build up a "library" of submaster gratings from which replicas can be made available to users. A description of the facility has been published in the KPNO Quarterly Bulletin, April–June 1974.

Infrared: The infrared program has been concerned with the evaluation of various infrared detectors, development of prototype instrumentation, and optimization of telescopes for
use in the IR.

The detector evaluation has concentrated primarily on InSb photovoltaic detectors for \( \lambda < 5 \mu \) and doped silicon photodetectors for \( 5 < \lambda < 25 \mu \). Both types of detectors look very promising for future use, both as individual detectors and in detector arrays.

InSb detectors have been incorporated into a JHKL photometric system, resulting in a substantial improvement in the signal-to-noise ratio. A doped silicon detector has been used in a prototype 8-14-\( \mu \) filter wheel spectrometer. This system also appears to be significantly more sensitive than previous instruments of this type.

The infrared group has participated with the stellar group in the modification of the 2.1-m and 1.3-m telescopes for use in the IR. The 2.1-m telescope has been fitted with an interchangeable secondary mirror structure with a chopping secondary and optimized geometry for IR work. The secondary structure of the 1.3-m telescope has also been modified to provide a low-emissivity background and a chopping capability.

**Panoramic Detector:** C. R. Lynds, director of this program, published a report of the activities of this group in the KPNO Quarterly Bulletin, April-June 1974. The objectives of the Panoramic Detector Program (PDP) are to purchase and to investigate in the laboratory as many promising state-of-the-art optoelectrical transducers as possible, to study the characteristics of such devices, to develop specific nonstandard auxiliary system components and/or techniques whenever deemed necessary for the practical and successful application of video detectors, and to assemble breadboard prototypes of systems.

Nonintensified and intensified camera tubes were tested, including the RCA silicon-target vidicon, GE magnetically deflected silicon-target Epicron, GE electrostatically deflected silicon-target FGS Epicron, RCA intensified silicon-target SIT vidicon, and the GE electrostatically deflected, intensified silicon-target FGS Epicron. Silicon-diode arrays including the Reticon, the GE CID, and the Fairchild CCD have been studied. A breadboard autocorrelating stellar interferometer was also developed.

**D. Staff Research**

**H. A. Abt** has completed the last manuscripts of recently deceased astronomers A. H. Joy and G. Van Biesbroeck. Joy's classifications of 426 M dwarfs were used to derive new mean luminosities (from trigonometric parallaxes) for M dwarf stars and to compare the types with colors. The luminosities are the same for dMe as for dM stars, but the former have larger \( R = 1 \) colors than the latter. The main sequence is very narrow and the frequency of dMe stars becomes complete at \( dM5.5 \). This cooperative research was revised to Joy's satisfaction before his death. Van Biesbroeck's final manuscript, which required considerable editing by H. Abt and C. Worley prior to publication, included about 2000 measures of 700 double stars.

Abt's study of marginal metallic-line stars shows systematically low rotational velocities relative to those of normal A-type stars but slightly larger ones than for the more extreme Am stars. The marginal Am stars also have a high binary frequency, which probably explains, through tidal coupling, the abnormally low rotational velocities.

The compilation by Abt of the previously unpublished individual radial velocities from the Mount Wilson Observato-

ry is now complete, having taken nine years and involving 23,000 measures of about 7200 stars.

Abt and E. S. Biggs are compiling a General Index to the Astronomical Journal, Volumes 51-75. The author index is complete and the subject index has been started.

**M. J. S. Belton** has worked on the measurement and interpretation of structure and motions in the atmosphere of Venus using the basic data set obtained during the Mariner 10 flyby. Belton has found many new global-scale phenomena including bow-like, zonal, and spiral waves. He has also studied the problem of heat deposition in the atmospheres of Jupiter and Uranus via overtones of the transition in CH\(_4\) and pressure-induced overtone transition in H\(_2\). Part of this work was incorporated in an effort with L. Wallace and M. Prather to calculate the thermal structure of Jupiter's atmosphere. As part of an effort to make a reliable quantitative assessment of the CH\(_4\)/H\(_2\) ratio on Uranus and Neptune, Belton acquired new spectra of these planets in the region of a band thought to be the \( 5 \mu \) transition in CH\(_4\). The spectra are about five times better in spectral resolution than any that have been previously reported and when combined with laboratory data recently acquired by K. Dick and U. Fink, should yield quantitative results. Belton has also been involved in the interpretation of the Mercury pictures and with the reduction and analysis of data on Comet Kohoutek obtained by Mariner 10.

**A. L. Broadfoot** has been heavily involved in the observational program for the extreme-ultraviolet experiment on Mariner 10. His experiment team members are M. J. S. Belton of KPNO and M. B. McElroy of Harvard; S. Kumar of KPNO has also been closely associated with this team. Preliminary analysis of the data has guided the observations, which include many objects. The Earth and Moon were observed shortly after launch. Extensive observations were made of Venus and Mercury, the prime objects of the Mariner 10 mission; the preliminary results have been published in *Science*. The extent and structure of the hydrogen envelope around Comet Kohoutek will be determined from observations taken on several days. Monthly observations of H \( \lambda 1216-A \) and He \( \lambda 584-A \) emission will provide information on the density and temperature of the interstellar wind. The ability of the instrument to operate on several wavelengths less than 900 Å may produce new data on interstellar activity. These observations continue during the cruise to a second and, possibly, a third encounter with the planet Mercury.

**D. F. Carbon** has continued his investigation of elemental and isotopic abundances in late-type stars. Model-atmosphere and spectrum synthesis techniques are being used to interpret high-resolution Coude' and Fourier transform spectra. So far, in collaboration with S. Ridgway, several M giants and a carbon star have been analyzed for abundances of C\(_{12}\), C\(_{13}\), N\(_{14}\), and O\(_{16}\). A model-atmosphere analysis has shown that the CO bands in several late-type stars are affected by a chromospheric temperature rise. A program with Ridgway to obtain temperatures for a sample of late-type M, MS, S, and C stars using narrow-band photometry and high-dispersion photographic spectroscopy is nearing completion. Preliminary results indicate good agreement with M. Dyck and G. W. Lockwood for the stars observed in common. An investigation is being carried out to determine the effects of molecular and atomic opacities on the atmospheric structures of K giants with normal and SMR characteristics. In collaboration with R. P. Kraft of Lick Observatory, model-
atmosphere techniques are being used to analyze Kraft's scanner observations of cool giants in M92. In collaboration with Ridgway and D. Wells, the angular diameter of $\mu$ Gem was determined from an occultation observation.

R. A. Chevalier has completed work on interpretation of a series of computations of an explosion in a plane-stratified medium, which showed that a strong supernova explosion above the galactic plane could result in mass loss from the galaxy. Another project involved following the evolution of ejecta from a supernova, such as is observed in Cas A. The high-velocity knots are expected to be surrounded by hot gas created in a bow shock. The knots will be heated by conduction to temperatures at which the gas emits x-rays. This hot gas, heavily enriched with heavy elements, may explain the central x-ray source observed in Cygnus. The interpretation of x-ray emission lines from such a source will be affected by time-dependent recombination effects.

Chevalier and J. Scott began work on the acceleration of relativistic particles in Cas A by turbulence set up by the fast-moving knots.

In collaboration with T. Gull, Chevalier obtained narrow-band filter photographs of galaxies and galactic nebulae, including the Crab nebula and IC 443. The data on the Crab nebula indicate that low-density, hot gas is streaming away in sheets from dense filaments. This structure is presumably related to the acceleration of the filaments.

In collaboration with J. Théys, Chevalier looked at the effect of perturbations on an optically thin radiating shock such as is found in old supernova remnants. Numerical calculations showed that a clamp forms in the lagging part of the shock front and that the clamp eventually moves out ahead because of its greater momentum.

Chevalier has also investigated the interaction between the interstellar medium and stellar winds from various types of stars. For early-type stars, observations of the results of this interaction may yield the best estimate of the mass-loss rate. In pre-main-sequence stars, cooling behind the shock resulting from the interaction may give rise to observed emission lines.

Chevalier has begun a combined theoretical and observational project on barred spiral galaxies. The bar appears to be a density wave which extends out to the corotation radius. Spectra of SB galaxies have been obtained to gather information on velocity dispersions and rotation.

J. G. Cohen has continued her work on optical interstellar lines, as a probe of conditions in the interstellar medium. Through a study of the ultraviolet Na I lines and the resonance lines of K I, she has strengthened her previous result that depletions of metals are larger in the particularly dense clouds of the interstellar medium such as the $\xi$ Oph complex. This, together with polarization work by L. Carrasco, S. Strom, and G. Grasdalen, has led to the concept of grain growth in the denser clouds. Together with T. E. Snow of Princeton, she has found that the diffuse interstellar lines $\lambda 4430$ Å and $\lambda 5780$ Å are weaker in dark clouds as a function of color excess than in the normal, less dense regions of the interstellar medium. Apparently, the diffuse interstellar lines are not related to grains or are suppressed when the grains become larger.

A program to try to determine the velocity structure within the Ophiuchus complex was carried out with G. Wallerstein of the University of Washington. According to their model, the radio molecules are concentrated in the densest regions of a cloud, the optical molecules (CH and CN) in the somewhat less dense regions, and the atomic Ca and Na on the periphery of the cloud, so that if there is any general expansion or contraction, we may see differences in the radial velocities of the various interstellar lines. For at least one star, velocity differences between the atomic lines and CH and CN indicated that the outer part of the complex is expanding.

With observations from Cerro Tololo, Cohen has also completed a study of optical interstellar lines in a group of southern stars. These stars show peculiarities in the Ca II/Na I ratio, as well as in the ratio of color excess to neutral hydrogen. This implies that there is at least some gas at significant heights above the plane and that the ionization at high galactic latitudes and $Z$ above 500 pc may be rather different from that in the plane; in a few cases, a large fraction of the hydrogen in the line of sight may be ionized. Cohen has also completed a study of the resonance line of K I in the extremely cool super-lithium stars, with the aim of proving that irrespective of peculiarities in the atmosphere, such as lower boundary temperatures, the super-lithium phenomenon is a real abundance effect.

D. L. Crawford continued his general program of obtaining photometric observations, primarily in the $uvby$ and $\beta$ systems, calibrating these systems in terms of intrinsic color, absolute magnitude, and chemical composition, and applying the data to problems of galactic structure.

During the past year, he finished the analysis of data for the NGC 6871 and the $\alpha$ Per galactic clusters. The calibration of the observed indices in terms of parameters useful for galactic structure was finished for the F-type stars, and is nearing completion for the A-type and the B-type stars. These calibrations should be in press by the end of 1974.

Crawford has also investigated interstellar reddening in front of southern hemisphere globular clusters, evaluated the effects of hydrogen emission lines on H$_2$, H$\beta$, H$\gamma$, and $uvby$ photometry, and obtained $uvby$ photometry for the clusters NGC 6910, NGC 6913, and IC 1805.

K. A. Dick's research involved photoelectric absorption spectroscopy of methane and of methane–hydrogen mixtures. Spectra have been obtained with a KPNO 1-m Ebert–Fastie spectrophotometer and the 38.6-m White cell of the Lunar and Planetary Laboratory, University of Arizona. For pure methane, the region covered was from $\sim$4000 Å to $\mu$ under a variety of different pressures and path lengths. At maximum abundance (6.5 km amagat), the spectral region 4000–6500 Å was studied with both pure methane and a methane–hydrogen mixture.

Dick is also involved in atomic emission spectral analyses in the XUV region. Spectra obtained down to 125 Å at the National Bureau of Standards have been partially analyzed to yield details of the ground-state term intervals of multiply ionized zinc and gallium.

W. K. Ford Jr., in collaboration with V. Rubin and J. Graham, has continued an observing program of Sc I galaxies. Optical velocities of 185 galaxies out of a sample of 200 have now been obtained. Details of this work are described under Visitor Highlights.

I. Furenlid has continued work on high-dispersion spectroscopy of early-type stars, late-type giants, and supergiants as well as on photometry of galaxies, the latter in collaboration with B. T. Lynds. An investigation of solar microturbulence determined from flux spectra has been carried out with A. R. Condal of the University of British Columbia. The results show the microturbulence parameter to be sensi-
tive to the method of analysis. The results also explain the discrepancy previously found between the microwaves in the Sun and in G dwarfs.

F. C. Gillett has studied the properties of H II regions, particularly the spectra and polarization of compact sources in H II regions. With W. Forrest, K. Merrill, and T. Soifer he has analyzed the spectra of such sources and the relation between the absorption and visual extinction. A similar program has been initiated with type I OH sources. One source of this type, W33A, has been found to have the largest absorption optical depth at 10 μ of any known source.

A third research program, with D. Kleimann and E. Wright, is IR spectroscopy of extragalactic sources. The first observations, of M82, have been published. A fourth subject has been IR spectroscopy of planets and satellites. Preliminary work has been done on Titan and the Galactic satellites (with R. Capps) and on limb brightening of Saturn (with G. Orton).

L. Goldberg is continuing a detailed study of the profiles of strong resonance transitions in late-type giants and supergiants. The primary observational material has been obtained by L. Ramsey, now at Indiana University. Additional spectra have been obtained in collaboration with I. Furenlid and L. Testerman. Goldberg is examining the line profiles in order to isolate and analyze their circumstellar components. He has continued his work on the interpretation of the solar ultraviolet spectrum.

G. L. Grasdalen, in collaboration with J. L. Pipher, University of Rochester, and B. T. Soifer, University of California at San Diego, has completed an infrared study of the compact H II regions G 30.8–0.0 in the W 43 complex. The 10-μ data indicate that these H II regions may be deficient in dust, compared to the normal interstellar gas. Estimates were made assuming that the radiating dust and ionized gas are thoroughly mixed. From a detailed study of the nearby compact H II region NGC 204, he has concluded that this may not always be the case. In NGC 204, the 10-μ radiation arises in an interface zone between the ionized material and the dense cloud within which the H II region is embedded. A 2.2-μ map of this region has revealed the star responsible for the ionization of NGC 204. Because this star is heavily reddened, it is one of the best cases now available for determining the interstellar extinction law in the infrared. Comparisons between its colors and those of the Becklin-Neugebauer source in the Orion nebula indicate that both of these sources owe their extreme red colors to interstellar extinction.

In collaboration with L. Carrasco, Instituto Nacional de Astrofisica Optica y Electronica, Mexico, Grasdalen has investigated a bright optical knot within the H II region NGC 2175. From radio data on this region and optical spectra of the nebulousity, they conclude that the knot is a dense, largely neutral cloud illuminated by a B star, S 252a, which was recently formed within the cloud. They further argue that the small amount of ionized material present is due to the gradual ionization of this dense cloud by S 252a.

Grasdalen has also obtained near-infrared (1.25–2.2 μ) integrated magnitudes for a sample of globular clusters. The mean intrinsic V–K color of a globular cluster was found to be 2.2 mag in good agreement with predictions based on the known stellar content of globular clusters. Surprisingly, the V–K color does not appear to correlate well with the integrated spectral type of the individual clusters.

A program has been started to investigate statistically the near-infrared properties of galaxies. The preliminary results show a remarkable homogeneity of V–K colors for elliptical galaxies. When account is taken of the radial gradient in the V–K colors of elliptical galaxies, the mean intrinsic color is 2.85 with a dispersion of only 0.05 mag. As yet, the data on spiral galaxies is insufficient for discussions segregated according to type.

In order to analyze these integrated colors in terms of a mixture of populations of varying metal content, it will be necessary to obtain accurate knowledge of the V–K colors and K magnitudes of late-type giants as a function of Z. The giant branches of four halo globular clusters have been observed as a start on this program. Comparison with theoretical evolutionary tracks gives good agreement with observations. It is intended to extend this program to clusters of higher metal content during the coming year.

In collaboration with S. P. Worden of Steward Observatory, University of Arizona, Grasdalen has conducted a digital analysis of the polarization within a nebula in Serpens. From the spatial structure of the polarization, it is demonstrated that a highly obscured star is responsible for the bright reflection nebula.

Grasdalen has been associated with a program of narrowband photometry of dMe stars carried out with S. P. Worden and E. Jensen. By choosing wavelengths that represent different levels in the stellar atmosphere, they have deduced not only the presence of starspots, but also associated "active regions" of enhanced chromospheric activity. These observations greatly strengthen the close relation between surface activity on these faint dwarfs and solar activity.

T. R. Gull has continued his observations of nebulae, and has obtained photographic plates of monochromatic light distributions in various objects. Most noteworthy are the plates of several H II regions taken at the 4-m prime focus through 90-Å-wide interference filters, which isolate [N II], [S II] λ6717 + λ6731 Å, continuum at several wavelengths, and Hβ. Many features such as bright rims, filamentary structure, a bow shock wave, and two Herbig-Haro objects were noted. In addition, some prime-focus plates have been taken of M8, M16, M17, and M20.

In collaboration with M. Cohen and others, Gull studied the peculiar star HD 44179 with interference filters at the 4-m prime focus and with an image intensifier at the No. 1 0.9-m telescope. A rectangular-shaped nebula appears on the plates in the red continuum.

The "Bubble Nebula" NGC 7635 was studied using a number of interference filters. Initial results have been combined with radio and infrared data of M. Cohen and M. Barlow.

The Kron electrographic camera was used to study the Orion nebula, with various filters isolating continuum, Hβ, O II λ3727, O III λ5007, and He I λ5876 Å. Intensity and relative ratio maps with 6-arcsec resolution were produced for these lines. The ratio of the continuum to Hβ is found to vary by a factor of 100 from the central region outward, as the nebula changes from an H II region to a reflection nebula. Polarization maps, again obtained with the Kron camera and in emission line images confirm that outer parts of the Orion nebula, although containing nebular spectrum, are reflection nebulae in character.

A detailed study of H II regions was continued with B. Balick and M. G. Smith. Radio observations of the 76 α transitions in M17 and M42, carried out with the NRAO 140-ft antenna, were published this year. Line profiles were
recorded on the brightest radio nebula at 2-arcmin intervals with 2-arcmin resolution. In M17, the profiles could best be fitted with double Gaussian functions, and the two line components were mapped throughout the nebula. The observations for M17 were extended to optical lines using the same nebular positions.

Gall used the AURA Fabry–Pérot at CTIO to observe the same 2-arcmin regions. He obtained line profiles for Hα, He λ5876 Å, [O III] λ5007 Å, [N II] λ6584 Å, and [S II] λ6731 Å, and found that the line profiles definitely vary with excitation. Line profiles of [O III] λ5007 Å are narrower than the split [S II] and [N II] lines, yet the Hα line profiles are very similar to the hydrogen 76 α profiles.

D. N. B. Hall has continued reduction of eclipse observations obtained from the Concorde eclipse flight. The principal scientific result is the observation of bright rings in the plane of the ecliptic at 10 μ, definitely establishing the source as thermal radiation by hot dust.

In collaboration with O. Engvold, Hall has made observations that substantially reduce the upper limit on the solar boron abundance. This new value is inconsistent with recently proposed cosmic boron abundances and raises some questions as to solar processing of light elements.

Hall and R. Allen have used the infrared spectrometer to accurately measure the solar limb darkening at a number of wavelengths between 1 and 10 μ. These data have been used to obtain a much more precise model of the photosphere, which varies substantially from presently accepted models.

J. W. Harvey has continued work using spatial interferometry, first in collaboration with M. Schwarzschild in a study of solar granulation. Existence of photospheric intensity features with spatial periods as small as 200 km was definitely established even though observations were made in average seeing. Experiments to allow calibration of interferometric solar observations were also undertaken, basically involving observations of the limb. While results are promising, the problem is still unsolved. Another collaboration with R. Lynds, C. Slaughter, and S. P. Worden is aimed at resolving surface details on nearby supergiants by the use of digitally processed speckle interferometry.

In August 1973, a high-latitude solar active region was reported by Gillespie, Harvey, Harvey, and Livingston as being perhaps the first sign of the new solar cycle. Similar regions were observed in November 1973 and February 1974. New highly sensitive equipment has allowed an early detection of the onset of a solar cycle; careful study of the progress of the new cycle may reveal some clues to the mystery of the solar cycle.

SkyLAB ATM and Kitt Peak observations are being studied by Harvey in collaboration with several ATM investigator teams. Ground-based observations of helium lines, compared with simultaneous x-ray observations from American Science and Engineering and EUV slitless spectrograms from the Naval Research Laboratory, have supported the idea advanced by Goldberg in 1939 that these helium lines are significantly controlled by radiation arising at much higher temperatures than the regions where helium is observed. As a result, it is possible to detect coronal holes and bright points with helium observations. These phenomena appear to be basically–magnetic in origin. The exact association of magnetic fields with coronal holes remains elusive. The case of bright points is more clear cut; separate studies by AS and E of x-ray bright points and by Harvey, Harvey, and Martin of short-lived bipolar magnetic regions, along with a joint study now in progress, have definitely confirmed that the bright points are associated with small magnetic active regions. Whether these phenomena are simply the small-scale extension of a spectrum of active region sizes or represent a new class of solar phenomena is not yet clear.

A. A. Hoag has been primarily concerned with the instrumentation and system development of the Mayall 4-m telescope. Observational interests have included further applications of very low dispersion slitless spectroscopy used for discovery of faint emission-line objects and for determining redshifts of faint galaxies.

D. M. Hunten has been working to define the final payloads of the 1978 Pioneer Venus missions. S. Kumar and Hunten derived a model of Venus' ionosphere based on a lower exospheric temperature (350 K) than had previously been used. The findings of Mariner 10 were in general agreement with the model, although the electron densities still show unexplained features. In connection with work on the National Academy of Sciences Climatic Impact Committee, Hunten has worked out a simplified method to treat quantitatively the transport of pollutants out of the stratosphere. The conclusion is that nitrogen from SST exhausts may be even more serious a problem than had been thought.

G. D. Illingworth is working to extend to galaxy spectra the Fourier techniques used previously to determine velocity dispersions from integrated light spectra of globular clusters. For this, he is taking spectra of the core region of some elliptical galaxies and of a range of spiral galaxies from Sa to Sc. The spectra are unwidened so that rotation velocities for the stellar component can be obtained by cross-correlation methods. By this means, he expects to obtain improved M/H values for the core populations of galaxies and to further the range of data available for comparison with predictions of dynamical models.

In addition, 4-m prime-focus plates of the globular clusters M5, M13, and M92 have been obtained and are to be used to determine radial surface density distributions for stars in several different mass groups.

T. D. Kinman continued his photoelectric photometry and polarimetry at the 2.1-m and 4-m telescopes, with particular emphasis on quasars with continuous spectra. In one of these objects, 0735 + 178, absorption lines with a red shift of 0.42 were found by Carswell, Strittmatter, Williams, Kinman, and Serkowski, in support of the hypothesis that these objects differ from accepted variable quasars only in the absence of emission lines.

Observations of OJ 287 in the visible were compared with those at 10.6 μ, to show that the spectral index of this object did not change while its flux decreased by a factor of 15. The mean spectral index in the visible also remained constant, although short-term variations were present. There is evidence that the spectrum of OJ 287 gets flatter toward the infrared and possibly the source becomes optically thick at wavelengths greater than about 30 μ. This would explain the absence of correlation between optical and radio variations.

The computer–photometer was used to obtain UBV colors of the two brightest knots in the jet of M87. These are consistent with a power-law distribution with a spectral index of 1.7. Both Rieke and Grasdalen failed to detect the jet at 10.6μ, with a 2σ limit of 0.02 Jy. As in the case of the continuous-spectrum quasars, there is evidence that spectrum of the jet flattens towards the infrared. Direct photographs taken at the prime focus of the 4-m reflector of the three spheroidal galaxies near M31, found recently by van den
Bergh, resolve these objects into stars and confirm their identity. They have a central surface brightness of about a thirtieth of the sky in the $V$ passband and a color $B - V$ of about $+0.8$. The fourth object found by van den Bergh near M31 has a $B - V$ of about 0.4 and, as he concludes, is not a dwarf spheroidal galaxy.

S. Kumar collaborated with A. L. Broadfoot on the Mariner 10 UV experiment during the major part of FY 74. They have detected a thin atmosphere on Mercury consisting mainly of helium. Upper limits were set for the abundance of various gases including H, O, C, Ar, Ne, and Xe. Helium was also identified on Venus for the first time from Mariner 10 data and were obtained on the distribution of H, He, O, C, and CO. An exospheric temperature of approximately 400° K was deduced for Venus from the H-Lyman-alpha data from Mariner 10. This is in excellent agreement with the pre-Mariner 10 temperature suggested by Kumar and D. Hunten (1974) in the basis of theoretical models and reevaluation of Mariner 5 data.

The possibility of atomic chlorine on Venus was explored. Kumar has suggested that existing rocket data may contain evidence of Cl in the upper atmosphere, with a mixing ratio as high as 10⁻⁴.

Kumar has continued research with C. S. Bowyer on the XUV sky background. Further evidence was obtained for an interstellar source of 584-Å emission.

W. C. Livingston was on leave from KPNO as an NCAR Visiting Scientist at HAO from 15 January to 15 June 1974. With E. Tandberg-Hanssen, Livingston studied the photographic spectra of quiescent prominences with special attention to the Ca K line profile. Out of 135 prominences observed spectroscopically in 1970–1973, 77% show some degree of line reversal ($K_\alpha$). Under conditions of poor seeing (low spatial resolution) the reversal tends to appear central and symmetric, but for spectra taken under well the best conditions (high spatial resolution) the reversal wavers about with respect to the mean profile, and in certain cases clearly departs and forms a separate entity having lower emissivity. They conclude that the $K_\alpha$ “absorption” could arise from a physically semidetached envelope of gas having a lower source function than the main prominence body. Model calculations substantiate this heretical conclusion.

Livingston and E. Hildner demonstrated that a faint and rather quiescent prominence was a possible source for the coronal transients of 11 September 1973. Highly energetic, eruptive events have previously been identified with such transients, but they propose that this is an example of magnetic structure that is relatively void of visible plasma and yet may produce sizeable coronal readjustments.

Livingston and R. White studied an extreme limb spectrogram of exceptional spatial resolution. Chromospheric continuum was detected for the first time outside of eclipse. Horizontal velocities higher than supposed (~7–10 km/sec) were indicated by Na D emission whiskers.

Livingston, collaborating with Y. Nakagawa, R. Levine, N. R. Sheeley, and J. Harvey began to relate Skylab XUV structures to force-free field calculations.

B. T. Lynds has completed an atlas of spiral galaxies which contains details of the galactic patterns of dust and H II regions in a collection of 41 spirals photographed with the 2.3-m telescope of the University of Arizona. She is continuing her analysis of the definition of spiral patterns in galaxies, based on the various constituents of a galaxy. In collaboration with T. Filenid, she is continuing a study of the Ho emission measures and the $B - R$ differential colors of these galaxies.

C. R. Lynds has continued a large-scale observational program on ring galaxies and related objects. The observations include both direct photographs with the Mayall telescope and extensive spectroscopic documentation of the kinematics of ring structures and associated companions.

Lynds began the development of spatial interferometric techniques intended primarily for use on the Mayall telescope. This work has included the application of analogue techniques similar to those of Labeyrie, in which image-tube assisted photographs of stars are subjected to spatial power-spectrum analysis by means of coherent optical processing. More than 100 stars down to ninth magnitude have been observed, in collaboration with H. Abt, J. Harvey, and others. Several binaries have been detected and attempts to observe the spectral dependence of the structure of α Orionis, though not definitive, look encouraging. However, because of excess telluric associated with processing like numbers of observations, a substantial effort has been applied to the development of an autocorrelating interferometer for use at the telescope. In addition to these activities aimed at spatial power-spectrum determination, there have been investigations of several techniques for spatial deconvolution by means of the interferometric information present in short-exposure photographs. These have been successful, but practical means for their execution on a routine basis are not yet in hand.

R. W. Milkey has continued to work with D. Mihalas on a detailed treatment of the frequency redistribution process in resonance line formation. The initial effort was directed toward the solution for Lyman alpha in the solar chromosphere by modifying the complete linearization radiative transfer code to account for the residual coherence in the line wings. The theory was then extended to cover the solar Mg II resonance lines (h and k) located around 2800 Å; significant differences were found between the complete and partial redistribution profiles. A good qualitative match between the observed and theoretical profiles was obtained with the partial redistribution formalism. Further work on the Mg II lines in stellar chromospheres is being undertaken in collaboration with R. Shine, T. Ayres, and J. Linsky. The theory has been reformulated to allow for two transitions sharing an upper level and work is in progress on the solar Ca II resonance lines (H and K).

The radiative transfer code was also modified to take account of the overlapping of transitions in He I and II, with the intention of studying the effectiveness of the He II resonance line at 304 Å in pumping the He I ionization in the chromosphere. It can be demonstrated that the 304-Å photons may provide a reasonably effective means of pumping the He I ionization in the regions where the 10 830-Å line and other observable helium transitions are formed.

In a collaborative project, Milkey, J. P. Mutschlechner, and L. Testerman calculated non-LTE line profiles for the resonance lines of neutral potassium, in order to fit the center-to-limb data and obtain a revised abundance. It appears that the non-LTE theory offers a considerably improved fit to these data. An exploration of the techniques by which one might treat the departures from LTE in the formation of the CO fundamental vibrational band has been undertaken by Milkey in collaboration with D. F. Carbon and J. N. Heasley. This problem is interesting in the context of surface cooling of late-type stars.
G. Oemler has been studying the galaxy content of clusters of galaxies. This is necessary for an understanding of galaxy formation, cluster morphology, and the influence of the environment of a protogalaxy on its later characteristics. Oemler is studying the membership of clusters of galaxies as a function of type of cluster and location within each cluster. Characteristics of galaxies in nearby clusters, determined from 4-m plates, will be combined with previously obtained data on these clusters to ascertain the importance of initial conditions in a galaxy’s neighborhood and subsequent interaction with the cluster environment in determining the present form of the galaxies.

Oemler is also studying the structure of supergiant D galaxies. Two of the most necessary pieces of information are their structure, as determined from their light distribution, and their internal dynamics, as found from velocity dispersion and rotation curve. He is using the Kitt Peak PDS machine to measure 4-m and Palomar 46-in. plates of supergiant galaxies to determine their light distribution, and has begun a study of their internal motions using the 4-m image-tube spectrograph.

Another program of interest to Oemler is the absorption red-shift systems in QSO spectra. He has begun, with R. Lynds, a systematic study of absorption red-shift systems in high-red-shift QSOs, with the hope of using the results in a statistical analysis of the distribution of absorption red shifts. The spectrum of 4C25.05, rich in absorption lines, shows only one system with sufficient lines for a positive identification. However, there is strong evidence that many of the remaining absorption lines are Lyman alpha in red-shift systems where the other expected lines are too weak to be seen.

T. D. Parkinson observed Io during the last stages of Jupiter’s 1973 apparition. The newly discovered sodium emission from that body was observed and the large (20-arcsec) spatial extent of the emission regions explored. Parkinson’s observations of large D_2/D_1 ratios has led to further development of his resonant scattering discussion.

Observations of atmospheric motion on Venus were attempted at the solar telescope. A phase-sensitive modulation system was put into the spectrograph at the McMath telescope to detect the 2-mÅ Doppler shift expected. The most recent image stabilizer was used to chop the image as well as to stabilize it against translational seeing effects. A new slow-scan TV system was used for definition and documentation of image positions. Although the technique needs further development, it is promising, and observations in late April 1974 gave an atmospheric velocity of 50 ± 50 m sec^{-1} in the retrograde sense.

A. K. Pierce continued work on a supplementary list of standard wavelengths of solar lines. This fills in and adds about 2000 new wavelengths to the tabulation of Pierce and J. Breckinridge, bringing the total number of wavelengths to 16 500. By a close examination of high-dispersion atlas tracings of the solar spectrum, Pierce has found a large number of unrecognized blended and faint Fraunhofer lines. A list of 1800 lines has been prepared.

Solar limb darkening has been observed by many people over the last 100 years, but previous work has been limited by small images, low spectroscopic resolutions, poor seeing, and scattered light. The McMath telescope provides an excellent opportunity to improve greatly the previous results, particularly in the wavelength region λλ3000–4000 where the continuum windows are very narrow. C. Slaughter and Pierce have completed one-third of an extensive program covering the interval λλ3000–10 000.

S. T. Ridgway has carried out an analysis of jovian spectra acquired by the FTS technique in the range 750–1200 cm^{-1}, which led to identification of ethane (C_2H_6), acetylene (C_2H_2), and phosphine (PH_3). Discovery of the hydrocarbons confirms earlier expectations of an interesting photochemistry in the upper atmosphere of Jupiter, and the spectra help discriminate among possible models of the thermal profile.

In collaboration with D. Carbon, Ridgway is continuing a study of ^12C, ^13C, N, and O abundances in late-type stars. At present, spectral resolution of 0.5 cm^{-1} in the IR is available. It has been verified that the CO fundamental bands will be useful in studies of stellar upper atmospheres, possibly including mass loss.

Ridgway has established an instrumental capability for lunar occultation observations. He observed a disappearance of μ Gem (M3 III) with a three-channel B, V, R photometer. His analysis, in collaboration with D. Wells and D. Carbon, gave a determination of the angular diameter to within about ±8%. Observations of several occultations in the near IR, 1.5–2.5 μm, has demonstrated that high-quality data are obtainable even in the daytime. With an IR system, the number of favorable events for diameter determination is quite large, ~30–60 per year. Many of these involve stars of spectral type M6 and later, about which very little is known. During the coming year, Ridgway plans observation of the most favorable events.

S. E. Strom and K. Strom continued their investigation of young stellar objects associated with dark interstellar clouds. In association with F. Vrba of the University of Arizona, they completed 2-μ maps of the Ophiuchus dark cloud region, and have begun a survey of the Lynds Cloud 1630 region (near M78). Their results confirmed the presence of large numbers of embedded sources in some dark interstellar clouds. The sources, in large measure, appear to represent the early-type members of embedded clusters of recently formed stars. The presence of such objects inside the dark cloud may considerably affect our estimates of the near-ultraviolet and visible radiation field present in dark clouds. This, in turn, could significantly influence our views regarding atomic and molecular equilibrium, at least locally, within these dark dust clouds.

The Stroms continued their work on the Herbig–Haro objects. They believe the optical H–H objects to represent reflection nebulae illuminated by extremely young stellar objects (“H–H stars”) analogous to extreme T Tauri stars. They located six infrared objects associated with optical H–H objects; in two trial cases they were able to demonstrate that the observed polarization for the optical object was consistent with the reflection nebula hypothesis if the illuminating star is assumed to be the observed infrared source. If their picture is correct, the H–H objects offer us a unique opportunity to observe some of the earliest phases of stellar evolution. The Stroms conclude, on the basis of their spectroscopic studies, that the H–H stars are losing mass at a rate a factor of 10–100 larger than that typical of an ordinary T Tauri star. This is an unexpected result since the H–H objects appear to be no more than a few times 10^6 years old. Recent theoretical work, on the other hand, suggests that objects this young should still be surrounded by infalling circumstellar envelopes. Hence, there appears to be a serious disagreement between theoretical and observational predictions regarding the early phases of stellar evolution.
The Stroms and A. E. Rydgren, of the Steward Observatory, continued their joint work on T Tauri stars. Their research suggests that the spectroscopic and infrared properties of these objects are most strongly influenced by the rate at which mass is lost in the stellar winds characteristic of stars of this type. Specifically, those T Tauri stars found in older O and B associations appear to have lower mass-loss rates, weaker infrared fluxes, and weaker optical emission lines than do younger objects of the same class. Thus, the mass-loss rate appears to be an excellent indication of the age of a T Tauri star. One can imagine an evolutionary sequence in which a T Tauri object begins as a Herbig-Haro star characterized by a mass-loss rate of between $10^{-8}$ and $10^{-7}$ solar masses per year. As the object approaches the main sequence, the mass-loss rate decreases to the values between $10^{-7}$ and $10^{-6}$ solar masses per year, characteristic of most T Tauri stars. The first stage might take place between $10^5$ and $10^6$ yr after the star is born. The second phase might occupy the time roughly between one and ten times $10^6$ yr; more normal spectra and lower mass rates are then found for older pre-main-sequence objects.

In collaboration with G. Grasdalen, the Stroms conducted an investigation aimed at detecting extragalactic H II regions in Sc galaxies at infrared wavelengths. Radio continuum observations of these regions suggested that they should be relatively strong infrared sources, were they analogous to galactic ionized hydrogen complexes. However, with the possible exception of IC 131 in M33, no 10- or 20-$\mu$m radiation was detected from 14 such regions. These observations support a model in which the 10- and 20-$\mu$m fluxes in galactic H II regions arise at the boundary between the ionized region and the molecular cloud; at present, it would appear that the H II complexes in Scs are not associated with molecular clouds, which precludes the production of IR radiation.

In collaboration with F. Vrba, the Stroms have begun a polarimetric study of stars embedded within and viewed behind dark clouds. The purpose of their investigation is to determine the role played by the magnetic field in the collapse of the dark interstellar cloud. Preliminary results suggest that the dark, tube-like structures found associated with many cloud complexes cannot be explained by demanding that collapse take place primarily along magnetic field lines. Rather, a model in which material flows down the field line into the core of the dark cloud is favored.

L. V. Wallace has calculated radiative equilibrium models for the thermal structure of Jupiter above the 0.1-atm pressure level. In the detailed calculations the composition of the atmosphere was restricted to H$_2$, He, and CH$_4$ in the abundances determined by spectroscopy in the visual region and occultation light curves. A model which includes solar heating due to methane in its 3.3-$\mu$m band and reradiation in its 7.8-$\mu$m band shows a steady increase in temperature from a minimum at 0.03 atm, through 140 K at 10 atm, to an essentially isothermal region at 155 K above 10 atm. A model that includes heating due to weaker near-infrared bands of CH$_4$ shows even higher temperatures at high altitudes. This model gives good agreement with the observed emission intensity in the 7.8-$\mu$m CH$_4$ band and its center-to-limb variation. The temperatures obtained from the $\beta$ Sco occultation are also in satisfactory agreement. This, however, is not the case for the preliminary Pioneer 10 radio occultation results, which show much higher temperatures than the calculated models. The Pioneer 10 results also show temperatures $\approx 700$ K where ground-based results give $\approx 150^\circ$ K, a conflict so large as to suggest that either Pioneer 10 is wrong or all previous ground-based studies of H$_2$ and CH$_4$ are wrong.

### E. Visitor Research Highlights

**Solar Astronomy:** Seventeen visitor solar programs employing the McMath solar telescope were carried out during FY 1974, several of which were undertaken in conjunction with Skylab. Solar abundances, velocity and magnetic fields, granulation and supergranulation, atmospheric structure, and solar oscillations were featured.

William N. Lennard has obtained a new evaluation of the solar Ni abundance by fitting the solar spectrum with a sum of Voigt profiles over a region of about 2 Â around the Ni I lines of interest. The KPNO high-resolution tracings yield new information concerning lines that appeared weak or blended in earlier photometric data of poorer resolution. Lennard has identified a line in the laboratory spectrum of Ni I at $\lambda 4633.03$ which has never before been observed. The identification is confirmed by its newly found presence in the Kitt Peak solar spectrum with intensity predicted by the measured gf value and the known Ni abundance.

Lennard used the new solar data for the ten weakest Ni lines to calculate a model-independent value for the photospheric Ni abundance $N_{Ni}/N_{H}$ = 6.28 $\pm$ 0.09 = 12.00 based on the results of new transition probabilities measured by Lennard and Whaling. This value is a factor of 2.3 larger than that published by Goldbert et al. and removes the discrepancy between the coronal and meteoric values and the photospheric values.

Joseph L. Snider and his colleagues have completed a two-year project of observing wavelength oscillations of the solar 7699-$\AA$ potassium line. They built a portable atomic-beam resonance-scattering apparatus to observe this line, and set it up in conjunction with the McMath east auxiliary telescope. They obtained long records of the 5-min-wavelength oscillations for a number of different areas of observations. Their chief conclusions are that the observed wavelength oscillations are associated with randomly phased elements of the solar atmosphere that are smaller than their smallest area of observation (8 arcsec); that there do not seem to be large areas of the solar atmosphere that oscillate coherently with significant amplitude; and that the power spectrum shows a peak at $\approx 3.2$ mHz with a FWHM of $\approx 1$ mHz within which subsidiary peaks appear, varying erratically from run to run.

H. Holwegar has also studied the 5-min oscillations by observing a rectangular (0.25 $\times$ 10 arcsec) area near the center of the solar disk. The spatial sequences covered one to two supergranulation cells in about 12 strips. Holwegar is examining the extent to which the equivalent widths of various Fraunhofer lines in nonactive regions could be regarded as constant quantities. He has found that variations, though small, are definitely present in both time and spatial sequences. They are of the order of 0.3-3 mÅ for line strengths of 30-120 mÅ. Well-developed velocity oscillations are found to be accompanied by simultaneous oscillations of equivalent widths. Holwegar suggests that the observed equivalent-width oscillations are due mainly to temperature variations associated with the thermal response of the high photosphere to the 5-min standing waves.

John G. Kirk is continuing his photometric measurements of the solar spectrum in the light from the center of the solar disk and in the integrated light of the entire visible solar hemisphere. He is developing a process whereby spectra ap-
proximating the disk-center form could be derived from stellar spectra, which are always obtained in integrated light.

Planetary Astronomy: Nine visitor programs were devoted to the study of planetary system objects. Comet Kohoutek was the subject of three of these.

Thomas B. McCord and his colleagues used the 2.1-m telescope with the MIT silicon vidicon imaging system to obtain direct imaging of the Moon at six wavelengths, to map compositional properties. Penalized by extremely poor seeing conditions, McCord obtained 200 low spatial resolution (5–20 km) images which are being used to produce color (0.40/0.56 μm) maps.

Clark R. Chapman has continued his observations of asteroids; among them were Trojans 624 Hektor and 911 Aganemnon (which have identical anomalous spectra), 887 Alinda (an Earth-approaching asteroid), several unusually black steroids such as 141 Lumen, which resembles type 2 carbonaceous chondrites spectrally, and 349 Dembowska (found to have a spectrum more closely resembling ordinary chondritic meteorites than any of the other 97 asteroids observed by Chapman and his colleagues).

J. L. Dunlap and his associates have also continued their UBV photometry of asteroids. They report that Vesta is not quite spherical and appears to have a surface or shape irregularity near the south pole. Toro is about 3 km wide and 9 km long.

Tobias Owen, Roger F. Knacke, and Richard Joyce have used the 2.1-m telescope and S-1 image tube to obtain spectra of Titan. These observers have shown that Titan has a very low radiative flux at 5 μm, indicating either that the surface is very dark or that the temperature is below 169°K. This result, together with observations at 3.5 μm and in the 17–25-μm range, places useful constraints on possible atmospheric models of Titan. Their data confirm in a general way the presence of water ice in the rings of Saturn and suggest that this material may also be present on Titan.

Marin Harwit and his colleagues are using a Hadamard transform spectrometer to study the jovian atmosphere and have obtained spectra in the 8–10- and 12–14-μm region.

M. Johnson and A. Betz have used their heterodyne spectrometer to obtain 11-μm absorption line profiles of CO and CO2 in the Martian atmosphere. A multichannel spectrometer was employed with a resolving power of 1.5 × 106 to yield equivalent widths of 50 mHz (0.0017 cm⁻¹) for three lines in the vibration–rotation spectrum of C18O.

Stellar Astronomy: Seventy-four visitor programs can be classified as research in stellar astronomy. Six programs specialized in specific problems related to galactic structure, 16 were devoted to analyzing various types of binary systems, and 52 related to a wide variety of individual stellar objects from the youngest to the oldest stars and from x-ray sources to the faintest infrared objects.

Peter S. Conti and Anne P. Cowley have reported on their spectroscopic observations of the x-ray binary HD 153919 = 2U1700–37. They found little variation in the Λ II λ4686 emission profile, and moderate changes in the emission lines at λ5096 C III and Ηα, which depend more on epoch than on phase. However, pronounced phase-dependent variations are found in the P-Cyg-like profile at λ876 Ηe I. The investigators interpret these as being due to distortions in the wind from the Of star by the presence of the compact x-ray source. The major distortions occur at phases around 0.7, after the passage of the x-ray source across the line of sight to the star.

Claude R. Canizares and Jeffrey E. McClintock have attempted to detect periodic components of the fluxes of the optical counterpart of x-ray sources, in the frequency range −0.1–300 Hz. No pulsations have been detected.

Conti, Cowley, and Johnson have studied the double-line spectroscopic binary HD 159176 and report that the stars are practically indistinguishable from one another and are of spectral type O7. The minimum masses are about 12 and 11 solar masses; the period is 3.368 days and the orbit is circular.

J. Bahng has monitored the variations of Ηα emission strengths in Be stars; preliminary results indicate that the Ηα emission is variable with a time scale of a few minutes in the star ζ Tau. Roland Pockeckt has detected significant variations in linear polarization in the Ηα line profiles of 12 Be stars. Shell stars like ζ Tau exhibit a decrease in polarization proportional to the emission strength. Stars considered 'pole-on' have no significant variations in polarization.

W. A. Hiller and Jon C. Thomas have been investigating the binary incidence among Be supergiants. Their analysis indicates that four stars in their group of 36 are probably binaries, two of which appear to have short periods and are known to possess double-line spectra.

Henry L. Shipman reports that the two helium- and oxygen-rich stars discovered last year give no evidence for variability. The colors confirm temperature of 25 000 and 28 000 deg for these stars and this confirms the oxygen over-abundances.

Saul J. Adelman has made spectroscopic scans of magnetic Ap and normal main-sequence stars in a comparative study of the continua of these objects. Although the flux distributions of magnetic Ap and normal sequence stars were found to match in a gross sense, many magnetic Ap stars are found to possess continuous absorption features which are identified as those produced by Si I bound–free discontinuities.

Stephen J. Shawl has observed 37 late-type stars for emission in the Ca II infrared triplet at λ8498, 8548, and 8662. None of the 11 non-Mira variables observed show emission, while five of the 12 M-type and six of the nine S-type Mira variables do show emission. The five carbon stars show absorption only. Preliminary results indicate that the observed emission-line strengths of the triplet are greatest near phase 0.36 rather than near light maximum when the H and K lines are in absorption.

I. Little-Marenin and S. Little have obtained red spectrograms of a number of M, MS, and S stars and they report the presence of the unstable element technetium in W And, and possibly in T Cet. They are continuing an analysis of 13C/12C ratios and atomic ratios of s-process elements.

Using the Wisconsin echelle spectrograph on the 4-m telescope, Christopher M. Anderson has obtained 30 spectrograms covering the entire yellow to near-infrared regions of seven dM and dMe stars. Three spectra are of sufficient resolution to detect axial rotation in the dMe stars and have revealed unexpectedly complex Ηα emission profiles.

Donald H. Martins has completed UBVRI photometry of variable red dwarf emission objects and has concluded that after allowance is made for the influence of flare activity (found to be very important), the "spot model" appears to be adequate when compared with observations. Bernard W. Bopp obtained spectra of six dKe and dMe objects and has discovered two new spectroscopic binaries, Gliese 517 and Gliese 815. Emission-line variations were seen in BY Dra.
Nebulae and Interstellar Matter: Nineteen visitor programs related to various aspects of nebulae and the interstellar medium were carried out in FY 74.

Michael Zeilik II and his colleagues have detected infrared emission from several H II regions including G45.5 + 0.1, G45.1 + 0.1, W40, W48, and G25.4 – 0.2. In most cases they obtained infrared power distributions from 2.2 to 21µµ; G45.5 + 0.1 and W40 were also mapped at 10.6µµ.

Judith L. Pipher and associates have also mapped a number of strong 100-µµ compact radio H II regions at 12.6µµ and obtained spectral data at 2.2–20µµ at selected points. The objects include W3, G76.4 + 0.6 = S106, G29.9 – 0.0, G133.8 + 1.4 = 5235, N44 and two new sources in W49 and G75.8 + 0.4. Pipher notes that the W44 complex is of particular interest in that one source (NRAO 584) has an unusually strong absorption at 10µµ, while other members of the complex are not nearly so strongly absorbed.

Larry Goad has completed a study of the inhomogeneities in planetary nebulae. Direct photographs, taken with narrow-band interference filters, have been used to prepare maps of the brightness of the nebulae in the prominent emission lines. Image-tube spectrometers were obtained in order to measure intensities of lines too faint or too closely spaced to be studied by isophotometry. The velocity field of NGC 2392 was mapped to study correlations between the velocity anomalies (~ 150 km sec⁻¹) and the [S II] line intensities.

David Allen has examined most of the stellar planetary nebulae north of δ = −20° in a search for 2-µµ continua. Infrared photometry defines three classes of objects: (1) those with no signals, (2) those with late-type stellar continua, and (3) an unusual group with infrared excesses due to circumstellar dust. Class (1) is probably the one containing the genuine planetary nebulae.

Robert A. Parker obtained monochromatic photographs of NGC 6888 and the Cygnus Loop in the light of selected emission lines. These photographs show a strikingly box-like structure for [O III] features as opposed to the ions of lower excitation and also an extensive [O III] structure outside the main body of NGC 6888.

Michel Breger has measured the wavelength dependence of polarization from 30 stars in Orion. More than half of these stars could be fitted with Serkowski's standard interstellar curve scaled for different particle sizes. A wide range of dust grain sizes were detected. For those stars with independently known spectral types and infrared photometry, an excellent correlation was found between the wavelength of maximum polarization and the ratio of the total to selective absorption. Circumstellar shell polarization was found to be much more sharply peaked in the visual/IR than intracloruster dust polarization.

Luis Carrasco has found that some 30 stars at high galactic latitude (b ≳ 15°) show significant amounts of linear polarization. Carrasco has found that this sample of stars contains some objects with polarization characteristics that point out an intrinsic origin of the polarization. The rest of the stars he observed — the ones with polarization that can be associated with interstellar dust — do not present any systematic trend with galactic latitude.

B. D. Savage has 15 very high signal-to-noise ratio spectrometers of highly reddened stars obtained with the Wisconsin echelle spectrograph on the 4-m telescope for the purpose of determining accurate profiles of the semidiffuse interstellar features at λ5780 and λ5797 Å.

John W. Warner has obtained a number of photographs at 1µµ of the dark cloud complex south of ρ Ophiuchi and has identified several 2.2-µµ objects thought to be newly formed stars.

Richard D. Schwartz obtained slit spectra of the emission and reflection nebulae associated with T Tauri in the wavelength range 4800–7600 Å. The velocities indicate that the matter-flow away from T Tauri is supersonic with respect to the ambient intracloud medium in which the star is embedded. He suggests that radiating shocks may form where the flow interfaces with the inhomogeneous intracloud medium, producing emission spectra similar to that predicted by the Cox's model. The H-H nebulae, if produced by the same mechanism, must involve central objects with a considerably higher rate of mass outflow than is indicated for T Tauri.

Star Clusters: Fourteen visitor programs were devoted to the study of galactic and globular clusters.

Arthur R. Upgren combined his KPNO photometry with his astrometric work at the Van Vleck Observatory in his analysis of dwarf stars. He has concluded that the $V, R - I$ sequence for the Hyades is essentially complete for the known members of its lower main sequence (dK2–M2) and is in general agreement with Eggen's photometry of many other stars. But a selection effect in the field dwarfs shifts the modulus derived from $R - I$ outward by about 10% (from about 3.02 to 3.22), bringing it into agreement with almost all of the other recent modulus determinations.

E. L. Robinson and Robert P. Kraft have discovered small variations in brightness with time scales on the order of days in several Pleiades dwarfs in the spectral-type range K3 II to M0 II; Hyades stars of similar types are constant. The investigators conclude that the brightness variations are fairly common in late K- and early M-type dwarfs of age 3 × 10⁷ yr but essentially disappear at an age near 5 × 10⁹ yr.

Robert D. McClure has completed a program of wideband $UVB$ and intermediate-band DDO photometry for giant stars in the old open cluster NGC 188. A scatter has been found in the strength of the cyanogen bands among these stars, which correlates with $(U - B)$ and the position in the color-magnitude diagram. McClure suggests that this is due to a variation in chemical abundances among the giant stars in the cluster. A similar effect has been found for giant stars in the globular cluster NGC 362.

McClure has obtained image-tube spectograms of a large number of giant stars in several other old open clusters in order to search for peculiar stars that may show evidence for mixing, such as the barium star in NGC 2420. It appears that no star as extreme as the barium star exists among a sample of about 80 giants in clusters.

Robert J. Zinn has been investigating the chemical composition of the red giants in globular clusters. He has found two stars having stronger CN bands than do other red giants in M5, which suggests that mixing from the interior to the surface has taken place. On M13, he reports variations in the G band strength similar to those detected in M92.

E. Barry Newell and Harold D. Ables have photographed M13 with the Kron tube on the 4-m telescope. Baum's photoelectric sequence extends down to $V = 22.93$ and with the KPNO PDS Microphotometer they have measured his sequence stars on the 4 1/2-h exposure and expect to extend this limit a magnitude or more.

Galaxies: Twenty-one visitor programs concentrated on extragalactic systems.
Paul W. Hodge has obtained photometrically calibrated Hα interference filter photographs of H II regions in 26 galaxies. Some of the H II regions were observed photoelectrically at Mt. Hopkins for absolute calibration. The largest H II regions are being analyzed to determine their structure to enable quantitative treatment of the problems of the sizes of H II regions and their use in determining extragalactic distances. F. R. Chromey obtained Hα photographs of 14 bright Sα galaxies; he is using these data to select galaxies suitable for dynamical investigations and to complete statistics on the occurrence, size, and position of H II regions in systems of early Hubble type.

A. E. Whitford observed three giant elliptical galaxies (NGC 4472, NGC 4486, and NGC 4649) in the Virgo Cluster. He reports that the dwarf-sensitive Wing–Ford band at 9910 Å is below the level of detection in these three galaxies. This extends a result previously obtained for the nuclear regions of M31 and M81; dwarf-enriched population models appear to be ruled out, and a plausible luminosity function would include enough M giants to explain the observed infrared colors. Whitford's results are in accord with the CO band strengths found by Baldwin, Frogel, and Persson, who concluded that the 2.2-μm radiation from the elliptical galaxies is dominated by high-luminosity stars.

Daniel W. Weedman has reported on his multiaperture BV photometry for 72 galaxies in the Coma cluster and 44 galaxies in the Perseus cluster. He has found apparent correlations between galactic nuclear magnitudes and galactic redshifts in the Coma cluster but not in the Perseus cluster. Weedman also concludes that either the absolute nuclear magnitudes of the Perseus cluster galaxies are about 1 mag brighter than those of the Coma cluster galaxies or the Coma cluster is a more distant relative to Perseus than its red shift implies.

Vera C. Rubin and W. Kent Ford Jr. used the 2.1-m telescope to observe spectrograms of an all-sky sample of Sc I galaxies, 14.0 < m < 15.0. These observations are being used to investigate the isotropy of the Hubble expansion at the distance defined by these galaxies. From observations at KPNO and CTIO, velocities are presently available for about 180 of the 206 galaxies in the sample. Their most recent analysis (made when 141 velocities were available) indicates that if the sky is divided into two almost equal areas, a velocity anisotropy exists at the 5- or 6-σ level, with mean velocities of about \( \langle V_x \rangle = 5000 \pm 200 \) and \( \langle V_z \rangle = 6400 \pm 200 \) km sec\(^{-1}\) for the two regions. However, diameter measures suggest that the galaxies of larger mean velocity are more distant, so an isotropy in the Hubble expansion appears not to be the explanation. Computer experiments indicate that a nonrandom distribution of intrinsic magnitudes caused by severe density fluctuations cannot account for the large observed effect, because of the constraints imposed by the observed velocity and apparent magnitude distributions.

Rubin and Ford have also obtained spectrograms of three barred spiral galaxies (NGC 1300, 3351, and 5383) and J. Goad has observed five type I irregular galaxies (IC10, NGC 1569, 2537, 3788, and 4214).

Jean Goad has finished a study of the kinematics in the inner region of M81. She has found that the inner kiloparsec of M81 is rotating rapidly, reaching a peak of over 300 km/sec at a radius of about 70 arcsec; this is even higher than the peak velocity in the outer velocity curve discussed by Roberts and Rots. Goad has also found that superposed on the general rotation are large nonrotational motions. The gas in the inner 10 arcsec is flowing away from the nucleus; outside 10 arcsec there appears to be a general inflow of gas.

Roger F. Knacke and R. W. Capps report that infrared polarization at 3.5μ (3.2 ± 0.4%, P.A. = 88° ±5°) and 10.2μ (2.3 ± 0.5%, P.A. = 84° ±7°), has been detected in the Seyfert galaxy NGC 1068. This is a reversal of the trend of decreasing polarization with increasing wavelength through the ultraviolet. The visible component of the infrared is bright at the ultraviolet and visible wavelengths. Polarized radiation could arise from either a compact nonthermal source or emission by grains. Knacke and Capps are continuing to observe a number of other galaxies in the infrared.

Judith L. Pipher used the 1.3-m and 2.1-m telescopes to observe the galaxies NGC 2903 and 3077 at wavelengths between 2.2-20μ. Hα regions were searched, as were some radio continuum knots in dark clouds known to be strong 100-μm emitters. Both types of regions yielded negative infrared detections.

A. G. Millikan is continuing his work in optimizing photographic detection with wide-field telescopes of large aperture and low f ratio by making observations with the KPNO 4-m telescope of clusters of galaxies, faint galaxies, interactive galaxies, and peculiar galaxies. John W. Warner used the 2.1-m telescope with a cooled S-1 image-tube camera to photograph galaxies in passbands from 0.7 to 1.0μ. H.-Y. Chiu has obtained images of M82, Zw 466, Arp 216, and Arp 178 with his vidicon system; he and his colleagues are processing the data to produce photometrically calibrated contour maps of these objects.

François Schweizer used the KPNO PDS microphotometer and CDC 6400 to trace and reduce 30 plates of seven spiral galaxies (NGC 3031, 4254, 4321, 5194, 5364, 5467, and 6946) taken at other observatories. The reduction of some 20 million data points resulted in photoelectrically calibrated surface-brightness and color-index maps for each galaxy. Schweizer reports that the exponential disks of spiral galaxies have very uniform colors; that the ratio of arm to disk light increases roughly linearly with radius, which explains the outward bluing of spiral galaxies; and that the star formation strength seems to correlate with van der Kruit's measure of the compression strength of the gas; that young stars drift through the spiral pattern predominantly in the direction of rotation; and that there are signs that some spiral arms were formed only recently.

Marie-Hélène Ulrich has completed her observations of a sample of 53 elliptical galaxies brighter than 15.7 and identified with radio sources. More recently, she has extended the sample to include 74 ellipticals with magnitudes between 15.7 and 16.5. The second sample is being studied to improve the statistical accuracy of the results found from the first sample.

### F. Telescope Allocation

Following is a summary of visitor usage of the KPNO telescopes and the programs under investigation. The first number appearing after the program description refers to the number of nights scheduled. The figures in parentheses are the actual hours of operation, and the last figures refer to the telescope by aperture in meters or centimeters. CF refers to the Couléd feed telescope.
H. Ables, U. S. Naval Observatory and E. Newell, Yale University: Electrophotographic Photometry of Globular Clusters in Elliptical, Lenticular, and Early-Type Spiral Galaxies, 1(84)4 m, 3(162)1.2 m.


D. Allen, Royal Greenwich Observatory: Two-Micron Photometry of Forbidden-Line Stars, 6(62)1.3 m.

C. Anderson, University of Wisconsin: Tests of Echelle Spectrograph, 18(107)4 m.

J. Bahns, Northwestern University: Variations of H-Alpha in Be Stars, 3(34)CF, 4(4492) cm.

J. Baumert, University of North Carolina: The Absolute Bolometric Magnitudes of Carbon Stars and Standards for Carbon Star Variation, 6(422)92 cm, 4(1941) cm.

P. Boeshaar, Ohio State University: A Spectroscopic Study of M-Dwarfs in the Solar Neighborhood and Hyades Cluster, 5(482)1 m.

T. Bohuski, Dyer Observatory: Markarian Galaxies, 8(6192) cm.

H. Bond, Louisiana State University: A Search for Optically Variable Extragalactic Objects, 5(4692) cm.

B. Bopp and D. Evans, University of Texas at Austin: Spectroscopic Observations of Flare Stars with Particular Reference to Starspots, 4(112)1 m.

M. Breger, University of Texas at Austin: Intracluster Dust in Orion, 6(4492) cm.

E. Burke, M. Spencer, and J. Vucolo, King College: Photometric Search for Periodic Variation in Ap Stars and Photometry of Eclipsing Binaries, 36(146)41 cm.

R. Canterna, University of Washington: Photometric Determinations of [Fe/H] and CN Abundances of G and K Giants in Globular Clusters, 3(27)2.1 m, 11(471)1.3 m.

L. Carrasco, B. Iriarte, and E. de la Rosa, Instituto Nacional de Astrofisica and University of California at Berkeley: Studies of Magnetic Fields in Centers of Dark Clouds, Extremely Young Clusters and Stars Connected with Cometary Nebulae, 9(45)2.1 m, 11(68)1.3 m; Studies of Dust at High Galactic Latitudes, 13(54)1.3 m.

C. Chapman and T. McCord, Planetary Science Institute and C. Pieters, M. Sneller, and A. Goldberg, Massachusetts Institute of Technology: Spectrophotometry of Trojan Asteroids and Other Objects, 17(129)1.3 m.

H.-Y. Chiu, S. Simkin, and R. Hobbs, Institute for Space Studies: Vidicon Photometry of Ring Galaxies and Other Peculiar Galaxies, 6(3792) cm.

F. Chromey, Poughkeepsie, New York: Incidence of H II Emission Regions in Spiral Galaxies of Early Hubble Type, 4(3792) cm.

R. Clegg, University of Maryland: Abundances of Carbon and Nitrogen in Subdwarfs, 6(59)1 CF.

A. Condal, Dominion Astrophysical Observatory: Spectroscopy of Galaxies, 3(692) cm.

P. Confl and S. Frost, Joint Institute for Laboratory Astrophysics: Spectroscopic Observations of O-Type Stars, 8(79)2.1 m.

A. Cowley and M. Hartoog, University of Michigan: Spectroscopy of Emission-Line Stars and Peculiar Binaries, 3(18)2.1 m, 4(39)CF.

R. Culver, Colorado State University: Space Motions of the Barium Stars, 12(11)1 CF; Two-Dimensional Spectral Classification of Eclipsing Binary Stars, 21(159)92 cm.

S. Danford, Yale University Observatory: Atmospheric Parameters of A Stars. III. The Field Horizontal Branch Stars, 3(32)2.1 m, 7(69)CF, 3(28)1.3 m, 5(249)92 cm, 5(224)91 cm.


J. Davis, University of Wisconsin: OAO-2 Photometry of M31 and M33, 8(63)41 cm.


R. Davis, Smithsonian Astrophysical Observatory: U, B, V, H8 Photometry of Stars Observed by Celescope, 17(97)41 cm.

J. Drilling, Louisiana State University: UBV Photometry of OB+ Stars, 11(78)41 cm.

J. Dunlap, M. Howes, R. Capen, R. Taylor, and R. Sather, University of Arizona: Light Curves of Asteroids, 6(384)1 cm.

I. Epstein, Columbia University: Spectral Scans of Short-Period Variables, 14(56)92 cm.

F. Fekel, University of Texas at Austin: Spectroscopic Investigations of Possible Multiple-Star Systems, 4(14)CF.

J. Frogel, S. Persson, and M. Aaronson, Harvard College Observatory: Infrared Study of Stellar Populations in Galactic Nuclei, 10(47)2.1 m.

M. Gisser, Goddard Space Flight Center and J. August, Ball Brothers Corp.: Photometric Measurements on Comet Kohoutek, 2(20)41 cm.

J. Goad, Center for Astrophysics, Harvard College Observatory: Investigations of Noncircular Motions in Normal Galaxies, 3(33)2.1 m.

L. Goad, Harvard College Observatory: Studies of Inhomogeneities in Gaseous Nebulae, 9(86)2.1 m, 6(3092) cm, 10(6441) cm.

J. Hackwell, University of Wyoming: Spectrophotometry of Stars Using a Ga-Ge Bolometer Array, 6(52)2.1 m; with R. Gehrz, J. Smith, and B. Bopp: Infrared Studies of Supergiant Stars, 12(107)1.3 m.


M. Harwit, G. Gull, L. King, and M. Tai, Cornell University: Ten-Micron Spectra of Astronomical Objects, 9(121)1.3 m, 6(67)92 cm.

A. Heiser, Dyer Observatory: uvby Observations of Faint Stars in NGC 2244, 4(2192) cm; UBV Photometry of B Stars in Monoceros, 16(92)41 cm.

W. Hiltner, University of Michigan: Binary Incidence Among B Supergiants, 10(90)92 cm.

P. Hodge, University of Washington: Giant H II Regions in Galaxies, 8(73)2.1 m.


D. Hollars and H. Beebe, New Mexico State University: High Dispersion Ca II H- and K-Line Spectroscopy of Gem and Class Ib Supergiants, 7(56)CF.

R. Honeycutt and C. Gow, Indiana University: A Systematic Search for Diffuse Interstellar Bands in the Near-Infrared, 7(67)92 cm.

R. Humphreys, University of Minnesota: Peculiar Motions in a Section (l = 123°-128°) of the Perseus Arm, 4(41)2.1 m.

P. Ianna, Leander McCormick Observatory: UBV Photometry of McCormick Parallax Fields, 19(143)41 cm.

C. Irvine, Case Western University: A Study of Carbon Stars Whose Spectra Have Shown Merrill–Sanford Bands.
panions, 4(32).2.1 m, 4(40).92 cm.
D. Sprandell and A. Witt, University of Toledo: Surface Brightness Profiles of Dark Nebulae, 5(45).92 cm.
R. Stachnik, State University of New York at Stony Brook, D. Gezari, California Institute of Technology, J. Fienlib, S. Lipson, and P. Nisen, ITEK: Speckle Interferometry, 7(71).4 m.
P. Szekody and E. Mannery, University of Washington: The Free-Free Emission from Dwarf Novae, 7(66).1.3 m, 10(102).92 cm, 10(98).41 cm.
S. Tapia, University of Arizona: Revision of the Spectroscopic Binary HD 698, 2(4)CF.
B. Taylor, University of Washington: Red Photometry of the M67 Main Sequence, 5(41).3 m.
N. Tolk and L. Lanzerotti, Bell Labs and H. Abt, Kitt Peak National Observatory: Solar-Induced Comet Optical Radiation, 2(9)CF.
M. Ulrich, University of Texas at Austin: Red-shifts Measurements of Elliptical Galaxies Identified with Radio Sources, 10(71).2.1 m.
A. Upgren, Wesleyan University: Photoelectric Photometry of Late-Type Dwarf Stars, 8(40).92 cm.
W. Van Altena, Yerkes Observatory: Measurement of Luminosities, Transverse Velocities, and Spatial Distribution of Very Faint Stars and for Exposure of Each Epoch Proper-Motion Plates of Selected Clusters, 4(36).4 m.
D. Weedman, Dyer Observatory: Photometry of Cluster Galaxies, 13(91).1.3 m.
D. Weistrop, Ohio State University: Intermediate Galactic Latitudes, 8(54).1 m.
R. White, Yerkes Observatory: A Study of the Ursa Major Cloud of Galaxies, 5(38).2.1 m.
A. Whitford, Lick Observatory: Observation of the Strength of the Wing of the Balmer Band in the Radiation of Giant Elliptical Galaxies, 6(59).2.1 m.
R. Wing, Ohio State University and J. Smak, Institute of Astronomy in Poland: Bolometric Magnitudes of Late-Type Stars, 7(11).92 cm, 12(69).91 cm.
A. Witt, University of Toledo: Photoelectric UVB Star-counts, 5(34).91 cm.
E. Woodward and D. La Poma, WM. Paterson State College and B. Gill, University of California at San Diego: Photoelectric Photometry of Eclipsing Binaries, 24(170).91 cm.
A. Young and J. Schad, California State University at San Diego: Search for Ap Stars in Galactic Clusters, 5(54).2.1 m; with C. Rossow and P. Etzel: Chromospheric Activity in Late-Type Spectroscopic Binaries, 4(7)CF; Frequency of Occurrence of Short-Period Binary Stars Among G-K Subgiants, 10(79).CF.
M. Zellik and E. Wright, Harvard College Observatory and D. Kleinmann, Smithsonian Astrophysical Observatory: Spatial Mapping of H II Regions and Comet Kohoutek, 5(325).1.3 m.
R. Zinn, Yale University Observatory; Spectroscopy of Giant Branch Stars in Globular Clusters, 10(44).2.1 m.

Visiting observers who used the facilities of the McMath Solar Telescope on Kitt Peak are listed below with a brief description of their research programs.

Apollo Telescope Mount (ATM): Daily Magnetograms in Cooperation with NASA.
A. Betz, M. Johnson, R. McLaren, and D. Peterson, University of California at Berkeley: Heterodyne Interferometer.
J. Breekinkridge, University of Arizona: Coherence Interferometer.
T. Connell, University of Texas at Austin: Determination of Solar Macroturbulent Velocity Fields from Weak High-Excitation Lines in the Solar Spectrum.
R. Falciani, Osservatorio Astronomico Capodimonte, Naples, Italy: Measurements of Photospheric Polar Equator Differences.
H. Holweger, Institute for Theoretical Physics, Kiel, West Germany: Fraunhofer Lines in Nonactive Regions.
C. Kumar, Howard University: UV Integrated Solar Spectrum.
B. Lites, Observatoire de Geneve, Switzerland: High-Dispersion Spectra of Metal Lines in Alpha Persei.
P. Mutschlechner, University of Indiana: Studies of Composition and Structure of the Solar Atmosphere; Small-Scale Structure of Granulation.
R. Noyes, Smithsonian Astrophysical Observatory: Skylab Oscillation Program.
M. Schwarzschild, Princeton University: Small-Scale Structure of Granulation; Spatial Interferometry of Solar Granulation.
A. Title, Lockheed Solar Observatory: Vector Magnetic Fields in Sunspots and Sunspot Groups in Conjunction with Skylab.
N. Tolk, L. Lanzerotti, and S. Neff, Bell Laboratories: Solar-Wind-Induced Comet Optical Radiation.
R. White and J. Leibacher, High Altitude Observatory: Packet Structure of the Five-Minute Oscillation.

Many visiting observers and the following visiting scien-
tists used the Grant Comparator and/or the PDS Microphotometer during FY 74: L. Bautz, Northwestern University; R. Carswell, University of Arizona; E. Craine, University of Arizona; C. Dahn, U. S. Naval Observatory in Flagstaff; R. Day, University of Texas at Austin; Dr. Fair, Hale Observatories; U. Fink, University of Arizona; J. Fountain, University of Arizona; V. Grace, San Diego, California; C. Jewsbury, University of Arizona; K. Johnson, University of Arizona; D. Kurtz, University of Texas at Austin; R. Messina, Dartmouth College; R. Peterson, Harvard University; E. Ramberg, University of Arizona; L. Ramsey, Sacramento Peak Observatory; M. Ruda, University of Arizona; F. Schweizer, Hale Observatories; P. Smith, University of Hawaii; J. Thomas, University of Michigan; L. Thompson, University of Arizona; A. Vaughan, Hale Observatories; L. Van Eps, University of California at Berkeley; C. Vesely, University of Arizona; G. Wlerick, Observatoire de Paris, France.

During FY 74 the CDC 6400 was used by the following visitors as well as by many visiting observers: P. Aanestad, University of Arizona; D. Ahmad, University of Arizona; R. Brinkman, Lunar Science Institute; R. Brown, Harvard University; F. Chaffee, Smithsonian Astrophysical Observatory at Amaodo; A. Dinger, University of Wisconsin; R. Dukes, University of Arizona; D. Dunham, University of Texas; J. Geary, University of Arizona; P. Goldreich, California Institute of Technology; J. Kirk, University of Toledo; O. Kriekke, Seattle Pacific College; R. Kurucz, Harvard College Observatory; W. Lennard, California Institute of Technology; J. Mahaffey, University of Colorado; M. Price, Planetary Science Institute; R. Thompson, University of Arizona; T. Weeke, Smithsonian Astrophysical Observatory at Amaodo.

III. CERRO TOLOLO INTER-AMERICAN OBSERVATORY

A. Personnel Notes

Staff Changes: Dr. B. Lasker was named Astronomer with tenure; and N. Walborn was appointed Assistant Astronomer. G. Newman was appointed Director of Administrative Services; R. Nagel was appointed Supervisor of the Advanced Technical Applications Group; and K. Abdel-Gawad Mechnical Engineer. P. Schaller, B. Frazier, and B. Grundseth were appointed as scientific and applications programmers, with C. Barber being named Senior Computer Programmer and Head of the Computing Department. B. Jorgensen was named Associate Engineer–Physicsist; C. Javurecek, Electrical Engineer; and J. Herring, Electrical Technical Associate. S. Williams was appointed CTIO school teacher. D. Conrad was appointed Head of the Machine Shops. S. Clapp and A. Mikeizell were, respectively, appointed Head and Assistant CTIO Liaison Officers at KPNO headquarters in Tucson, Arizona. G. Ingram and E. Figueroa assumed the respective positions of Mountain Superintendent and Head of Tololo Support Services which they had discharged previously on an acting basis. F. J. Matte became the CTIO Purchasing Agent. Retirements were attained by Senior Mechnical Engineers D. J. Ludden and W. W. Baustian; Purchasing Agent, V. Glasinovic; and Liaison Officer, R. Baker, the latter for medical reasons. Resignations were received from Senior Computer Programmer, S. Bracker; Senior Electrician, H. Seeberger; Associate Engineer, R. Aikens; and Instrument Maker and Head of Machine Shops, M. Robertson. The last two individuals received appointments at KPNO.

B. Committee Meetings

A majority of the AURA Visiting Committee, chaired by Dr. J. Jefferies and including E. M. Burbidge, J. W. Evans, J. Gaustad, R. Giacconi, W. Golden, and R. B. Leighton visited CTIO 21–23 January 1974 to hear reports on the operations of the AURA observatories with emphasis on CTIO, to inspect the CTIO facilities, and to advise AURA on various aspects of the operations and possible problem areas.

On 3 June 1974 a committee including Dr. S. C. B. Gascoigne, Dr. R. Shack, Dr. R. Shannon, and Dr. A. Vaughan plus KPNO and CTIO staff scientists Dr. V. Blanco, Dr. L. Goldberg, Dr. J. Graham, and Dr. R. Lynds met at KPNO headquarters to review the status of the primary mirror for the CTIO 4-m telescope. A report on the polishing of the mirror was given by N. Cole. The committee decided that an excellent optical figure had been achieved but recommended further mirror polishing to remove a slight residual astigmatism before the mirror was shipped to Chile. (See item D below.)

C. CTIO Reorganization

During FY 74, a reorganization of the Observatory was instituted. As Director of Administrative Services, G. Newman supervises three major support groups as follows: (1) Facilities Support which provides all logistic and technical services required in the operation of the facilities at Cerro Tololo; (2) Administrative Support which provides accounting, payroll, personnel, and purchasing services as well as operations and maintenance of the La Serena facilities; and (3) Associated Support which provides Engineering, Legal, representation services required in Santiago, as well as liaison with the KPNO offices. A Director’s Office Support group headed by J. Munoz provides library, scientific secretarial pool, and radio–tele communications with KPNO headquarters in Tucson. In addition, a Stellar Program with Dr. P. Osmer as advisor has been implemented to provide special scientific services required by visitors and staff in connection with the use of the CTIO telescopes and auxiliary instrumentation, and an Advanced Electronic and Computer Applications Program with Dr. B. Lasker as scientific advisor was implemented to develop at CTIO specialized advanced instrumentation that is not practicable to develop at KPNO headquarters. Assistant Director J. Hesser continues to help the CTIO Director in various aspects of the observatory operations and serves as scientific advisor for the Director’s Office Support group.

D. Instrumentation

4-m Telescope: The mounting of the telescope was erected under the engineering supervision of A. Abraham of KPNO and A. Bird as the CTIO resident supervisor of the erection. Dr. J. Graham acted as scientific advisor for the project. The primary mirror for the telescope was finished at the KPNO optical shops under the supervision of N. Cole. Preliminary reduction of the final optical tests prior to shipment of the mirror to Chile shows a light concentration of 81% to 0.3 arc sec, and 100% at 0.6 arcsec with a root mean square of less...
than 0.09A from the theoretical figure of the mirror, and no residual astigmatism. Installation of the mirror on the mountain is programmed for September 1974, after which numerous engineering tests on the performance of the telescope are scheduled.

Yale I-m Telescope: The f/10 Ritchey-Chrétien astrometric reflector of Yale University was transferred from Bethany, Connecticut, installed at CTIO, and preliminary observations were initiated during FY 74. Dr. J. Hesser acted as scientific supervisor of this project.

Auxiliary Instrumentation: (1) An ultraviolet-transmitting objective prism yielding specially low dispersions was fabricated and made available for use with the University of Michigan Curtis-Schmidt telescope. The prism is useful for the detection of special spectral class groups to mB = 16.0. (2) A Grant Measuring Engine for spectral measurements and microphotometry was installed in La Serena. A new Coude camera producing a reciprocal dispersion of 18.6 A/mm with a 600/mm grating was installed in the Coude spectograph of the 1.5-m telescope. (4) A Dacartec 6024-S computer was put into operation in La Serena and the old IBM 1130 computer was retired from service.

E. Staff Research

V. M. Blanco has obtained a series of sky-limiting exposures of the Large Magellanic Cloud with nitrogen-baked IIIa-J plates under conditions of extremely good seeing to prepare a high-resolution composite photograph covering an area of 9° x 9°. The Curtis-Schmidt telescope was used and stars to magnitude 21.5 were photographed. He also designed the small-dispersion objective prism for the Curtis-Schmidt telescope mentioned earlier. In collaboration with O. Hansen he carried out a near-infrared spectroscopic survey of 21 unidentified infrared sources found by Price and rated as yielding definite signals. The proportion of M- and C-type stars found to agree in position with the infrared sources is similar to that found for other infrared surveys.

J. A. Graham has carried out a photometric study of 81 RR Lyrae stars in a field 1° x 1° in the Small Magellanic Cloud. The frequency of the mean apparent magnitudes of these stars peaks sharply at V = 19.6 and B = 20.0. With the best current estimate of the SMC distance, this corresponds to a mean absolute visual magnitude of +0.6 ± 0.3. A further interesting result is that, viewed as a group, these SMC variables resemble the RR Lyrae stars in the Leo II dwarf spheroidal system much more than the variables in any Galactic globular cluster or in the Galactic disk halo. Graham also completed B and V photoelectric photometry of 100 Sc I galaxies, previously selected for velocity observations by V. Rubin and W. K. Ford (Carnegie Institution of Washington). The photometry has now been reduced and the results are being analyzed. A study of southern galaxy chains has been initiated. Photographs and spectrograms are being obtained of a number of new groups recently identified from Schmidt telescope surveys. These will be used as basic material for a study of the population and dynamical characteristics of a sample of such systems.

O. L. Hansen is pursuing a long-range project of simultaneous infrared (10-20µ) and visual (BVR) photometric measurements of a large sample of asteroids. The purpose of the project is to obtain the sizes and albedos of enough asteroids to permit statistical classification. In addition, broad-band spectra between 8 and 25µ are being obtained of the brighter asteroids in order to investigate possible non-blackbody emission.

At shorter wavelength (1.5-3.5 µ), Hansen has followed up on the survey results from Hansen and Blanco by obtaining photometric measures of a group of very red stars which, according to the survey, appears to have spectral types too early to be so red.

In collaboration with E. E. Becklin, G. Neugebauer (CTI), and H. Kieffer (UCLA), Hansen has worked on an absolute calibration for 10- and 20-µ flux measurements. The calibration combines spacecraft measures of Mars with ground-based measures of several "standard" stars as well as Mars.

Hansen has also devised and applied a new technique for measuring the surface temperature of the planet Mercury. The technique, which is independent of calibration and emissivity, relies on Mercury's large orbit eccentricity.

J. E. Hesser, in collaboration with F. D. A. Hartwick was engaged in the following programs. (1) A color-magnitude diagram to V ≈ 19.0 of the metal-rich globular cluster NGC 104 (47 Tuc) was prepared from new photoelectric and spectrographic observations of 180 stars, 40 of which were below the turnoff from the main sequence. A photographic luminosity function for the cluster was also obtained from data covering some 1500 stars. Age estimates and a review of the available metallicity data support the conclusions reached by Eggen, Lynden-Bell, and Sandage in regard to the galactic collapse and the formation of the galactic halo. (2) Extensive DDO intermediate-band photometry of stars in Hyades-age open clusters (NGC 2660, NGC 2477) and in metal-rich globular clusters (47 Tuc, NGC 6304, 6352, 6441), as well as in ω Cen, has been carried out and the results are being analyzed. These data will hopefully provide a more quantitative picture of the process of metal enrichment in the earliest stages of the formation of our galaxy. (3) Numerous faint foreground early-type stars selected on the basis of objective prism Schmidt plates of the above-mentioned clusters are being carried out in the four-color Hβ system, in order to provide the best possible estimate for the reddening of these objects. (4) Four-color and Hβ photometry for main-sequence stars in NGC 2477 has confirmed many of the previous findings concerning reddenings and magnitude scales for this important southern hemisphere open cluster. A discrepancy found between [Fe/H] inferred from mB (main-sequence) and CN (giants) measured to the investigation of rotational velocity effects on the data, and to the suggestion that the main-sequence stars in NGC 2477 may have V sin i > 200 km/sec.

In addition, Hesser has found two carbon stars near NGC 2477 whose possible membership in this open cluster is under investigation. The period of the 71-sec variation of DQ Her has been investigated in collaboration with Herbst and Ostricer. Observations of some 107 cycles from 1954 to 1971 show an extreme stability of the period compared to expected damping or evolutionary time scales, a result that suggests a rotational interpretation of the periodic variations. Hesser has also collaborated with N. Walborn in the study of interstellar calcium absorption features in Eta Carinae.

W. E. Kunkel analyzed photometric data for UV Ceti and found a low-level (10^8 Hz) random ultraviolet light variation that is apparently not associated with flare activity. The star Wolf 630 appears to show a periodic variation in flare activity coupled with the orbital period. A review of published data on flare stars of type dMe suggests that the young flare
stars in the solar vicinity are younger than those in the Hyades and that the oldest have ages comparable to that of the Galaxy. Duplicity appears to prolong the flare-active phase of stellar evolution. Photometric scans in sky areas free of stars with $W < 18$ have been carried out by Kunkel in an effort to detect the red dwarf component of the galactic halo. In the scans, features correlating with TiO bands shown by dwarfs later than $K3$ are searched for. Preliminary results indicate that these features are very weak, even for scans made close to the galactic bulge. Kunkel has also continued his observations of an equatorial set of standards for $BVRI$ photometry, and photometric standards of stars with different abundance are also being established to be used in the calibration of observations with a vidicon tube. In collaboration with S. Demers Kunkel is engaged in a search for variables and in establishing a $BVI$ color–magnitude diagram for the dwarf Fornax galaxy. Material is being gathered also for similar work on the Sculptor and Reticulum dwarf galaxies.

B. M. Lasker has pursued the observations of objects of potential variability on a time scale of milliseconds. The results from this program show invariance within well-determined limits for HD 77581, the supernova in NGC 5253, SMC X-1, and Cen X-3. In various phases of these studies Lasker has collaborated with R. H. Miller, J. E. Hesser, S. Bracker, and C. Pennybacker. Lasker will continue this program as interesting candidate objects appear, and the new Datacraft computer facility in La Serena should serve to decrease the long delays associated with previous reductions.

Following the new work of Vaughan and McAdam on the position of the Vela pulsar, Lasker restudied his old data and observed "star A" again. The conclusion that this object is invariant at the $1\%$ level stands.

With Hesser and Osmer, Lasker reported the resolution of 29.08- and 30.15-sec oscillations in the blue variable CD-42° 14462, and suggested that the observations are best interpreted as G-mode oscillations on one member of a white-dwarf binary system. Further analytical work on this and other white-dwarf systems is being done following the recent completion of a new set of programs for the La Serena Datacraft computer.

Lasker also continues to observe the small number of lunar occultations for which stellar diameters are obtainable; the data reduction is in progress.

P. S. Osmer has been surveying spectrophotometrically the brightest early B-type supergiants in the Magellanic Clouds. He finds definite evidence for a systematic difference between the SMC stars and their counterparts in the LMC and the galaxy in that the SMC stars have weak lines of Si, N, O, and possibly C and Mg. Since the strengths of the hydrogen and helium lines and the ionization of silicon are consistent with the color and known luminosities of the SMC stars, a metal deficiency on the order of a factor of 4 is the most likely explanation of the line weakening. This constitutes the most direct evidence obtained so far for a difference in composition between the SMC stars and the ones in the LMC and the galaxy. Osmer and W. A. Hiltner extended their spectrophotometric study of binary x-ray sources to the recently identified optical companions of SMC X-1 and Cen X-3. SMC X-1 is as powerful as any known binary x-ray source. Cen X-3 is the only x-ray pulsar with a massive companion, and the orbit of the x-ray object is known from observations of the x-ray pulses. For SMC X-1, Osmer and Hiltner spectrograms show variable emission of the He II A4686 line which has a large (semi-amplitude 260 km sec$^{-1}$) velocity variation and is approximately in phase with the x-ray object. Evidence for orbital motion of the primary is also found. The available data implies that the mass of the x-ray object is about 2M$_{\odot}$, which is consistent with its being a neutron star. Although Cen X-3 would be the ideal system for investigating the origin of the A4686 emission, since the x-ray orbit is known, the observations show that whatever emission is present will be difficult to separate from the component produced by the optical companion. They derive a spectral type of O6–O7 and an intermediate luminosity class for the primary, which makes it hotter than previously thought. Since the mass function is available from the x-ray orbit, it is possible for the first time to derive a fundamental value for the mass of the early-type primary in an x-ray system (the only other x-ray pulsar, Her X-1 occurs in a system of much lower mass). In conjunction with J. A. J. Whelan, Osmer and Hiltner show that the mass of the primary, 18 M$_{\odot}$, is less than half that expected from standard evolutionary models of stars with its luminosity and spectral type. The 1.5 M$_{\odot}$ value found for the x-ray pulsar is consistent with it being a neutron star. The lower than expected mass of the primary means that it is premature to conclude that x-ray sources such as 240900 – 40 and 241700 – 37 are black holes solely from consideration of the temperatures and luminosities of the primary stars.

Osmer, M. G. Smith, and D. W. Weedman have been studying activity in a wide range of southern galaxies with peculiar nuclei through photoelectric spectrophotometry of their emission-line and continuous spectra. The Seyfert galaxy NGC 1566 has the weakest Balmer line emission yet measured, whereas its spectrum is similar to the classical Seyferts. NGC 2783 is one of the brighter examples of Seyfert nuclei showing asymmetrical Balmer-line wings; the galaxy itself is a well-defined barred spiral with nearly circular arms. Observations of six Sérisc–Pastoriza spirals with hotspot or amorphous nuclei show that their Balmer-line luminosities are one to two orders of magnitude larger than those of giant H II regions but the metal enrichment appears less than what is normally found in the inner regions of spiral galaxies. Available data point to a transitory burst of star formation as the cause of the observed nuclear activity.

The peculiar galaxy NGC 5253 and the interacting galaxy NGC 2992 differ from the Sérisc–Pastoriza galaxies in that their spectra show higher excitation. The absolute level of activity in NGC 5253 is comparable to that of a giant H II region and its composition appears normal. NGC 2992 is notable for its large Balmer decrement and high Balmer-line luminosity; its activity may have been triggered by its interaction with the nearby NGC 2993.

M. G. Smith spent the first three months of FY 74 in the United Kingdom concluding his consultancy to the British Northern Hemisphere Observatory planning committee; cost- ing models and a draft of the scientific case for the observatory were completed. On his return he completed studies of Mira variables in Tertian 5 with Spinrad and Harlan, the nuclei of peculiar emission-line nuclei with Osmer and Weedman, and on old planetary nebulae with Bohuski. Smith also continued his observations of the Hydra and Centaurus cluster of galaxies, completing spectroscopy with Bautz (NSF) and photometry with Weedman of over 40 galaxies in each cluster. He also obtained preliminary luminosity profiles of selected galaxies in each cluster to enable total magnitudes to be estimated from photoelectric.
measures. Working with Osmer and Pastoriza observations for a second spectrophotometric study of peculiar emission-line nuclei have been completed. With Gull, Smith used the Fabry–Pérot interferometer to make observations of M17 at five different wavelengths with similar spatial resolution, and at identical points to a radio line-profile survey performed at NRAO. From these data a model has been derived of the behavior of the gas within and outside the region of ionizing radiation close to the exciting stars. Smith has also undertaken a survey for emission-line galaxies using the new thin prism on the Curtis–Schmidt telescope. Nearly 100 emission-line galaxies have already been found, even though winter observing in southern skies has to be confined to regions quite close to the galactic plane. At least half a dozen of these objects seem likely to be Seyfert galaxies.

N. R. Walborn has undertaken three extensive, long-range programs: (1) spectral classification of O stars in the Magellanic Clouds, to include systematic comparison with their galactic counterparts; (2) a radial velocity search for spectroscopic binaries among southern Wolf–Rayet and O stars of special interest; and (3) a systematic survey of OB spectra in the yellow–red (AA5400–6600) region.

An unexpected early result of the last program was the discovery of a broad (1800 km/sec), strong (up to nearly 30% above the continuum), and rapidly variable (time scale of hours) emission band at Hα in the spectrum of the helium-rich star Sigma Orionis E. Despite some indications of a period near 3.5 days, no binary motion could definitely be established, and the range of any velocity variation is probably smaller than about 10 km/sec. Further observations are planned for the coming season, in the hope of acquiring further insight into the nature of the phenomenon.

Considerable effort was devoted to the reduction of Cloud spectrograms of stars in the Carina nebula (NGC 3372) obtained in cooperation with J. E. Hesser which revealed the presence of spectacular structure in the interstellar Ca II lines within the nebula. As many as six components spread over 200 km/sec have been measured in a single spectrum. The profiles vary markedly over small angular distances, and a total velocity range of 330 km/sec has been observed. Stars in the outer parts of the nebula have single calcium lines, suggesting that the additional components in the inner region are formed there. The nebular emission lines are double, as previously found interferometrically by Smith and coworkers; the presence on the spectrograms of a single He I λ3889 nebular absorption line, however, with velocity in agreement with the more negative component of the emission pairs, allows one to suggest that the more positive-velocity ionized material lies beyond the stars.

F. Visitor Research Highlights

Galaxies: Fifteen observational programs on galaxies were carried out at CTIO, six of which were related to the Magellanic Clouds. During the past year, L. Aller and S. Czyzak studied ten nebulosities in the SMC and 26 in the LMC. Their data suggest similar chemical compositions in the nebulosities of the two galaxies except that nitrogen appears to be less abundant by a factor larger than 2 in the SMC. This result confirms a finding by R. Dufour. The first M-type supergiant stars to be classified in the MK system outside our galaxy were observed. Eight such stars with $M_v$ values in the range of $-6.6$ to $-7.7$ were classified in the LMC, by R. M. Humphreys. Four-color and Hβ photometry of B-type stars in the clouds was carried out by D. L. Crawford and J. V. Barnes. The data are being used to determine interstellar reddening, and distance moduli. M. F. Walker continued his program of photometry of faint stars in selected Magellanic Cloud clusters for the purpose of calibrating electronographic photometry carried out previously at CTIO. For the LMC “blue” cluster NGC 1866, an excess of $E_{B-V} = 0.05$ and a true distance modulus of $18.05 \pm 0.1$ were obtained. This modulus is appreciably smaller than is commonly accepted for the LMC.

Observations on other galaxies included 55 spectroscopic observations by G. A. Welch of bright galaxies in the field of the Fornax cluster for a study of the kinematics and dynamics of the cluster. D. W. Lovato obtained spectra with M. G. Smith obtained photographic and photoelectric data for a study of magnitudes, colors, morphology, and H II regions for some 100 galaxies in the Centaurus and Hydra clusters. V. Rubin and K. Ford continued their observation of the southern Sc I galaxies contained in an all-sky sample of such galaxies within the range $14.0 < V < 15.0$. One hundred and eighty out of 206 galaxies have now been observed and a preliminary reduction of radial velocities for 141 galaxies divided into two groups corresponding to approximately equal sky areas shows mean velocities of $5000 \pm 200$ and $6400 \pm 200$ km sec$^{-1}$. This suggests an anisotropy in the Hubble expansion for the particular group of galaxies that were studied. Diameter measures suggest that the more distant galaxies in the sample have higher velocities, but no evidence of nonrandom distributions of the galaxies in the two sky areas has been found.

Stellar Clusters and Associations: Eleven programs were carried out in this category. Over 200 stars in seven open clusters were studied by M. R. Hartoog in a survey of the frequency of Ap stars, and preliminary results indicate a deficiency of such stars. O. H. Lovato obtained spectra for classification, radial velocity, and rotational velocity determinations in six open clusters. The cluster NGC 6649 was studied photometrically by B. F. Madore. The data established an accurate period of 5.2551 days for a Cepheid variable in the cluster. Reduction of the observations will enable Madore to determine the distance modulus of this cluster.

An extensive program of photographic and photoelectric $UBV$ observations of 12 metal-rich globular clusters was continued by R. White. For selected stars in the clusters, spectroscopic and DDO photometric system observations were carried out. Blue stragglers in five globular clusters were observed spectroscopically by J. Whelan in order to determine whether all blue stragglers are binary stars. Surprisingly, four blue stragglers with well-determined cluster membership did not show radial velocity variations so that the binary mass-exchange theory of blue stragglers is not confirmed for these four stars. R. D. McClure and J. Norris studied, with the DDO photometric system, giant stars in the globular cluster NGC 362 which shows an anomalous red horizontal branch. A spread in CN strengths which correlates with a similar spread in ultraviolet excesses suggests that there is a spread of chemical abundances among this cluster's giant stars.

Galactic Structure: Fifteen programs on classical galactic structure were undertaken during FY 74. Photometric data of highly reddened globular clusters in the nuclear region of the galaxy were obtained by R. Racine for a determination of their spatial distribution. P. Jennings found numerous subgiants in the south galactic pole region in the $m_v$ range
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11–13, which corresponds to Z values of less than 1 kpc. Few such stars were found beyond Z ≈ 1 kpc. The data suggests metal deficiency for the subgiants with Z > 400 pc.

J. C. Muzzio obtained long-exposure plates with the Curtis telescope and the new low-dispersion objective prism. Areas in the region 300° < l < 360° are being surveyed for faint OB stars. The survey reaches fainter than m_p = 15. A new supernova remnant in Centaurus was discovered by N. J. Irvine and C. E. Irvine.

Stars and Interstellar Matter: Forty-three programs were carried out in this category. Approximately one-fourth of these programs had to do with the optical identification or the study of objects already identified as x-ray sources. Groups of investigators including C. Jones Forman, W. A. Hiltner, D. Mook, L. D. Petro, and W. Liller surveyed photometrically objects found within the error boxes of over 30 x-ray sources. Hiltner, Mook, and Mook concentrated on repeated observations of identification candidates for LMC X-2, Cen X-3, WRA 977, Sk 160, 2U0900 – 40, 3U1223 – 62, Cir X-1, and 3U0614 + 09 to determine variability characteristics. C. Jones Forman and W. Liller did photometry and spectrophotometry of SMC X-1, 3U0900 – 40, and 3U1700 – 40 and carried out survey studies in many unidentified sources. As described previously, W. A. Hiltner and P. Osmer collaborated in detailed studies of the x-ray binaries SMC X-1 and Cen X-3. Spectrophotometric observations of the x-ray binary HD 153919—2U1700 – 37 by P. S. Conti and A. P. Cowley showed substantial little variations in the strength of the emission line He II 4686 in contrast to other x-ray binaries where large variations have been detected. Phase-dependent variations in the P-Cygni-like profile of He I 5876 were found suggesting that the outflow of material from the Of component is disturbed by the x-ray source and that the orbital velocity of the source exceeds that of the outflow. C. R. Canizares and J. McClintock found no optical counterpart in Cen X-3 for the 4.8-sec x-ray pulsation. These investigators also searched with negative results for periodic short-time-scale fluctuations in other x-ray sources including WRA 977, 2U0900 – 40, SMC X-1, Hen 715, and NP 0532.

W. A. Deutschman and R. E. Schild practically completed an extended program of photometric UBV and Hβ observations of over 3000 stars observed in the Celestial experiment. These data will be combined with ultraviolet Celestial observations for the study of the ultraviolet properties of interstellar reddening. R. Garrison, W. A. Hiltner, and R. E. Schild continued to collaborate on the UBV photometry and spectral classification of southern stars in the Heidelberg catalogue. M. Madore classified over 500 stars in the spectral class range B6–FO. Spectral classifications with objective prism plates obtained with the Curtis telescope have been undertaken by A. Landolt for a set of equatorial selected areas. P. Keenan and R. McNeil continued their program of establishing southern MK standards.

H. M. Johnson found that the radio source G 2.4 + 1.4 contains a peculiar star immersed in what appears to be a supernova remnant. This object was earlier discarded as a candidate for the x-ray source GX 3 + 1 but it still appears to be a most unusual object. The central star in the planetary nebula NGC 1360 was found to be a subdwarf of type O4–O5 by V. Niemela Monteagudo and R. Mendez. The W Ma system V566 Oph was observed some 2000 times by B. B. Bookmyer and found to show a marked change in periodicity.

High-dispersion blue spectrograms of seven carbon stars were obtained by H. Richer. From the reversals of the Ca II H and K lines, absolute magnitudes were derived. Four of the stars are similar in luminosity to ordinary G8–K2 giants. These stars are all classical R types. The other three stars were found to be hydrogen-deficient supergiants with luminosities corresponding to class Ib. D. N. Brown, A. Rich, and W. L. Williams searched for circular polarization in the radiation of eight white dwarfs with negative results.

Filar micrometric observations of 170 close southern visual binaries were carried out by F. Holden. The micrometer used was formerly at the Lamont–Hussey Observatory and has been loaned to CTIO by the University of Michigan in order to foment the observation of southern visual binaries.

G. Telescope Allocation and Weather Conditions

During FY 74, 116 astronomers from 43 institutions made observations at CTIO. Observations were carried out on 310 nights; 89% of these were of photometric quality.

In the following listing of visiting observers and their programs, the first number indicates the number of nights scheduled, the hours of actual observing time are in parentheses, and the last figure denotes the telescope used by aperture in metric units.

L. Aller, University of California at Los Angeles and S. Czyzak, Ohio State University: Photoelectric Spectrophotometry of Gas in the Magellanic Clouds and of η Carinae, 5(451.5) m, 5(35)91 cm.

J. Bahng, Northwestern University: Variations of Hα in Be Stars, 4(33)1.5 m, 8(67)91 cm.

L. Bautz, Northwestern University, W. Forman, Harvard College Observatory, and M. G. Smith, Cerro Tololo Inter-American Observatory: Spectroscopic Study of the Hydra I Cluster (A1060), 7(651.5) m, 3(32)6191 cm.

W. Becker, U. Steinlin, University of Basel and A. Gurugehofer, University of Vienna, Switzerland: Three-Color Photometry of Six Star Fields in the Southern Milky Way, 8(546)191 cm.


B. Bookmyer, Clemson University: Photoelectric Photometry of Selected Eclipsing Binary Systems, 21(104)41 cm.

I. van Breda and D. Whittet, University Observatory, St. Andrews, Scotland: Study of the Law of Interstellar Reddening, 3(323)1.5 m, 4(18)91 cm, 5(33)914 cm.

L. Celes, Universidad Catolica de Chile: UBV Observations of Mira Stars, 53(38741 cm; with W. Kunkel, Cerro Tololo Inter-American Observatory: B, V, R, I, J Photometry of Bright Red Stars, 10(74)41 cm.

P. Conti, JILA, University of Colorado: Spectroscopic Observations of O and Of Stars, 8(821.5) m.

C. Crawford and J. Barnes, Kitt Peak National Observatory: Four-Color and Hβ Photometry of OB Stars in the Large and Small Magellanic Clouds, 6(4091 cm.

S. Danford, Yale University Observatory: (a) Atmospheric Parameters of A Stars, (b) The Field Horizontal Branch Stars, 5(50)1.5 m, 6(54)91 cm.

C. Dean, Ohio State University: Eight-Color Photometric Observations of M Dwarfs Within 10 Parsecs, 5(46)1.5 m, 3(19)91 cm.

P. Demarque and R. McClure, Yale University Observatory:  

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Photometry of Southern Stellar Clusters, 10(701) 1 m.

S. Demers, Laurentian University and W. Kunkel, Cerro Tololo Inter-American Observatory: Photometric Photometry of Giant Branch Stars in the Fornax Dwarf Galaxy, 3(201) 1.5 m.

W. Deutschman and R. Schild, Smithsonian Astrophysical Observatory: UBV Photometry of 3000 B Stars, 4(369) 1 cm, 10(82) 61 cm.

J. Drilling, Louisiana State University: (a) UBV Photometry of Luminous Stars in the Southern Milky Way, (b) Space Distribution and Motions of OB+ Stars, 2(5) 91 cm, 20(121) 61 cm, 12(754) 41 cm.


R. Garrison, David Dunlap Observatory, Canada: Spectral Classification in Globular Clusters, 5(47) 1.5 m, 2(219) 91 cm.

T. Gull, Kitt Peak National Observatory, B. Balick, University of California, Santa Cruz, and M. Smith, Cerro Tololo Inter-American Observatory: (a) Velocity Studies of Two H II Regions, (b) Interference-Filter Photometry of Galactic H II Regions and Planetary Nebulae in the Southern Hemisphere, 10(99) 91 cm.

E. Hardy, Universidad de Chile: (a) Integrated Photometric Photometry of Areas in the LMC, (b) A Study of Compact Groups of Galaxies and Peculiar Galaxies, 4(361) 5 m, 6(52) 91 cm.

M. Hartog, University of Michigan: A Search for Ap Stars in Galactic Clusters, 6(52) 1.5 m, 4(349) 91 cm, 6(48) 1 cm.

F. Hartwick, University of Victoria, British Columbia and J. Hesser, Cerro Tololo Inter-American Observatory: (a) Observations of Metal-Rich Globular Clusters, (b) The Faint End of the Stellar Luminosity Sequence, 8(82) 1.5 m, 8(72) 91 cm.

H. Helfer and P. Jennens, University of Rochester: Determination of Fundamental Properties of Distant G and K Field Giants in the Galactic Plane by Seven-Filer Photometry, 5(24) 1.5 m, 11(349) 91 cm, 8(60) 61 cm, 6(52) 41 cm.

W. Hiltner, University of Michigan and P. Osmer, Cerro Tololo Inter-American Observatory: Radial Velocity Observations of SMC 160, 10(81) 1.5 m; with L. Petro: (a) Photometric Observations of SMC 160, (b) Photometry and Spectroscopy of Southern OB Stars, (c) Photometry of Optically Identified X-ray Sources, 9(102) 91 cm, 20(846) 1 cm, 17(284) 41 cm; with L. Petro, University of Michigan and P. Osmer, Cerro Tololo Inter-American Observatory: Spectroscopic Observations of Cen X-3, 6(62) 1.5 m; with L. Petro, University of Michigan, C. Canizares and J. McClintock, Massachusetts Institute of Technology: Photometric Observations of Identified X-ray Sources and Search for Unidentified Ones, 19(117) 1 m, 8(366) 61 cm.


R. Humphreys, University of Minnesota: Luminosities of Late-Type Supergiants, 9(80) 1.5 m, 6(245) 91 cm.

R. Hunstead, University of Sydney, Australia and B. Lasker, Cerro Tololo Inter-American Observatory: Limiting Optical Studies in the Fields of Southern Radio Sources, 3(261) 5 m, 2(166) 91 cm.

N. Irvine, University of Michigan: Multicolor Photometric Photograph of a Field Containing Suspected TT Tauri Stars, 4(30) 61 cm, 2(25) 41 cm.

S. Jeffer and W. Weller, York University, Canada: Time Resolved Spectroscopy of Optical Candidates for X-Ray Sources and also Early-Type Stars, 10(121) 5 m, 5(41) 41 cm.

H. Johnson, Lockheed Missiles and Space Co.: Symmetric Galactic Nebulae, 3(35) 1.5 m, 4(209) 91 cm.

T. Johnson and R. Newburn, California Institute of Technology: Observations of Comet Encke, 4(45) 1.5 m.

C. Jones and W. Liller, Harvard College Observatory: Photoelectric Photometry and Spectrophotometry of the Optical Components of X-Ray Sources, 5(28) 1.5 m, 15(48) 91 cm, 7(00) 41 cm.

P. Keenan and R. McNeil, Ohio State University: Spectral Classification of Selected Standards, Carbon Stars and CS Stars, 4(33) 1.5 m.

A. Landolt, Louisiana State University: (a) Objective Prism Work in Selected Areas, (b) Photometric Work on Selected Variable Stars and Eclipsing Binaries, 6(326) 91 cm, 3(24) 41 cm; (c) Continued VRI Photometric Observations of Selected Binary Stars, (b) UBV Monitoring of Helium Stars, (c) Coude Spectroscopy of SV Centauri, 1(10) 1.5 m, 15(116) 61 cm, 6(326) 91 cm, 4(44) 41 cm.

O. Levato and S. Malaroda, Universidad de La Plata, Argentina: (a) Binarnism and Rotation of Southern Galactic Clusters and Association, (b) Spectroscopic Studies of B8-FO and GO-KO Stars, 7(47) 1.5 m, 12(118) 91 cm, 12(82) 41 cm.

W. Liller, Harvard College Observatory: Photoelectric Photometry of Suspected Optical Counterparts of X-Ray Sources, 10(81) 91 cm, 7(04) 41 cm; with M. Liller: A Photometric Study of NGC 6624, 8(38) 1 m.

G. Lockwood, Kitt Peak National Observatory: (a) Near Infrared Photometry of Infrared Stars, (b) Near Infrared Photometry in a Heavily Reddened Cluster in Ara, (c) Near Infrared Photometry of Bright Southern Miras, 6(329) 91 cm, 7(38) 41 cm.

B. Madore, David Dunlap Observatory: Variables in the Open Cluster NGC 6649, 5(39) 1.5 m, 5(42) 1 cm.

R. Mendez and V. Monteagudo, Instituto de Astronomia y Fisica del Espacio, Argentina: Studies of Wolf-Rayet and Off-Planetary Nebulae, 3(361) 5 m, 5(55) 91 cm, 8(91) 41 cm.

E. Miller and B. Bok, University of Arizona: Photographic and Photometric Observations in the Vela-Puppis Section of the Milky Way, 4(351) 1.5 m, 9(73) 91 cm, 4(40) 61 cm.

D. Mook and F. Boley, Dartmouth College: Simultaneous Spectroscopic and Photometric Observations of UHURU X-Ray Sources, 4(28) 1.5 m, 4(44) 91 cm, 2(13) 41 cm.

J. Muzzio, Universidad de La Plata: A Search for Faint OB Stars in the Centaurus to Scutum Section of the Milky Way, 3(00) 1.5 m, 4(24) 91 cm, 5(396) 91 cm, 3(25) 61 cm.

R. McClure and J. Norris, Yale University Observatory: Photometry of Stars in M55 and NGC 362, 6(51) 1.5 m, 5(48) 91 cm.

R. McNeil, Ohio State University: Photometry of G, K, M Stars in the South Galactic Pole Cap, 4(33) 1.5 m, 10(62) 41 cm.

E. Newell and J. Norris, Yale University Observatory and L. Auer, U. S. Naval Observatory: Characteristics of the
Cluster Populations in Galaxies, 2(16)1.5 m, 8(64)91 cm.

J. Norris and E. Newell, Yale University Observatory and L. Auer, U. S. Naval Observatory; Coudé Spectroscopy of Early-Type Stars with Abundance Anomalies—HD 163181 and the Zeta Sculptoris Cluster, 8(67)1.5 m, 4(34)91 cm.

M. Pastoriza, Universidad Nacional de Córdoba, Argentina, M. Smith and P. Osmer, Cerro Tololo Inter-American Observatory: Spectrophotometry of Southern Emission-Line Galaxies, 4(46)1.5 m.

R. Racine, David Dunlap Observatory: Photometry of Globular Clusters, 7(10)1.5 m, 6(38)91 cm.

H. B. Richer, University of British Columbia, Canada: Ca II H–K Reversals in Carbon Stars, 6(53)1.5 m, 5(33)61 cm.

W. Sanders, New Mexico State University: Photometric Classification of Be Stars, 1(7)61 cm, 22(172)41 cm.

A. Slettebak, Ohio State University: A System of Standard Stars for Rotational Velocity Determinations, 7(78)1.5 m.

J. Tatum and J. Stilborn, University of Victoria, Canada: Cometary Spectroscopy, 4(21)1.5 m.

University of Chile: Seven advanced astronomy students received instruction from J. Hesser, Cerro Tololo Inter-American Observatory: Studies of Southern Stellar Clusters, 4(27)1 m.

T. Vives, Instituto de Astronomía y Física del Espacio: (a) Photometric Studies of Two Eclipsing Variables, (b) Photoelectric Observations of Peculiar Eclipsing Binary Stars, 27(187)41 cm.

M. Walker, University of California, Santa Cruz: (a) Photoelectric Observations of Zero-Point Stars in Selected Star Clusters in the Magellanic Clouds, (b) Reconnaissance Photographs of Star Clusters Associated with the Magellanic Clouds, 9(75)1.5 m, 4(28)91 cm.

J. Warner, Carnegie Institution of Washington: Infrared Narrow-Band Photometry of Unidentified 2.2-Micron Objects, 5(16)1.5 m, 9(57)91 cm.

D. Weedman, Vanderbilt University and M. Smith, Cerro Tololo Inter-American Observatory: Photometry of the Centaurus Cluster of Galaxies, 4(38)1.5 m, 5(59)1 cm, 2(21)61/91 cm.

W. Weiss, University Observatory, Vienna: Photometry of Magnetic Stars, 5(55)91 cm, 19(40)41 cm.

G. Welch, Wheaton College and H. Rood, Michigan State University: Kinematics and Dynamics of Southern Clusters of Galaxies, 5(45)1.5 m.

J. Whelan, University of Arizona: (a) Are Blue Stragglers Binaries? (b) The Energy Exchange Mechanism in the W UMa System, TW CET, 11(84)91 cm.

N. White, Lowell Observatory: Near-Infrared Photometry of M Supergiants, 13(56)61 cm.

R. White, University of Arizona: Spectroscopic and Photometric Observations of Stars in Certain Southern Globular Star Clusters, 5(40)1.5 m, 10(100)91 cm, 4(42)61/91 cm, 6(60)61 cm.

W. Williams and A. Rich, University of Michigan: (a) Search for Circular Polarization in White Dwarfs, (b) Observation of Stars with Large Infrared Excess for Circular Polarization, (c) Search for Circular Polarization in White Dwarfs and the Nuclei of Planetary Nebulae, 13(132)1.5 cm.

B. Woodgate and J. Angel, Columbia University, and R. Kirshner, California Institute of Technology: Observations of Coronal Lines from Supernova Remnants, 17(89)41 cm.

E. Woodward, The William Paterson College of New Jersey: Photoelectric Studies of Selected Eclipsing Binary Systems, 13(134)1 m, 19(85)61 cm, 5(29)41 cm.

IV. PUBLICATIONS

KPNO and CTIO have issued Facilities Books, describing the instrumentation available to visitors and publish quarterly bulletins in which instrumental developments in programs are reported. The Facilities Books also contain details on weather statistics and scheduling policies and will be kept updated as new policies and new equipment are adopted. The Facilities Book and Quarterly Bulletins are sent free of charge to any institution which may have staff interested in using the facilities of the National Observatories.

Staff members as well as visiting scientists and graduate students who have done research at either KPNO or CTIO, and whose work was published between 1 July 1973 and 30 June 1974 are included in the following list:


Allen, D. A.—see Loer, S. J.


Andrew, B. H.—see Kinman, T. D.

Angel, J. R. P.—see Stockman, H. S.


Ayres, T. R.—see Noyes, R. W.


Barnes, J. V.—see Crawford, D. L.

Barnes, J. V.—see Crawford, D. L.

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Becklin, E. E., Hansen, O., Kieffer, H., and Neugebauer,
Beebe, H. A.—see Milkey, R. W.
Begot, J.—see Beckman, J.
Beichman, C. A.—see Dyck, H. M.
Belton, M. J. S.—see Broadfoot, A. L.
Belton, M. J. S.—see Murray, B. C.
Betz, A.—see Peterson, D.
Blanco, V. M.—see Hansen, O. L.
Boese, R. W.—see Regas, J. L.
Bosel, J.—see McCord, T. B.
Bowyer, S.—see Kumar, S.
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Bowyer, S.—see Parese, F.
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Brandi, E.—see Jaschek, M.
Brault, J. W.—see Lites, B. W.
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Capps, R. W.—see Dyck, H. M.
Capps, R. W.—see Ridgway, S. T.
Carswell, R. F.—see Weedman, D. W.
Castore de Sistore, M. E.—see Sistore, R. F.
Chapman, G. A.—see Shimokurou, F. I.
Charvin, P.—see Beckman, J.
Chetin, T.—see Jones, C. A.
Chiu, H. Y.—see Gull, T. R.
Conlin, E. K.—see Kinman, T. D.
Costero, R.—see Osterbrock, D. E.
Coucke, M.—see Hoag, A. A.
Cowley, A.—see Marlborough, J. M.
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Crawford, D. L. — see Tapia, S.

Danielson, G. E. — see Belton, M. J. S.

Danielson, G. E. — see Murray, B. C.


Davies, M. E. — see Belton, M. J. S.

Davies, M. E. — see Murray, B. C.


Dicke, R. H. — see Wickes, W. C.

Dixon, M. S. — see MacConnell, D. J.

Douglas, J. N. — see Wills, B. J.

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Dupree, A. K. — see Huber, M. C. E.


Dyck, H. M. — see Capps, R. W.

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Dyer, C. C. — see Roeder, R. C.

Edelson, S. — see Shimabukuro, F. I.

Einsenstein, J. P. — see Snider, J. L.

Elsasser, H. — see Voelcker, K.


Fibon, J. — see McClure, R. D.

Fix, J. D. — see Neff, J. S.

Flower, P. J. — see Hodge, P. W.

Forbes, F. F. — see Johnson, H. L.

Forbes, F. F. — see Thompson, R. I.


Ford, W. K., Jr. — see Rubin, V. C.


Forrest, W. J. — see Dyck, H. M.

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Frogel, J. A. — see Baldwin, J. R.

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Frogel, J. A. — see Danziger, I. J.

Frost, S. A. — see Conti, P. S.

Furenlid, I. — see Lutz, T. E.

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Gault, D. — see Belton, M. J. S.

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Goldberg, L. — see Huber, M. C. E.
Golson, J. C.—see Crawford, D. L.


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Green, M.—see Kinman, T. D.

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Hall, D. N. B.—see Beckman J.

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Moreno, H.—see Gutierrez-Moreno, A.
Murray, B. C.—see Belton, M. J. S.
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Rubin, V. C.—see Graham, J. A.

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Schoening, W. E.—see Millikan, A. G.

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