Calif Inst. Tech.

CR-59727.
Code 1
Pages - 12
Cat. 30

UNPUBLISHED PRELIMINARY DATA

SEMI-ANNUAL STATUS REPORT - NASA Grant NsG-426

1 April - 1 October 1964

The present report covers the first half of the second year of operation of NASA Grant NsG-426. Because of the rather broad variety of activities carried on under this Grant, the report is divided into a number of sections which deal with the individual investigations. A brief statement of the overall budgetary status follows the individual reports.

I. COSMIC RAYS (H. V. Neher)

Seventy-five balloon-borne ionization chamber instruments were to be made under this contract. Of these, twenty have been completed, and the remainder are completed except the final assembly of the quartz-fibre system that goes into the ion chamber. Some of the twenty were flown at Thule, Greenland during the summer. In all, six flights were made, all of which were completely successful. Before proceeding further with the remaining quartz systems, some research is needed to develop a system that is less temperature sensitive, since some flights will be made at Thule during the winter when the sun is down. A system having a temperature coefficient less than 0.01 percent per degree would be desirable and it appears that this can be achieved.

Five ionization chambers for Mariner C have been completed and delivered to JPL, two of which will be placed aboard the (two) Mariner spacecraft to be launched during the month of November 1964.

Six instruments are being prepared for POGO, which is scheduled to be launched before mid 1965. Some of these instruments have been delivered but minor faults have developed in some of the others (primarily gas leaks at the terminals of the base. These are being repaired).

II. COSMIC RAYS (R. Vogt and E. C. Stone)

During the past 6 months the buildup of laboratory facilities and instruments has progressed to a point where the major effort may now be directed toward specific cosmic ray experiments.

The present professional staff consists of two faculty members, a senior electronics engineer, a junior electronics engineer, and a technician. Four graduate students and several undergraduates are in training and participate in the work.

A new meson telescope with the necessary support electronics (nanosecond coincidence circuitry, HV distribution panels, limiters, etc.) has been built and is operating in addition to two others. Design tests of light-collection and light-piping systems for scintillation counters are under way. Also, computer programs have been written which yield energy-loss and range calculations useful for counter telescope design.

In the following we discuss briefly the major projects underway:

1. OGO-C and D

Experiment 5008 (POGO) is a joint experiment with J. A. Simpson and C. Y. Fan of the University of Chicago. The experiment packages are being constructed by Chicago, while the calibration, testing, bench checking

at STL and spacecraft integration are Caltech responsibilities. Both the prototype and first flight unit have been integrated on the S-50 spacecraft. Although some of the initial calibrations had to be carried out at Chicago by Dr. Stone, the recently completed laboratory setup at C.I.T. is now used to perform these calibrations. In addition, programs for processing the calibration data on the C.I.T. IBM 7094 have been completed and are used routinely.

2. OGO-F

More detailed design calculations and other preparatory work for the proposed OGO-F detector system (NASA SC No. 7725) have been performed. This work resulted in a supplement to SC No. 7725, proposing to extend our spectral measurements up to 15 Bev/nucleon. Also, upon request by NASA, we have submitted another addendum to SC No. 7725 with a design modification allowing the measurement of proton spectra with fluxes up to 10^6 cm^{-2} sec^{-1} sr^{-1}, which includes the largest known solar flares.

3. Balloon borne experiments

In the design of instrumentation for balloon borne experiments great attention is being given to standardization, so as to allow quick exchange of circuit elements (i.e., scalers, amplifiers, pulse-height analyzer, etc.) among different systems. Also, all experiments will use an identical magnetic data recording and readout system. We have completed the construction of an electronic storage and "BRPE" driver system for conversion of magnetic balloon data tapes to computer-compatible paper tapes. We are converting a commercial playback deck for this purpose. A number of electronic circuit elements for the balloon instrumentation have been

breadboarded and have undergone environmental tests. Many of the circuits will be similar to those designed for spacecraft applications. However, efforts are being made to substitute less expensive components wherever possible under the somewhat less stringent requirements for balloon systems.

Two balloon-borne experiments are presently under design and construction:

a) p, α, e - system

The p, α, e - system is a modified version of the proposed OGO-F system (SC No. 7725). It also includes a simple dE/dx-$\check{C}$ telescope for measuring the direction flux of protons and alphas above 400 Mev/nucleon. Parts of the detector system have been tested. Construction of the flight unit will begin shortly. We expect to launch the system for the first time in Summer 1965 at Fort Churchill.

b) Digitized spark chamber system

A completely new electronic scanning system accommodating up to 8 chambers has been built and is presently used with 3 chambers of 24 lines/inch in design tests for the optimization of spark chamber parameters. The original coincident readout of the magnetic memory core system has been replaced by a 16-line parallel readout, giving a much improved signal to noise ratio. The scan system reads into the same electronic system which is being used for conversion of balloon magnetic tapes to paper tapes. Computer programs have been written for quick analysis of spark chamber data. Investigations of magnetic memory cores resulted in the adoption of a special type (EMI, No. 51-114, 50 mil O.D.)

for optimal signal to noise ratio. Our chambers presently have single spark efficiencies of better than 98 percent. Edge-sparking, a common problem, has been eliminated by special chamber design. Design calculations for the scintillator and Čerenkov counters associated with the spark chamber system are underway. Tests of "side-view" Č-counters have been successfully completed.

4. Joint p, α, e experiment with the University of Chicago

Balloon flights were again performed in Summer 1965, and at least one good flight from both the proton spectrometer and the improved total absorption Cerenkov electron detector was realized. A more detailed analysis of data from previous years was going on at Caltech and is continuing with particular emphasis on problems of atmospheric secondaries, albedo, and interactions.

III. THEORETICAL ASTROPHYSICS (R. F. Christy)

The computational survey of pulsation in models of RR Lyrae stars (and some Cepheids) has been completed and a paper is being written.

The effects on pulsation characteristics of different values of the helium content, temperature, mass and luminosity have been explored and systematized. This work was reported at the Hamburg International Astronomical Union meeting and at the Flagstaff American Astronomical Society meeting.

The work on neutrino cross sections has been completed so that there are now available reasonable estimates of absorption cross sections for various nuclei and neutrino energies above 15 MeV.

IV. INTERPLANETARY MAGNETIC FIELDS (L. Davis, Jr.)

A considerable effort has been put into preparations for the Mariner C magnetometer experiment. The analysis of the Mariner R2 data has been carried farther and several joint papers with the other experimenters have been completed and either published or are on the verge of submission for publication. These include a study of a collision-free hydromagnetic shock in interplanetary space (Phys. Rev. Letters, 13, 153, 1964), a complete report on the magnetometer aspects of the Venus encounter, and a discussion of the magnetic structure of interplanetary space for the JPL Solar Wind Conference Report.

Work is in progress with three graduate students on various problems involving magnetic fields in the solar system. In collaboration with J. R. Jokipii, a possible explanation of the 30-50 kev electrons observed near the earth's bow-shock is being developed.

V. INFRARED ASTRONOMY (G. Neugebauer and R. B. Leighton)

During the last six-month period, the main work of the infrared astronomy group was concentrated in starting the systematic sky survey for sources emitting radiation between 2 to 2.5μ.

A third 62" epoxy mirror was poured and aluminized and placed in operation in early June. It has achieved the desired optical resolution of about 1.5 min of arc and after 4 months of use shows no appreciable deterioration.

A preliminary survey covering about 1/3 the total sky was run between June and September to evaluate the problems encountered in conducting such a

survey. From this preliminary survey, the following conclusions could be drawn:

a) With but slight modifications in the detector layout, we feel that the detector, the telescope, and the electronics are finished and ready for survey work. The instrumentation is as sensitive as anticipated and, furthermore, is useful in making specialized, non-survey observations.

b) The limit on the number of stars to be catalogued will be set by the problems of data reduction rather than the sensitivity of the telescope and detector system. At present, data is recorded on an 8-channel strip-chart recorder, whose records are scanned visually. This procedure has proved excessively time-consuming and as a result a machine, linked with the Campus 7090 computer, which automatically records the information from the strip chart is being designed and built. There are so many sources near the threshold of sensitivity, however, that even with this semi-automatic recording scheme, only sources with strengths about 6 times the minimum detectable signal can be recorded.

c) It is increasingly obvious that a prime goal of the group should be the production of a catalog of all detectable and measurable infrared objects. A complete coverage of the sky north of -33° declination should be attained in about one year time. If the present acceptance criteria are maintained the catalog should contain more than 5,000 sources.

In early September, a survey utilizing what is probably the final detector configuration and scan pattern was started. Four PbS cells,

filtered to detect K magnitudes (2-2.5μ) are scanned in a strip 40' in declination while a Si cell, filtered to measure I stellar magnitudes (0.7-1.1μ) sweeps the center 20' declination. The telescope is raster-scanned such that each night a strip 3^{o} in declination is covered, each source being observed at least twice. The accuracy in locating sources is about 0.1 min in right ascension and about 1' in declination; magnitudes can be measured to about ± 0.1 magnitudes.

A fully automatic data acquisition system in which data are recorded directly on magnetic tape which goes directly to the computer is being considered. This would enable us to catalog all stars down to our minimum detectable signals.

During the present survey about 60 stars per night are recorded. With but a small fraction of the sky scanned so far, two sources have been found which show a I-K magnitude difference of greater than $7^{m}.5$. (A typical I-K index for a class M6 star is about $4^{m}.0$). The spectra of these sources are now being studied using conventional equipment. A note describing the survey and these unusually red sources is in preparation.

In addition to the survey, continued work has gone into the development of a photometer to be used in studying infrared sources with conventional reflecting telescopes. The photometer has been field tested on the 60" telescope on Mt. Wilson and is undergoing changes mainly to increase its flexibility and ease of operation.

A copper-doped germanium cell is being installed in a Dewar in order to extend the survey to the 10-14μ region. Field tests of this system are being carried out.

VI. PLANETARY SPECTROSCOPY (G. Münch)

a) Jupiter and Saturn

The variations in strength of various molecular bands of CH_4 and NH_3 over the disk of the planets has been continued. Most of this work is based on photographic infrared material taken with the 100-inch coude spectrograph, although some photoelectric scans with the same instrument also have been obtained. Besides the zonal (meridional) variations found and reported earlier, the variations in strength of the bands along parallels as function of distance to the limbs have been studied. It has been found that not all lines and bands vary in strength in the same manner. Generally speaking, the lines vary in intensity less pronouncedly than if they arose by absorption from rays simply reflected by a cloud layer. Some of the weaker lines appear to remain sensibly constant in strength up to the closest distances from the limb where measures can be made. This can be understood only if the lines arise through diffuse reflection (multiple scattering). The different behavior of various bands and lines probably arises from their varying degree of sensitivity to pressure broadening. Approximate integrations of the relevant equation of line formation have been carried out for a linear dependence on optical depth of the ratio between the line and continuous absorption coefficients. In order to make more realistic the model integrations, it will be required to calculate model atmospheres (dependence on pressure or the density) and to obtain independent information about the scattering coefficient. The latter can be found from an interpretation of limb darkening curves in the continuum. By comparing the limb darkening measured on direct photographs taken at the coude focus of the 200-inch

telescope with broad-band filters, and theoretical curves computed for different albedos and phase functions, it appears possible at least to fix the albedo and degree of asymmetry in the phase functions. These limb darkening calculations have been carried out by Mr. C. M. Anderson, graduate student in Astronomy, in part supported by the NASA NsG-426 grant. Independently of this approach, Mr. Lawrence Trafton, also graduate student in Astronomy, has shown that the thermal opacity of the Major Planets is mostly due to the pressure induced dipole rotational absorption of H_2. Model atmospheres with this source of opacity and various compositions (helium content) are now being constructed to serve as a basis for an intepretation of what is known about the temperature structure of Jupiter's atmosphere. At a later date they will be applied to the interpretation of absorption line variations and limb darkening contours.

b) Photoelectric coude scanner

The pulse counting system for the 100-inch coude scanner is being readied for the Mars opposition. After considering various other possibilities, it was decided to follow the design of the system developed for the prime focus scanner of the 200-inch telescope. Essentially the system operates by chopping both signal and monitor channels, the "dark" pulses from the photomultipliers being subtracted from the count in the open position of the choppers by means of reversible counters.

c) Infrared coude spectroscopy (G. Münch and G. Neugebauer)

The development of the high spectral resolution system for measuring the 2.05 micron CO_2 band in Mars has been continued. A test was made at the telescope using the Moon as a source. With a slit 16 mm = 42 arc sec long, spectral scans with a resolution of 3 Angstroms

were obtained, showing clearly the rotational structure of the CO_2 band of interest with a signal-to-noise ratio around 10, with a 25 sec time constant. For the actual Mars measurement we have only to construct an image slicer which will enable us to fill a 35 mm long slit, in order to obtain a signal-to-noise ratio in Mars larger than 15.

d) Magnetic Resonance Spectrometer (G. Münch and S. Ridgway)

On July 1, 1964, Dr. S. Ridgway joined the Institute on a 2/5-time basis under the grant NsG-426 to participate in the design and operation of a magnetic resonance spectrometer using the same principle as that used by Blamont to study solar strontium lines. Here, the objective is to produce an instrument which may be used at very low light levels for a variety of stellar applications. He is now working on the design of the most suitable resonance chamber for the spectrometer. The possibility of using atomic beams in a vacuum chamber placed in the 2-inch gap of a magnet with 4-inch pole pieces was explored in detail, but in the construction of satisfactory ovens serious difficulties were encountered. For the time being a system with cells made of pyrex is being designed. These are much easier to construct within the space limitations we have set. For the alkaline-earths, however, it still appears that an atomic beam is required, which may be possible with a larger magnet. It is hoped to have the spectrometer ready for tests, with the cells, by the end of the year.

VII. INSTRUMENT DEVELOPMENT (B. Rule and E. W. Dennison)

Several projects involving the design and construction of auxiliary instrumentation for the major telescopes, particularly the 200-inch, have been underway for some time. At present, these include

1. A wide-field corrector lens for the Cassegrain focus of the 200-inch. This corrector will enable the telescope to reach its ultimate capabilities in photographically recording faint objects over a relatively wide field of about 20' arc. The lens mounting assembly is now complete, and the final optical polishing,correction, and testing of the meniscus is very near completion.

2. An observing cage for the 200-inch Cassegrain focus. This cage will be carried on the telescope and will accommodate not only the observer but also a considerable weight and volume of auxiliary optical and electronic equipment. As now planned, the cage will be about 15 ft. in diameter and will weigh about 3500 lb. A wooden mock-up has been built and tested, and the final engineering design and detailing have been started.

3. A fast, versatile data handling and readout system for the 200-inch telescope has been under development and many of its basic design features have been successfully tested at the telescope. The complete system, as currently planned, will include multiplex channels from the observing stations to permit automatic recording of wavelength of the spectrum scanner, filter wheel positions, time, telescope coordinates, and object designations as well as the intensity data that emerge from the pulse-counting system. The fundamental pulse-counting circuitry has been used in observations at the telescope on two occasions with complete success, and final design of the overall system will be undertaken shortly.

Two other activities of the instrument development group were carried on under NASA Support during the present report interval: Four seeing monitors were constructed and tested, and are essentially ready for use in testing