tation. Guest investigators are selected on the basis of a proposed observing program. It is expected that guest investigators will be involved in the operation of the experiment in real time from the experiment control center which will be located at Boulder (Colo. USA).

The launch of the experiment is scheduled for May 1973.

4. *Laboratory investigations related to astrophysics*

Under N. Coron, L.P.S.P. is also developing very high sensibility far IR detectors of the cooled bolometer type. A star detectivity of $5 \times 10^{12}\ W^{-1}\,cm \times \sqrt{Hz}$ is currently achieved. Observing programs of astrophysical interest are in progress in cooperation with Dr. P. Lena at Meudon observatory. Let us quote in particular, the observation of the Galactic Center from a plane in the submillimetric range.

APPENDIX II

DEVELOPMENT OF NEW INSTRUMENTS AND TECHNIQUES IN THE SOLAR SATELLITE PROJECT AT HARVARD COLLEGE OBSERVATORY

A. Dalgarno

The solar satellite project is currently engaged on the development of the following flight instruments:

1. A sounding rocket spectrometer to study the emission from the quiet sun in the wavelength range 1550 Å to 1660 Å with a resolution of 0·03 Å. This instrument was flown successfully on July 27, 1972, and a further flight after modification is planned for February 1973 to study the wavelength range from 1850 Å to 2300 Å with a resolution of 0·06 Å.

2. An extreme ultraviolet (EUV) spectroheliometer to be flown on the Apollo Telescope Mount (ATM) of the Skylab space station which is scheduled for launch in May 1973. This instrument is designed to obtain up to seven simultaneous spectroheliograms in the range 280 Å to 1340 Å with a spatial resolution of 5 arc sec., as well as spectra with a resolution of 1·6 Å over the same wavelength range.

3. Three sounding rocket spectroheliometers to be flown as part of the calibration program for the Skylab spectroheliometer. These instruments will cover the same wavelength range and have the same spectral resolution as the Skylab instrument and will be used to re-establish its photometric calibration by simultaneous measurement of the emission from a quiet area near the center of the solar disc. The three calibration flights are currently planned for the manned periods of Skylab operation during May, August and November 1973.

The laboratory program supporting these photoelectric flight instruments has been aimed at improving the quality of the standards available for photometric calibration over the wavelength range 300 Å to 2500 Å and also at developing detectors of increased sensitibity and stability over the same wavelength range. The aim of the laboratory calibration program is to establish an absolute photometric accuracy for the rocket instruments of better than $\pm 10\%$ during flight and to attempt to maintain a similar accuracy for the satellite instrument during the orbital lifetime. For this purpose, a series of laboratory standards are being developed having pedigrees directly traceable to the National Bureau of Standards. The standard light sources used in the laboratory are Eppley total irradiance tungsten filament lamps emitting in the visible and 'Penray' mercury lamps used in conjunction with interference filters at 2537 Å. A Samson type, rare gas, double ionization chamber is used as the absolute standard detector at EUV wavelengths and a Reeder gold-black thermopile is used as a primary standard detector to transfer a calibration from the visible standard sources to the EUV detectors. Transfer standards in use are open tungsten diodes for the wavelength range 300 Å to 1400 Å and a sealed Spicer Cs-Te diode with a MgF_2 window for the wavelength range

1160 Å to 2500 Å. Bendix and Mullard open structure cone channel electron multipliers have also been used as transfer standards in the wavelength range 300 Å to 1400 Å although they are not completely satisfactory for this purpose. No suitable secondary standard photomultiplier has yet been developed for use in the wavelength range 1400 Å to 2500 Å. The sealed Spicer diode and a set of open Al–Al_2O_3 diodes are used to transfer calibrations between the NBS and HCO laboratory standards.

The laboratory studies of detectors are being undertaken with three major objectives:

1. To develop stable secondary standard photomultipliers for the wavelength range 300 Å to 2500 Å having cathode uniformities equal to those of the standard diodes.
2. To develop stable, high efficiency, open structure photomultipliers for use in flight instruments.
3. To develop position sensitive open structure photomultipliers for use in future flight instruments of improved optical design.

As part of the first objective, the performance of a number of open structure channel electron multipliers produced by Bendix, EMR, and Mullard has been evaluated in the wavelength range from 300 Å to 1400 Å. Since none of the devices so far tested proved completely suitable for use as a secondary standard investigations are still proceeding with special emphasis being placed on the use of micro-channel array plates. These devices produce a saturated output pulse height distribution when two plates are used in cascade and hence are suitable for use in a pulse counting mode identical to that of the single channels. Several sealed photomultipliers for the wavelength range 1160 Å to 2500 Å are also being evaluated. As in the case of the open multiplier, no device so far tested has proved suitable for use as a secondary standard.

In an attempt to improve the efficiencies of available open structure multipliers at short wavelengths (less than 700 Å) the photoelectric yields of MgF_2 and LiF have been measured in the wavelength range 461 Å to 1216 Å. Peak values of 43% and 34%, respectively, were obtained with 2000 Å thick samples at wavelengths around 550 Å and at 45° angle of incidence. Since the stability of the MgF_2 photocathode appeared to be equal to that of conventional metallic and semi-conducting cathodes, it was concluded that MgF_2 would be a practical, high efficiency photocathode for use at short wavelengths in the extreme ultraviolet. An added advantage in the use of MgF_2 is the very low photoelectric yield at wavelengths longer than 1200 Å. This is particularly important for reducing scattered light background levels in solar experiments on sounding rockets and satellites. Accordingly, the cathode of a channel electron multiplier of the type to be used in the calibration rocket spectroheliometer was coated with a 3000 Å thick layer of MgF_2. This produced no significant deterioration in the electrical properties and increased the sensitivity by factors of 1·62, 2·76 and 2·60 at wavelenghts of 742 Å, 584 Å and 461 Å respectively. Studies of the long term stability are continuing; however on the basis of the current data it is expected that MgF_2 coated detectors will be used in future instruments on both sounding rockets and satellites.

Finally, studies are being undertaken to develop a position sensitive detector for use at extreme ultraviolet wavelengths. The system currently being evaluated consists of two micro-channel array plates in cascade coupled to a linear array of 64 individual collectors. These collectors are connected via a charge distribution network to a pair of charge sensitive amplifiers and a charge quotient circuit. This system produces output pulses having amplitudes proportional to the position in the array at which they are detected and is thus equivalent to an assembly of 64 single channels. The present spatial resolution is expected to be better than 200 micron using array plates constructed of 40 micron channels. Future developments will be aimed at improving the spatial resolution to 20 micron or less and expanding the system to a two-dimensional array of 64 × 64 elements. Such a system would be employed in a stigmatic extreme ultraviolet spectroheliometer to provide simultaneous spatial and spectral information at right angles to, and in the plane of dispersion of the diffraction grating, respectively.

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APPENDIX III

A REVIEW OF SCIENTIFIC RESULTS FROM OAO-2

A. D. Code, B. D. Savage

Introduction

The Orbiting Astronomical Observatory-2 (OAO-2) has been successfully carrying out astronomical investigations in the ultraviolet since launch on December 7, 1968. Earlier reviews of preliminary data analysis have been presented in 04.061.031; 02.113.027; 02.113.033; 06.013.009. In this discussion, data obtained with the University of Wisconsin photometric instruments are presented. The discussions are primarily concerned with data analysis involving University of Wisconsin astronomers. Numerous results obtained by OAO guest investigators can be found in the Proceedings of The OAO Symposium (1) held in Amherst, Massachusetts, August 22–23, 1971.

The OAO spacecraft, operating above the ultraviolet absorbing layers of the earth's atmosphere, provides the capability of pointing telescopes to approximately one minute of arc in the direction of any selected celestial object and maintaining that pointing to approximately one second of arc. In addition, the spacecraft provides command and data links with the ground control stations. It is in every sense a versatile astronomical space observatory. The observatory contains instrument packages from the University of Wisconsin and from the Smithsonian Astrophysical Observatory.

The Wisconsin equipment consists of five telescopes employing photoelectric filter photometers over the spectral region from approximately 1200 Å to 4000 Å, and two objective grating scanning spectrophotometers. The spectrophotometers provide a spectral resolution of about 10 Å from 1100 Å to 2000 Å and 20 Å resolution in the region from 2000 Å to 4000 Å. The photometric accuracy and long term stability of most of these instruments has been exceptionally good. Details of instrumental operation and reliability can be found in Code *et al.* (04.113.017).

One of the major objectives of OAO-2 was to determine the spectral energy distributions of stars in the ultraviolet. Ultraviolet magnitudes for a large number of stars of diverse types are provided by the OAO filter photometers. Such information will provide basic data for determinations of stellar effective temperatures, bolometric corrections, chemical composition, and inter-stellar extinction. This information will ultimately be provided in the form of a catalog of ultraviolet magnitudes. Note the very large range of ultraviolet magnitudes for stars of different types. The $(1700-V)_0$ color changes approximately 10 magnitudes for every 1 magnitude change in $(B-V)_0$ color. Since the photometric accuracy of the OAO-2 ultraviolet measurements is comparable to that of the $B-V$ determinations, the ultraviolet color provides a much more sensitive measurement of the

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