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SUBMILLIMETER OBSERVATIONS OF SOLAR LIMB-BRIGHTENING IN THE TOTAL SOLAR ECLIPSE OF 31 JULY 1981

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Final Technical Report

Submillimeter Observations of a Total Solar Eclipse

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I. INTRODUCTION

This report is a brief outline of the results of the Submillimeter Solar Program conducted by the KAO in July 1981. We will briefly outline the scientific results of the program in this section, and in the next section discuss some of the technical problems which we and the KAO crew addressed to allow the KAO to undertake solar observations.

A total of 8 flights of the KAO were devoted to solar observations in this program, the last flight in which was accomplished the successful observation of a total solar eclipse. The observations were made simultaneously at 30, 50, 100 and 200 microns, wavelengths which are inaccessible from the ground. The only other solar data collected in this band heretofore has depended on a few balloon observations using somewhat smaller telescopes than the KAO 0.9 meter. The successful adaptation of the KAO for solar observations thus has allowed us to acquire the most detailed data to date in this spectral band.

The results which have emerged from a preliminary analysis of the KAO data can be summarized by four main points: (1) The 200 micron limb is extended about 3 arc sec above the 30 micron limb. This result, which was obtained by observing the solar limb occultation during eclipse, indicates the presence of cool dense material up to the altitudes of spicules, well above the heights predicted by smooth chromospheric models. (2) Strong radial darkening of the quiet sun intensity profile appeared at 200 microns, where smooth model atmospheres predict weak limb brightening. This is probably an indication that hot material in the low chromosphere is recessed into vertical magnetic flux tubes embedded in a colder non-magnetic substrate, which obscures the heated material approaching the limb. (3) Active regions were observed to undergo a strong increase in contrast above the quiet sun background at wavelengths of 100 microns and longer. (4) The moon was mapped for use as a photometric standard for determining the absolute intensity of the sun in all four wavelength bands.

The importance of the 30-200 micron continuum stems from the fact that most of the radiation in this band emanates from the low chromosphere where non-radiative heating of the solar medium first becomes of major significance. The fact that the continuum forms in LTE with the electron temperature, and that the source function is proportional to this temperature in accordance with the Rayleigh-Jeans Law makes the submillimeter continuum a direct and extremely useful tool for studying the temperature structure of the solar medium.

II. TECHNICAL ASPECTS

A number of adaptations were necessary to enable the KAO to do solar observations. The main problem was proper attenuation of visible light to protect the optics of the telescope and finders from focused visible sunlight. The latter problem was solved mostly by using a series of neutral density filters and aluminum-coated mylar at the aperture and focal plane positions of the finder and tracker. The apertures of both finder and tracker were stopped down to about 1 inch. A filter in the focal plane of the finder was removable, allowing the viewing of the solar corona against the moon during the totality phase of the eclipse.

The problem of protecting the 0.9 meter telescope from visible sunlight was solved by fixing a plane of 6 mm thick high-density polyethylene over the primary mirror, which scattered the visible light, but passed the far infrared. The observed radiation had to pass through this sheet twice, once before it encountered the primary mirror, and again after reflecting from the primary before hitting the secondary mirror. The proper application of this technique requires a sheet of material with constant optical thickness in order to preserve the image quality of the telescope optics. In fact, the sheet which we used had aberations exceeding 50 microns in places, and this caused smearing of the beam profile, particularly at the shorter wavelengths, limiting the resolution to 1.5-2.5 arc min.

The polyethylene was mounted in quadrants onto the top surface of the primary mirror well in rigid metal frames, specially designed to accommodate the large shrinkage of the plastic as it cools during exposure to the high altitude environment.

We hope to have the opportunity in future solar observations either to obtain flatter material for solar protection, or perhaps to figure an existing sheet to allow a resolution of less than 1 arc min, particularly at the shorter wavelengths, where diffraction is less severe.

In summary, we note that the KAO solar program has been highly successful from every apsect both scientific and technical. New scientific results have been obtained which will contribute important information for modeling of low chromosheric fine structure. Our experience with this first solar program, we expect, can provide excellent guidelines for future solar infrared observations by the KAO.