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INTRODUCTION

Among the lines of greatest interest in the long wavelength part of the solar ultraviolet spectrum is the resonance doublet of singly ionized magnesium at 2795.5 Å and 2802.7 Å. These two absorption lines produce a deep depression in the solar spectrum. J. D. Purcell, D. L. Garrett and R. Tousey (1963) among others have reported detailed profiles of these lines, pointing out the strong emission cores with absorption cutting into the centers of the emission cores. The structure of the lines is similar to the H and K lines of singly ionized calcium, although the emission components in Mg II are stronger than in Ca II. It would be expected that monochromatic pictures of the sun in the Mg II lines probably represent chromospheric structures at a somewhat higher level in the solar chromosphere than the Ca II spectroheliograms do.

The first filterheliograms in the Mg II line at 2802.7 Å were obtained on 12 April 1965, from an Aerobee-Hi rocket. A second rocket with improved instrumentation was flown on 2 December 1965.

INSTRUMENTATION

The photographic system consists of a Cassegrain-Maksutov telescope, behind which is placed a Solc-type birefringent filter and an automatic camera, using 35 mm Eastman 103-0 film. The overall length of the instrument is 22 inches, with a total weight of 40 pounds.

The telescope is a modified Questar with optics of fused silica and a temperature compensated body. The system works at f/19, with an aperture of 8.9 cm and an effective focal length of 169 cm.

The birefringent filter is mounted between the telescope and the camera. It is of the type developed by Solc, and consists of a pile of uniformly thick retardation plates and two linear polarizers, one at each end of the filter (See J. W. Fvans (1958) for a description of the Solc filter). The big advantage of the Solc filter over other types of birefringent filters when working in the ultraviolet region of the spectrum is the need for only two polarizers. In this region it is difficult to obtain satisfactory polarizers with high transmission. A combination of different types of linear film polarizers and a calcite Rochon prism was developed by the author to meet the requirements of the system. Various parts of a Solc filter put to my disposal by Y. Öhman could be used for this purpose.

The filter used in the spectroheliograph is actually a combination of two Solc filters plus a 110 Å wide interference filter. Table I gives characteristic data for the double Solc filter used in the two flights.

Since the transmission peak of the filter will shift with changes in temperature, the filter was surrounded by a thermal

TABLE I

	12 April 1965	2 December 1965
FILTER DATA		
Peak Wavelength	2802.7 Å	2802.7 Å
Bandpass (full width at half Intensity)	4.0 Å	3.5 Å
Peak Transmission	0.13%	1.1%
PICTURE DATA		
Time of Exposure UT	$14^h53^m33^s$	$17^h31^m53^s$
Rocket Altitude	150 km	118 km
Film	103-0	103-0
Developer	D-19	D-19
Exposure Time	1/8 sec	1/9 sec
Max. smearing due to pointing error elev.	0.3'	0.4'
Max. smearing due to pointing error azim.	1.0'	1.0'

control unit capable of maintaining the in-flight temperature to within $\pm 0.2^{\circ}C$ of nominal, which corresponds to a wavelength shift of less than ± 0.04 Å. Only the 2802.7 Å line of the Mg II doublet could be isolated by this particular filter, if it were to operate at a reasonable temperature.

The instrument was flown with a Ball Brothers Research Corporation biaxial solar pointing control aboard an Aerobee-Hi rocket launched from White Sands Missile Range in New Mexico. The first rocket (NASA Aerobee 4:49 GS) was launched at UT 14:48, 12 April 1965, and the second rocket (NASA Aerobee 4:145 GS) was launched at UT 17:30, 2 December 1965.

RESULTS

Figures 1 and 2 show one Mg II picture from each flight compared with spectroheliograms in Hα and CaK obtained from Sacramento Peak Observatory at approximately the same time. In the pictures heliocentric north is at the top and heliocentric east to the left. Table I gives all data concerning the Mg II pictures.

The optical system is capable of a resolution of about 10 sec of arc. Unfortunately, the flight stabilization was not that good, so the obtained resolution is completely determined by the changes in pointing during the exposure time. The fastest motions were in the azimuth direction about the rocket spin axis. Two full time telemetry channels recording the output signals from the fine pointing sensors made it possible

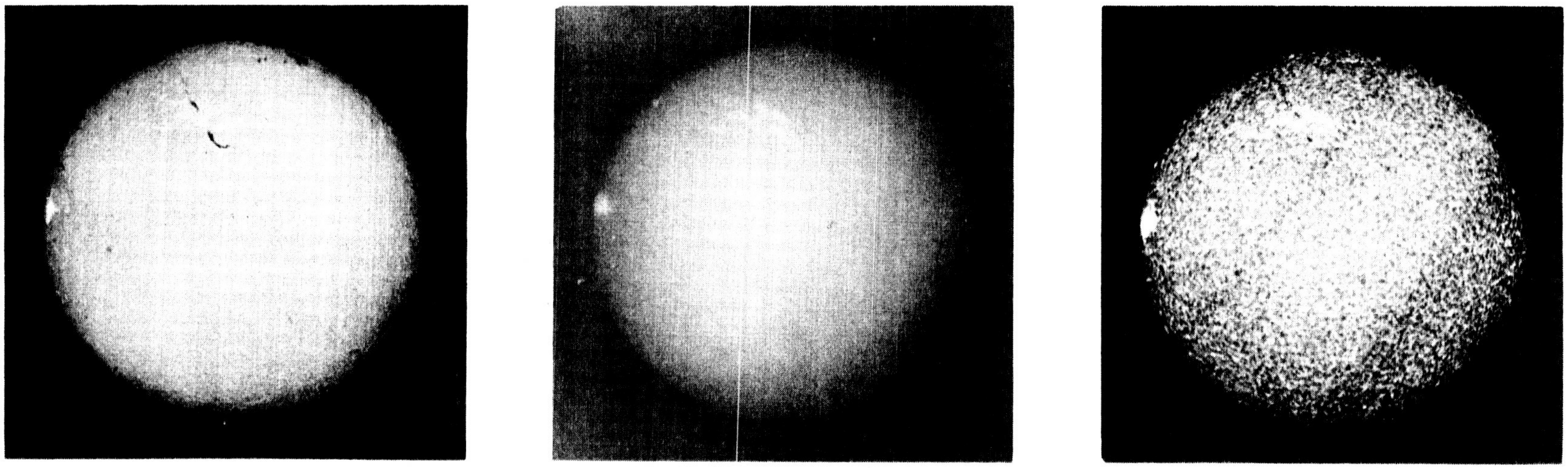

Figure 1 Three monochromatic pictures of the sun obtained on 12 April 1965.

(a) Hα filtergram at 14:49 UT, bandwidth 0.5 Å
(b) Mg II filtergram at 14:54 UT, bandwidth 4.0 Å
(c) CaK spectroheliogram at 14:41 UT, slitwidth 0.5 Å

(Hα and CaK pictures by courtesy of Sacramento Peak Observatory, Air Force Cambridge Research Laboratory)

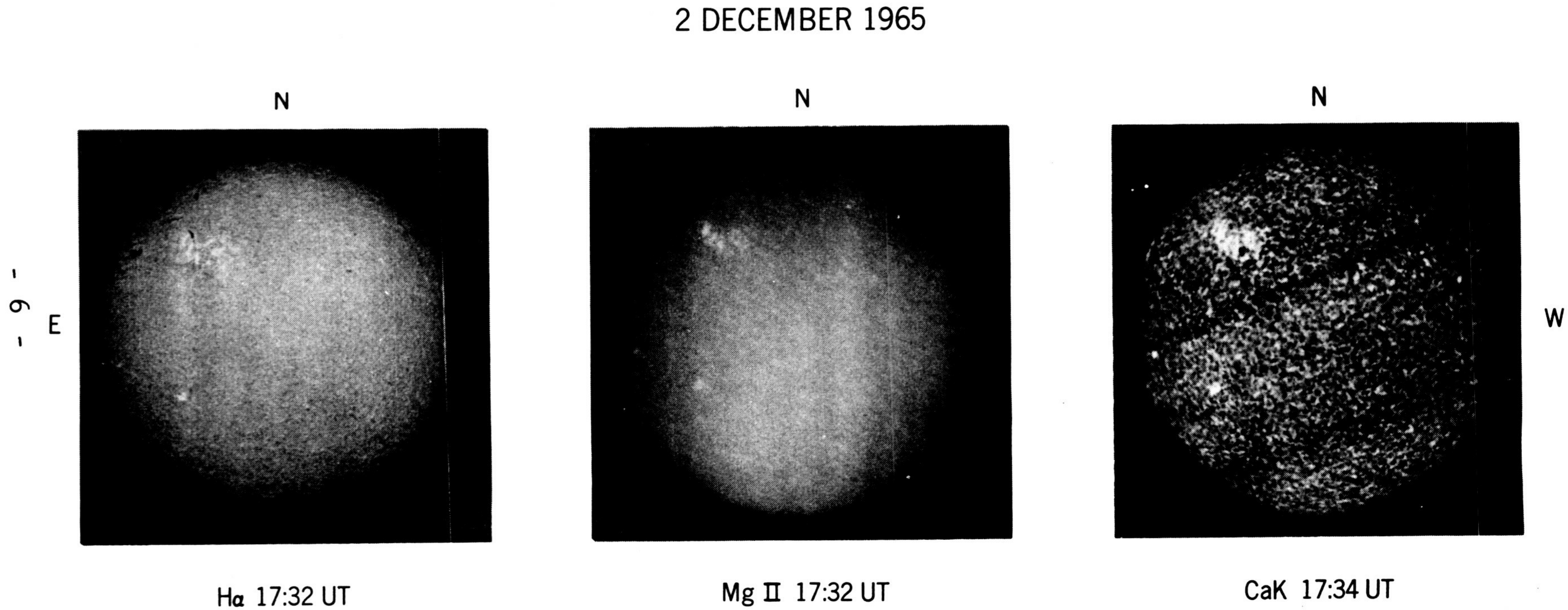

Figure 2 Three monochromatic pictures of the sun obtained on 2 December 1965.

(a) Hα filtergram at 17:32 UT, bandwidth 0.5 Å

(b) Mg II filtergram at 17:32 UT, bandwidth 3.5 Å

(c) CaK spectroheliogram at 17:34 UT, slitwidth 0.5 Å

(Hα and CaK pictures by courtesy of Sacramento Peak Observatory, Air Force Cambridge Research Laboratory) to exactly determine the smearing of the picture due to pointing errors for every exposure. In both the pictures presented here the maximum smearing in azimuth is 1.0 arc-minute from peak to peak (NE - SW direction in the pictures). The error in elevation is about a third of the azimuth error. No significant rotation around the solar vector is noticed.

At a first look at the Mg II picture from 2 December 1965, the resolution in azimuth seems to be somewhat better than 1.0 arc-minute. This is because during this exposure the azimuth pointing error was less than 0.4 arc-minutes for more than 2/3 of the exposure time.

DISCUSSION

All plage regions in the Mg II pictures correspond very well to the plages in the CaK spectroheliograms. Even the detailed structure shows very good correlation. Only a few of the dark filaments in the Hα pictures are noticeable in the Mg II pictures. A small Hα prominence at the SE limb shows up on one of the longer Mg II exposures from 2 December 1965.

The coarse mottling network, so typical for CaK$_2$ spectroheliograms, is also visible in the Mg II pictures. In spite of the blurring due to pointing inaccuracies, it seems likely that the mottling structure in the Mg II is of about the same size as the structure seen in the CaK$_2$. Because of the differences in spectral bandwidth, approximately 4.0 Å for Mg II vs. only 0.5 Å for the CaK picture, it is difficult to compare the contrast between active and undisturbed regions on the sun in the two pictures. But the fact that the mottling is visible with a bandwidth of 4.0 Å in Mg II, suggests that the contrast in a Mg II picture would be greater than that for CaK if a narrower filter, isolating the emission core in the center of the absorption line, were used.

An important observation from both flights concerns the relative intensities of the different active regions. In the Hα picture of 12 April 1965 the small plage just coming around the east limb is considerably brighter than the more extended area on the northern hemisphere. In the Mg II picture from the same day the intensities of the two areas are approximately equal. In the 2 December 1965 picture we have also one big active region fairly faint in Hα (at 27N, 27E) and a small region of higher intensity (at 18S, 33E). In the Mg II picture, however, the bigger area is the more intense of the two. Even some of the different parts within the larger active region show this intensity reversal between Hα and Mg II. The relative intensities of the CaK plages fall somewhat in between those of Hα and Mg II but are more similar to those of Hα.

The effect is apparently connected with the life history of the active regions. Both the big plage areas are old active regions previously visible one solar rotation earlier, while the small plage areas are young, newly formed regions. The larger area shown in the 12 April 1965 picture was formed on or before 11 March 1965. The smaller area at the eastern limb was probably formed only a few days before it became visible at the eastern limb. The larger area shown in the 2 December 1965 picture was formed on or before 31 October 1965. The smaller area in the same picture was only three days old.

Together with information about at what height in the chromosphere the Mg II ions predominantly are formed, this observation may give a clue to the formation and development of active regions.

The Mg II pictures from 2 December 1965 show long absorption structures of low contrast. Most of them are oriented in the NE - SW direction and are probably only an effect of the smearing due to the pointing error in azimuth. But the most outstanding one, with the approximate coordinates 04N, 35E is also faintly visible in several simultaneous CaK spectroheliograms and is most likely real. Structures of this type have been observed from time to time in CaK, but even less seldom in Hα. J. D. Purcell and R. Tousey (1961) have reported similar dark features visible in Lyman-α photographs, but not always present in simultaneous Hα or CaK spectroheliograms.

A more thorough analysis of these Mg II pictures is presently being performed by the author. A future experiment with a narrower bandpass filter is planned. For a more complete understanding of the chromosphere it would be most desirable to obtain simultaneous spectra giving line profiles of the Mg II lines in different active regions. Also, simultaneous photographs of the sun just outside the Mg II absorption lines showing the photospheric faculae would be of great interest.

The author is very much obliged to Professor Y. Öhman, Stockholm Observatory, Sweden, who originally suggested this experiment and to the late Dr. John C. Lindsay for all the support given me at Goddard Space Flight Center, Greenbelt, Maryland.

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