X-RAY PICTURE OF THE SUN TAKEN WITH FRESNEL ZONE PLATES

G. ELWERT
(Lehrstuhl für Theoretische Astrophysik, Universität Tübingen, Germany)

It is well known that Fresnel zone plates act as a lens with a focal length inversely proportional to the wavelength. At Professor Moellenstedt's Institute of Applied Physics in Tübingen, a technique has been developed to manufacture micro-zone plates electronoptically from Buckbee-Mears zone plates. These micro-zone plates have a diameter of 0·5 mm approximately, 38 zones and a focal length of 30 cm for X-rays of nearly 50 Å. Their resolving power is of the order of a few seconds of arc (Einighammer *et al.*, 1966). One finds, however, experimentally as well as theoretically that the sharply defined image is surrounded by a halo having a diameter of a few minutes of arc for the above-mentioned zone plates. Whereas for a point source the intensity of a halo is poor and therefore unimportant, for extended sources it becomes large as a result of the superposition of the contributions from the individual points of the source. This has been demonstrated by the photometer curves of the images of circular sources by Einighammer (1966) (Figure 1). The halo is not noticeable in case of very narrow sources (curves *a* and *b*). With increasing diameter of the source

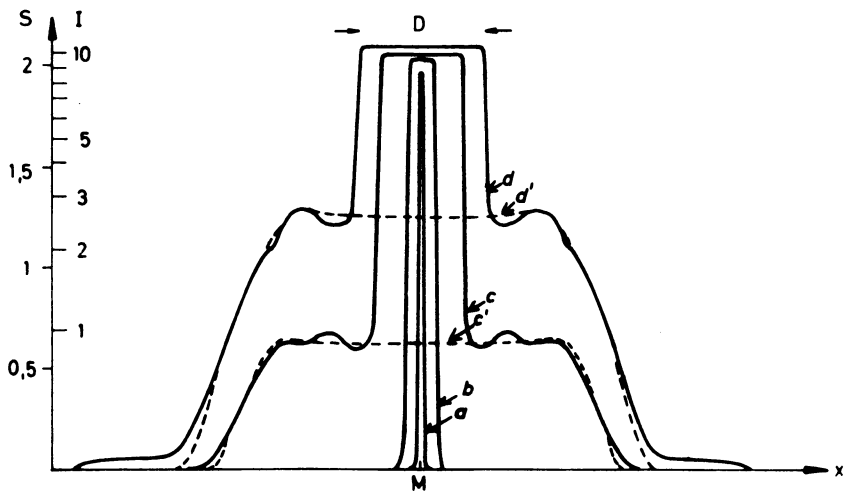

FIG. 1. *Photometer curves of the images of circular sources (according to Einighammer, 1966).*

Kiepenheuer (ed.), Structure and Development of Solar Active Regions, 439–443.

the intensity of the halo rapidly increases (curves c and d). For the same source the brightness distribution of the halo agrees practically with the one obtained by a pinhole camera, provided the diameter of the hole and that of the zone plate are equal; these brightness distributions are represented by the dashed lines $c'd'$ in Figure 1.

During a previous congress, Dr. Friedman kindly consented to insert some plates in one of his pinhole cameras. The zone plates were built by Von Grothe under the guidance of Professor Moellenstedt for the line of O VI at 34 Å and the line of Si XIII at 51 Å, which were found to be strong lines by Tousey. The launching took place on October 4, 1966.

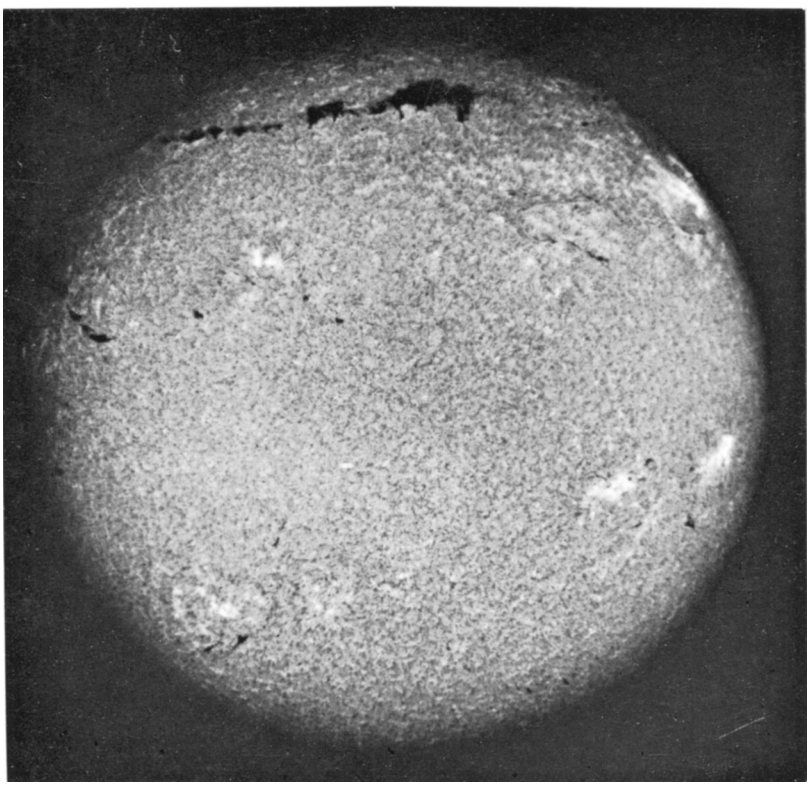

FIG. 2. *Hα-spectroheliogram taken on October 2.*

A Hα-spectroheliogram (Figure 2) taken at the Sacramento Peak Observatory on October 2 shows two plages in the neighbourhood of the West limb seen on the right side, one of which disappeared on October 4 (Figure 3). As the condensations are situated above the plages, it is to be expected that on the day of launching both X-ray

https://doi.org/10.1017/S0074180900021884 Published online by Cambridge University Press

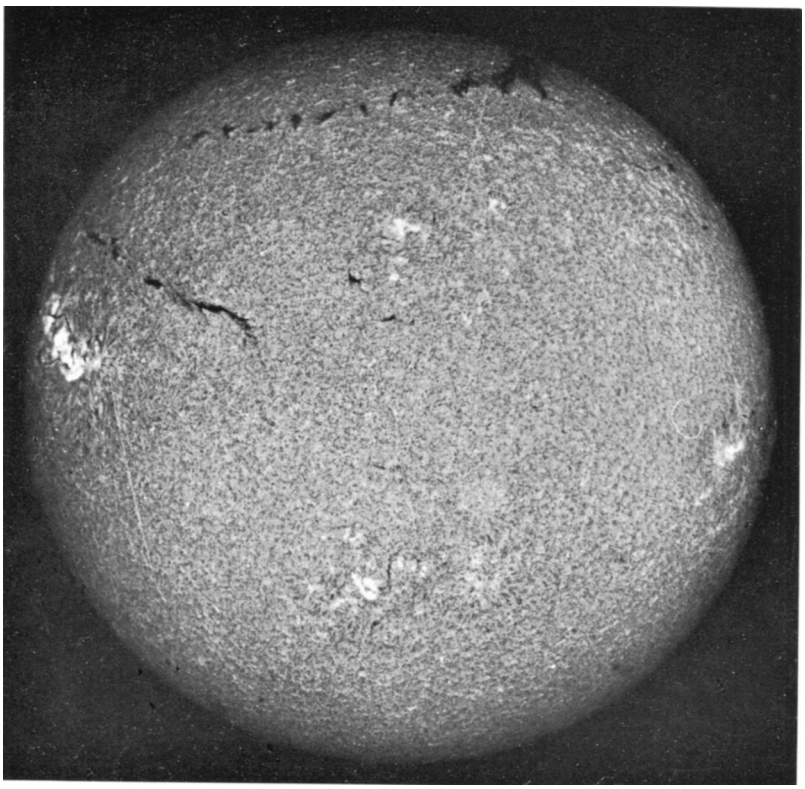

FIG. 3. *Hα-spectroheliogram taken on October 4.*

sources on the limb were visible. This was found to be true. On the East limb, one extended plage appeared on October 4. Unfortunately the attitude control did not work satisfactorily. During the time of exposure the rocket rotated around the direction to the Sun's centre by an angle of 70° nearly, so that the pictures of active regions were smeared.

The photograph taken in the focus of 51 Å (Figure 4) shows smeared arcs with a thickness of approximately 0·2 solar diameter. They are due to the halo, and a small part may also be contributed by the out-of-focussing of the O line of 34 Å. Within these smeared arcs on the West limb, however, narrow arcs of small width can be detected. In addition to that, on the disk and on the East limb very narrow arcs are to be seen. From these sharply defined structures which arise from the central peak of the diffraction pattern, one can conclude that small sources of the Si line at 51 Å exist.

The results of the photograph taken in the focus of 34 Å are somewhat different (Figure 5). On the West limb, a diffused arc, the width of which corresponds to the

https://doi.org/10.1017/S0074180900021884 Published online by Cambridge University Press

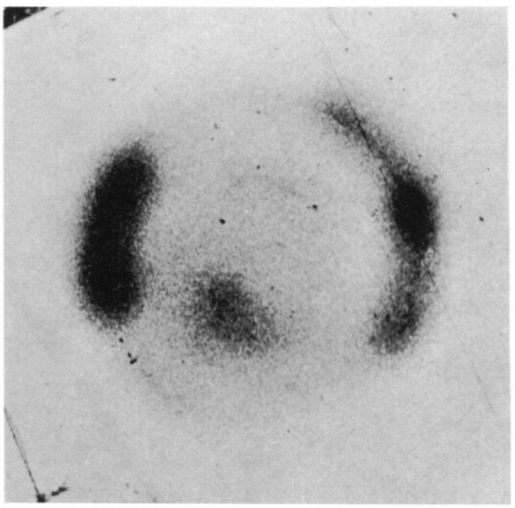

FIG. 4. *X-ray picture of the Sun taken in the focus of* 51 Å.

FIG. 5. *X-ray picture of the Sun taken in the focus of* 34 Å.

halo of the 34 Å radiation, is to be seen. It contains again a relatively small region of emission at 34 Å. However, its extension is somewhat larger than that of the 51 Å radiation. On the East limb and on the disk, on the other hand, no sharply defined structure can be detected.

I have already mentioned that one can show experimentally as well as theoretically that for the same source the brightness distribution of the halo agrees practically with

the one obtained by a pinhole camera, provided the diameter of the hole and that of the zone plate are equal. According to Einighammer (1966) it is therefore possible to eliminate the halo experimentally if X-ray pictures of the Sun are taken simultaneously by means of a zone plate and a pinhole camera, as described above. This is supposed to be exploited for later launchings. More details will be published elsewhere.

Acknowledgements

It is a pleasure to express my gratitude to Professor Moellenstedt and Mr. von Grothe for manufacturing the zone plates and to Dr. Friedman for consenting to launch them. I would also like to thank Dr. Unzicker for arranging the insertion of the zone plates into the rocket. He and Dr. Conrads (Institute for Plasma Physics, Yülich, Germany) kindly procured the filters. Finally I am grateful to Dr. Bruzek for providing the spectroheliograms.

References

Einighammer, H. (1966) *Naturwissenschaften*, **53**, 272.
Einighammer, H., Elwert, G., Mayer, U. (1966) in *Space Research*, VII, p. 1336.

DISCUSSION

Burton: Please would you give details of the types of filters used to cover the zone plates, and of the photographic film used for recording the solar images?

Elwert: Filters of Aluminium and Parlodion (Fig. 5) or Macrolon (Fig. 4) have been used. The film used was Kodak SC-5 ultra-fine grain.