Les clichés montrent également des structures intéressants des étendues plus vastes. Quelquefois de singuliers alignements courent, isolés ou parallèles, comme des stries ou des coups de rateaux; ils concernent, soit les granules eux-mêmes, soit la matière sombre. En plusieurs endroits, aussi, des régions quelquefois aussi grandes que 30″ de diamètre se montrent parsemées de grains plus petits, et un peu plus serrés. Nous savions déjà, depuis les travaux de Lyot, que les granules sont souvent plus petits autour de la pénombre des taches, là où les champs magnétiques sont plus intenses.

Les clichés pris au bord du disque nous montrent les granules jusque près du contour du Soleil. Leur contraste devient très faible à 40″ du bord, la profondeur optique concernée y étant voisine de la surface de transition avec la chromosphère. Les granules sont plus grossières et allongés parallèlement au bord. Cette propriété, que Lyot avait déjà signalée, en 1943, a été clairement confirmée par J. Rösch plus récemment; elle prouve que les masses brillantes sont des colonnes verticales dont la hauteur est limitée. Les images obtenues en ballon au bord du disque, moins réussies que celles des parties centrales, confirment les observations antérieures, mais sans apporter, sur ce point, nettement plus de détails.

Des courbes d'égale intensité ont été tracées, pour différentes valeurs de la brillance, à l'aide du traceur d'isophotes de l'Observatoire Sacramento Peak dans le New Mexico. Les lignes isophotes montrent clairement la grande complexité de la forme des granules. Grâce à la qualité de l'image dépourvue de la diffusion par les troubles atmosphériques, le contraste entre les granules brillants et les intervalles sombres peut être déterminé sans trop d'altération. Les mesures, corrigés des effets instrumentaux, donnent 30 à 40%.

La courbe d'auto-corrélation qui lie les écarts de brillance entre de nombreux points choisis à des distances croissantes les unes des autres a été établie avec l'aide du calculateur électronique de l'Université de Cambridge. La partie initiale de la courbe montre une branche descendante dont la demi-largeur est 0″57. Cette valeur fixe l'ordre de grandeur de la résolution; elle permet de comparer la qualité de différents clichés. Les photographies du Dr Miller, obtenues au niveau du sol, étudiées par G. Wlérick, donnaient 0″9. Le gain de pouvoir résolvant est donc très appréciable.

L'étude complète de clichés, entreprise par les Dr Blackwell, Dewhirst et l'auteur, n'est pas encore achevée.

RÉFÉRENCES

[1] Dollfus, A. *C.R.* **239**, 954, 1954.
[2] Blackwell, D., Dewhirst, D. and Dollfus, A. *Nature, Lond.* **180**, 211, 1957.

2. SOLAR GRANULATION PHOTOGRAPHS FROM THE STRATOSPHERE

MARTIN SCHWARZSCHILD

The Princeton University Observatory carried out last summer three unmanned stratospheric balloon flights for the same purpose as that described in the preceding communication, namely to obtain high-definition photographs of the solar granulation. The special telescope for this purpose was built by the Perkin-Elmer Corporation, the electronic pointing mechanism was constructed by the Boulder Research Laboratories, and the balloons were manufactured and flown by General Mills Inc. The project was sponsored by the U.S. Office of Naval Research and by the U.S. Air Force.

The telescope consisted of a fused quartz mirror with an aperture of 12 in. and a focal length of 8 ft. The primary image was enlarged twenty-five times through a small lens, so that the effective focal length was 200 ft. The photographs were taken on 35-mm fine-grain film ($\lambda\lambda$5100 Å and 5900 Å) with one frame each second and with an exposure time of 1/1000 of a second and a frame size of 1·2 by 1·7 minutes of arc. Care was taken to minimize thermal disturbances within the instrument; in particular, the small secondary

mirror which reflects the light of the primary image into the enlarging lens was mounted on a rotating arm so that this mirror spent only 3% of the total time in the hot primary image. In the pointing mechanism photo-diodes were used to provide the electric signals to keep the telescope pointed at the Sun with the help of two motors, continuously and fully automatically.

Three balloon flights were carried out last summer, all three at an altitude of 80,000 ft (25 km, air pressure 4% of ground pressure). The first of these flights had the purpose only of testing the pointing mechanism, but in the second and third flight the full telescope was flown. Eight thousand photographs were taken on each of these two flights. Focusing was achieved by scanning the range of focus-uncertainty in twenty consecutive exposures and by continuously repeating this scanning so that unavoidably only a small fraction of all the frames was in good focus.

The best of the photographs of the solar granulation thus obtained are of high definition and show the granulation to have a quite peculiar character; the granulation appears to have a cellular, though highly irregular, structure with the bright elements being separated by narrow dark lines. This type of structure had already been suggested by the best photographs of Leighton on Mount Wilson, by Thiessen's visual observations and by one of the early plates taken by Janssen. The diameters of the bright granules are found to range from about 1500 km down to about 250 km, the latter corresponding to the diffraction limit of the telescope. The existence of the large elements agrees with the observation of perspectivical foreshortening near the Sun's limb found by Rösch on Pic-du-Midi. The existence of the very small elements as well as the sharpness of the dark lines agrees with the theoretical expectation that the scale height of the photosphere should present an effective linear scale for the granulation. The root-mean-square intensity fluctuation was found to be about $\pm 5\%$, corresponding to a root-mean-square temperature fluctuation of about $\pm 60°$, in serious discord with the value of $\pm 400°$ previously derived from other indirect data.

The character of the solar granulation shown on these new stratospheric photographs closely simulates that of 'non-stationary convection' earlier studied by Siedentopf in the laboratory; this character is distinctly different from stationary Benard cells on the one extreme and from well-developed turbulence on the other extreme.

DISCUSSION

DR J. RÖSCH presented in the form of lantern slides a number of photographs of solar granulation taken at Pic-du-Midi. These photographs demonstrated the high state of the art in ground-based studies of solar granulation.

3. ASTROPHYSICAL MEASUREMENTS FROM ROCKETS

HERBERT FRIEDMAN*

X-RAYS FROM A QUIET SUN

The X-ray spectrum of a quiet Sun can be approximated by a 500,000° K Planckian distribution. In the absence of coronal excitation, as evidenced by the intensity of the Fe XIV green line, the X-ray spectrum has a short wave-length limit near 20 Å. Coronal activity is accompanied by weak emissions down to wave-lengths as short as 6 Å, which appear to be associated with coronal hot spots at temperatures of 2×10^6° K or higher. One may draw the conclusion that rocket data support a picture of localized hot condensations

* For unpublished material reported here, the author is indebted to his colleagues of the Optics Division, U.S. Naval Research Laboratory: T. A. Chubb, J. E. Kupperian, Jr., J. C. Lindsay, R. W. Kreplin, E. T. Byram, J. E. Milligan and A. Boggess III.