LETTERS TO THE EDITORS

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The Scintillation of Stars

How the heart of the astronomer would rejoice if the scintillation of stars were due, as Prof. Hartridge[1] considers possible, to physiological causes rather than to non-homogeneity of the earth's atmosphere! It is the practice of many observing astronomers, before 'opening up', to look at the sky and note, on some estimated scale, (i) the degree of clearness or *transparency* of the sky, and (ii) the degree of steadiness or *goodness of seeing*. (i) may be judged (in the absence of strong moonlight) by the limiting magnitude of stars just visible to the eye at various altitudes, and is important, in the case of photography, for judging exposure times; (ii) may be judged by the scintillation-frequency of the brightest stars; the greater the frequency the worse the 'seeing' will be. On the very best nights the stars appear nearly steady, the occasional winking being slow and infrequent. Such nights are suitable for measuring close binaries, the Airy disks and their diffraction ring systems appearing steady, often for many seconds together; on such nights, also, the finest planetary details are to be seen. When scintillation is conspicuous and rapid, the images of stars, viewed through a telescope, appear larger than the Airy disks and show a rapidly changing and uneven distribution of illumination. If the telescope is put out of focus, the star will appear as an illuminated disk showing, on a steady night, a number of fine concentric rings as in a 'zone plate'. On an unsteady night, rings are no longer visible, the whole disk appearing to 'boil'. It has been noted by British astronomers that both the scintillation and the telescopic images of stars are, in general, worse when the wind is in the east. Planets are only observed to scintillate when viewed at a low altitude on a night of exceptionally bad seeing.

'Artificial stars', made by reflecting a distant light source in a small drop of mercury, are in use at many observatories. These are not observed to scintillate unless the light path is through unevenly heated air or through air the moisture content of which is not constant, when they may be observed to do so. Such artificial stars may, however, be caused to scintillate in all but the most steady air conditions by viewing them through a telescope the objective of which is next to the eye. It will be seen that, in this case, the angular size of the source is reduced in the ratio of the 'minification' of the telescope.

In view of the foregoing it would appear that any physiological component in star scintillation would be likely to be very small, and possibly altogether absent in the case of the trained astronomer.

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Dec. 12.

[1] *Nature*, **164**, 999 (1949).

Hartridge and Weale[1] advance evidence for a physiological explanation of the scintillation of stars. I have made a simple observation which seems to contradict this. Sirius, seen through a misted car window, appeared as a large area of diffuse blue-white light, subtending perhaps five degrees: this light fluctuated markedly and at roughly the same frequency as the star seen through an unobscured area of the window. The effect was more readily seen when looking twenty or thirty degrees away from the star, but could be seen by direct observation.

It has been suggested to me that the diffuse area may have been made up of minute sources from each droplet which could show the 'Hartridge effect'. This seems to me invalid, for it would surely imply a statistically improbable coincidence of fluctuations from many different sources.

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[1] *Nature*, **164**, 999 (1949).

In a letter on this subject by Prof. H. Hartridge and Dr. R. Weale[1] it is stated ". . . very bright stars do not scintillate". This, however, is contrary to experience, for Sirius, for example, can be seen to scintillate in favourable meteorological conditions, as I reascertained last night.

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[1] *Nature*, **164**, 999 (1949).

In our letter in *Nature* of December 10, we were careful to point out that the scintillation of stars may have two causes: one physical, the other physiological. In certain circumstances one or other of these may make the larger contribution.

The idea that the earth's atmosphere is in a state of turbulence appears to be very reasonable, and yet the weight of evidence seems to be against the optical effects which are ascribed to it.

(1) There should be apparent movements of the star images at right angles to the line of sight. R. W. Wood suggested that the striæ of different refractive indices had widths of about 30–40 mm. In our opinion, they definitely must be smaller than this because the scintillations of certain stars, which are clearly seen by the unaided eye, are no longer seen when a low-power telescope of 18-mm. aperture is used. If the optical effects of the striæ are to be averaged out by so small an aperture as this, the striæ themselves must have quite small dimensions. As these striæ move along in a more or less horizontal direction, they presumably refract the light from the stars and so cause the wave-fronts to vary in direction. In these circumstances we would expect the images of the stars to be in a state of tremor rather like the Brownian movement which fine particles suspended in a liquid are seen to undergo when they are examined through a microscope.

(2) It would be expected that these oscillatory movements of the star images would often be greater in one direction than in another at right angles to it, and that the direction of the larger oscillations would correspond to the direction of travel of the striæ, that is, to the prevalent direction of the wind. Thus if, as Mr. Gregory says, scintillations are usually worse in Great Britain when the wind is in the east, then the striæ are presumably travelling from east to west and therefore the oscillations should be more marked in this direction.