white ones. Such details may perhaps be accounted for by physiology.

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¹ *Nature*, **164**, 999 (1949) and **165**, 146 (1950).

² *Mon. Not. Roy. Astro. Soc.*, **87**, 506 (1927). Strömgren, B., *Festschr. Norlund*, 1945; etc.

³ Minnaert and Houtgast, *Z. Astrophys.*, **10**, 86 (1935).

NONE of the correspondents writing on this subject appears to have taken into account the fact that, as viewed by most people, most of the stars do not scintillate when observed with the naked eye from a point within the tropics. This at any rate is my clear recollection after spending more than three years in the tropical zone.

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PROF. HARTRIDGE¹ may well inquire whether a subjective element contributes to the scintillation of stars, for there is more in twinkling than meets the eye. But tremulous images are not entirely due to the observer; they can be detected by the photographic plate. Schlesinger² discovered changes in atmospheric refraction which give rise to small oscillations of the telescopic image, with an amplitude of about 1" and a period of about 1 min. Even zenith stars are affected³, though to a less extent and with a shorter period. The effect on twinkling caused by these irregularities of refraction could perhaps be determined by visual and photographic measures made simultaneously.

On the other hand, Prof. Hartridge will derive support for his ideas from the motion of 'jumping stars' (the so-called *Sternschwanken*), into which, in some cases at least, a subjective element would seem to enter⁴, especially when the eye is tired. As regards dispersion, stars near the horizon sometimes appear to be drawn out into short spectra; at smaller zenith distances the dispersion would not be appreciable.

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¹ *Nature*, **165**, 146 (1950).

² Schlesinger, F., *Mon. Not. Roy. Astro. Soc.*, **87**, 506 (1927).

³ Barocas, V., and Withers, R. M. J., *Observatory*, **68**, 153 (1948).

⁴ Weyer, G. D. E., *Astro. Nachricht.*, **119**, No. 2841 (1888).

THE observations of scintillation of stars reported by Gregory and by Morton¹ can be extended and confirmed by simple experiments. Using either field-glasses or a hand telescope, the image of a star such as Sirius can be made to move rapidly in circles over the retina. By controlling the shaking of the hands, the period of the movement and the size of the circles can be varied at will. The image of a star then appears as a circle of light, and the scintillation is seen as variation in the brightness and the colour of different parts of the circle.

If stellar scintillation were largely a retinal phenomenon, as suggested by Hartridge and Weale², the pattern on the circles would be expected to vary little with changes in the period of oscillation of the image, or the size of the circles traced out. If the effect is largely atmospheric, the rapidity of the brightness changes will not be affected by the movement, so that the appearance of the bright lines

on the retina will change from lines of coloured dots to coloured streaks as the speed of movement of the image increases. This is found to be so. Scintillation is very obvious with bright stars like Sirius down to those in the Pleiades, even in a telescope giving a magnification of $\times 20$. Planets show scarcely any trace of this effect.

Morton's observation of Sirius through misted glass can readily be repeated by defocusing, and the defocused image can be moved as before. Scintillation is still visible, and is clearly almost synchronous over the whole disk of the image. Although the 'boiling' effect mentioned by Gregory shows as an occasional flash in the width of the ribbon of light, flashes must cover hundreds of times the retinal area covered by the image of the star when in focus.

It would be interesting to know what effects could be observed with Prof. Hartridge's apparatus if his small bright light were viewed in a slightly agitated mirror.

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¹ *Nature*, **165**, 146 (1950).

² *Nature*, **164**, 999 (1949).

THERE are a few simple experiments, perhaps not widely known, which have a bearing upon the physical interpretation of this phenomenon.

We have at the Royal Observatory, Edinburgh, a 6-in. objective prism set up in combination with a 5-in. aperture $f/5$ camera lens. The spectrum of Sirius on a 'scintillation' night appears as a narrow line of rainbow colours about $\frac{1}{2}$ in. in length. Viewed through a low-power lens, the light in any part of the spectrum appears to show little fluctuation. If the viewing lens is now given a rapid vibration of small amplitude in the direction at right angles to the plane of dispersion, so that the spectrum is broadened and separated out into its *time elements*, a most surprising effect is seen. Each of these elementary spectra has one or more broad regions of colour missing: some exhibit only red and violet, others green or blue, and so on. Moreover, each of these patterns is seen to be changing along the length of the spectrum with great rapidity and in an apparently haphazard fashion. When the lens stops vibrating the time elements become superposed and the eye integrates, by the persistence of vision, all these instantaneous patterns, so that we obtain once more what is the normal state of affairs, a steady continuous spectrum. It seems that this phenomenon was first reported by Respighi in 1872.

We must infer, therefore, that when we observe a scintillating star directly, either with the unaided eye or through a small telescope, the 'white' image which we see is, in fact, composed of a succession of colours changing at such a high frequency that the eye is unable to distinguish them separately. If this be correct, it follows that we should be able to observe these colour changes in the image of a star if only we could separate them out on a time base.

Now this can be done by very simple means. Take a pair of prismatic (or Galilean) binoculars, focus on Sirius, or any other 1st mag. star at low altitude. Then give by hand to one end of the instrument a rapid rotary motion, so that the star image appears to be drawn out around the circumference of a small circle, oval, or figure-of-eight. The observed effect is one of extreme beauty: the line of light is seen to be divided up into a splendid array of sparkling colours.