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To cite this article: Dr. P. Glan (1881) XV. On a spectrum-telescope , Philosophical Magazine Series 5, 11:66, 110-113, DOI: [10.1080/14786448108626982](https://doi.org/10.1080/14786448108626982)

To link to this article: <http://dx.doi.org/10.1080/14786448108626982>



Published online: 12 May 2009.



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XV. *On a Spectrum-Telescope.* By Dr. P. GLAN*.

SINCE the discovery of methods for examining the solar prominences at all times, and since hitherto such examination has been confined to only small parts of the circumference at the same time, the efforts of physicists and astronomers have been directed to the simultaneous observation of larger portions of the sun's edge in monochromatic light. These efforts have become of more importance since the observation was made that the passage of a star behind the sun's limb takes place at different times, according as the sun is observed in the usual way (in white light) or in spectral homogeneous light. The latter method of experimenting, as is well known, consists in throwing an image of the sun from the objective of a telescope upon the slit of the spectroscope, and examining through the telescope of the latter a small part of the spectrum of that portion of the solar image which falls upon the slit. Even when the dispersion is great and the slit as wide as possible, we cannot by this means see more than a small part of the sun at one time. I shall describe here a method of observation which allows a considerably larger part of the sun to be seen at once in homogeneous light, and which permits the telescope to be used in the ordinary way, namely with its eyepiece and cross-wires—so that, for instance, it is easy to measure the sun's diameter as seen in the different spectrum-colours.

The method is the following:—Upon the eyepiece of a telescope I screw a small direct-vision spectroscope with collimator and telescope. In the latter, at the place where the spectrum is thrown, there is a movable diaphragm with a slit-shaped opening. The spectroscope is so adjusted that the Fraunhofer lines and the edges of the diaphragm are seen clearly at the same time. The eyepiece of the spectroscope is unscrewed, and the eye is placed immediately behind the slit of the diaphragm, after the slit and that of the collimator have been widened to about one third of a millimetre. The eyepiece of the telescope with the spectroscope screwed to it is then moved till the image of the sun becomes distinctly visible. The image of the sun thrown by the objective of the telescope thus gives rise, by means of the eyepiece of the telescope and the collimating lens of the spectroscope, to a second image, which in my apparatus falls immediately in front of the train of prisms. This image is seen enlarged through the objective lens of the telescope (which acts as a magnifying-glass), in

* Translated from the *Astronomische Nachrichten*, No. 2309, with additions communicated by the Author.

that colour of the spectrum of the collimator's slit which, falling upon the diaphragm of the eyepiece, passes through its slit. I used a terrestrial telescope of Schmidt and Haensch of 50 millims. aperture ; and by this means I was enabled to see nearly half the sun at once in homogeneous light. Seen by the naked eye, the sun appeared white in almost all parts of the spectrum excepting in the red, where it assumed a yellowish-white tint. This agrees with the observation that all colours become white if of sufficient intensity. The image at parts of the edge at right angles to the slit, to a distance of about 40° on both sides, was perfectly sharply defined. The other parts of the sun's edge were less sharp. These slight residues of lateral diffraction are probably chiefly due to the circumstance that every point of the sun's image gives a line-spectrum through the train of prisms, and that the slit-shaped opening before the eye allows a little line of this spectrum, and not a mere point, to pass through.

This residual diffraction, however, is only slight; and I hope to eliminate it further by future improvements in the apparatus. Further, it is possible to see every part of the sun's edge perfectly distinctly. For this it is only necessary so to turn the spectroscope that its slit stands at right angles to the edge under observation. Such an attitude of the slit would, for instance, be advantageous in observing the beginning of the transit of a planet. I have found that any diffraction which might be caused by the slits of the spectroscope is sufficiently removed by giving the slits a width of $\frac{1}{3}$ millim., or at most $\frac{1}{2}$ millim. If the slit be narrower than $\frac{1}{3}$ millim. the edges parallel to the slit appear very washed out ; and when the slit is exceedingly narrow, the sun's image is pulled completely out broadwise. A slight diffraction may also have been caused by the use of a train of direct-vision prisms, which does not refract homocentrically the sun's image, which is in this case at a finite distance from it. I would therefore, in future, recommend the use of an equilateral prism, employing the angle of *minimum* refraction: this is always homocentric.

In the examinations of the sun which I undertook, from the 29th of January to the 10th of February, 1880, I was unable to detect any protuberant eminences on the sun's edge. This was no more than was to be expected, from the slight dispersion of the train of prisms. On the other hand, I have been able to observe satisfactorily the beginning and changes of sun-spots. I shall describe one observation. On the 4th of February I saw a large spot close to the upper edge, a second one of about the same diameter more towards the centre, and a group of three (two larger, and a smaller weak nebulous spot) to

the right of them. Without the spectroscope, with white light I saw, in the case of the larger spots, the very black nuclear speck and the *penumbrae* with admirable sharpness. With the spectroscope there were also seen all the spots, and in some the nuclear specks and *penumbrae*, although they were not so sharply separated. In the methods hitherto described, when the spectroscope was added it was necessary to alter the adjustment of the telescope. If it were required to make use of the spectroscope and still leave the telescope totally unaltered in position, as it is usually adjusted with its micrometer cross-piece, an auxiliary lens has to be interposed immediately between the slit and the eye-diaphragm. With my telescope I used a lens of 67.5 millims. focal length. When I arranged the telescope in the ordinary way and then fastened to the eyepiece the convex lens and the spectroscope, one immediately behind the other, I was able to see the objects in homogeneous light as clearly as previously in white light, without having to alter the adjustment of the telescope in the least. Other lenses would have to be selected for other telescopes.

The arrangement of the apparatus hitherto adopted, which was made by Schmidt and Haensch in Berlin, was only a provisional one. The prisms and lenses of this spectroscope were selected without any special examination of their surfaces; and this may have contributed to deprive the homogeneous images of their highest possible sharpness. I hope to be able to have the apparatus made in a more complete form.

Addition (Dec. 21, 1880).

I add a few data concerning the focal length of the lenses and the dimensions of the spectroscopes employed. The focal length of the collimator-lens was 40 millims.; its free opening was 8 millims. The focal length of the objective lens of the telescope of the spectroscope was 44 millims.; its free opening was 12 millims. The train of Amici prisms was 75 millims. long. The total length of the spectroscope (without its eyepiece), which was screwed on to the eyepiece of the terrestrial telescope, was 165 millims., measured from the slit of the collimator to that of the eyepiece.

I may add the following to the previously described observations on the sun-spots. The spots, when viewed in orange, green, and especially in blue, homogeneous light, appeared distinctly darker than in red light. The difference appeared to me to be most noticeable when the air was exceptionally clear, and failed as the weather clouded. As this estimation depends upon judgments of the luminosity of the sequent

images, such comparison is not quite trustworthy. On each of the four days, however, when I made observations in the different homogeneous colours, I believe that I noticed a greater darkness with the blue.

XVI. *On the Coefficient of Expansion of Gas-Solutions.* By
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Fellows of the Johns Hopkins University, Baltimore.*

[Plate II.]

IN the determination of the coefficient of expansion of aqueous gas-solutions the methods used for ordinary liquids by Pierre, Kopp, Matthiessen, and others are open to serious objection. For the research about to be described here, which is confined to the study of the expansion of aqueous solutions of ammonia, the writers devised an apparatus better adapted to their purpose.

This apparatus consists of a bath, B (fig. 1), in which is immersed the glass bulb of the dilatometer, D. The straight portion, N, of the neck of the dilatometer dips at its lower end into a larger glass tube, T, filled with mercury. S is a mirror-scale graduated to millimetres. The neck N can be fastened securely to the scale at *k*. The mercury-tube is adjustable to different heights. The thermometer, *t*, shows the temperature of the bath. H is the stirrer.

With this apparatus there is no evaporation, nor escape of gas, the solution being kept entirely from the air. Aside from this advantage over the open-mouthed dilatometers is that of very great sensitiveness, due to the great size of the bulb compared with the capacity of the neck. The convenience in filling is also of importance when one is experimenting with volatile liquids.

Our method of volume-measurement was as follows:—The dilatometer was filled, then placed in the bath in the position shown in fig. 1 (the bulb being wholly below the surface of the liquid), and was securely fastened. The adjustable tube *t* was then raised until the end of the neck of the dilatometer dipped into the mercury. The filling was performed at a temperature higher than that of the bath, so that the mercury might rise somewhat in the neck. The bath was then cooled by intervals of a few degrees each; and the height of the mercury in the neck, after each cooling, was noted. From these readings and the corresponding temperatures our results were calculated. To obtain from these readings the relative volumes of the solution for different temperatures the following data were necessary:—

* Communicated by the Authors, having been read before the American Association for the Advancement of Science, Boston, August 28, 1880.