

An easy Method for Adjusting the Collimator of a Spectroscope

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However, in grains of *tous-les-mois* starch, phenomena closely analogous to those above described as presented when σ is constant may be easily observed under a moderately high power—the only difference in the phenomena being that, in consequence of the grain of starch being generally an unsymmetrical body, the lines are distorted, the black cross, for instance, being neither rectangular nor rectilinear. See “The Optical Properties of Starch,” *Phil. Mag.* for August 1876.

II. *An easy Method for Adjusting the Collimator of a Spectroscope.* By ARTHUR SCHUSTER, *Ph.D., F.R.A.S.*

THE ordinary method for adjusting the collimator of a spectroscope for parallel rays is only applicable to the mean rays of an achromatic combination. At the extreme ends of the spectrum a readjustment has to be made. If the ultra-violet rays are observed, and if the lenses are of quartz, the ordinary method cannot be used. The following method is so simple that I cannot help thinking it has often been in use; yet I have nowhere seen it described, and I know that others, like myself, have often found a difficulty in making the adjustment without much loss of time and with simple apparatus.

The adjustment, as the following consideration will show, can be made on each line of the spectrum without any apparatus whatever. The only requirement is that the prism should be movable.

Suppose the rays which fall on the prism to be either convergent or divergent; then, after their passage through the prism they will seem either to converge to or diverge from a point, which is the secondary focus: as the prism is turned, so as to change the first angle of incidence, the secondary focus will change. If the rays are strictly parallel, then, whatever be the position of the prism, the focus will not be altered. This, then, is a delicate test for ascertaining whether rays proceeding from the collimator are parallel or not. It remains to be shown how it can be converted into a rapid method to put the collimator into the right adjustment.

The three fundamental equations for the passage of a ray of light through a prism,

$$\sin i = n \sin r, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

$$\sin i' = n \sin r', \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

$$r + r' = \alpha, \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

give

$$\frac{di'}{di} = - \frac{\cos i \cos r'}{\cos i' \cos r} \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

In these equations i and i' are the angles which the ray makes with the first and second surfaces respectively on entering and leaving the prism; r and r' the two corresponding angles of refraction, and α the angle of the prism. The right-hand side of equation (4) will, as a little reflection will show, steadily decrease when i is increased from 0 to $\frac{\pi}{2}$. This shows

that the greater the first angle of incidence the more nearly parallel are the rays. The following system of consecutive approximation will therefore give the desired result.

Suppose the collimator is out of adjustment: move the telescope slightly out of position of minimum deviation; then two positions of the prism exist which will bring the desired ray into the middle of the field. Call the position in which the first angle of incidence is greatest A, the other B.

1. Put the prism into the position A, and focus the *telescope* until the line in question, either dark or bright, is distinctly seen.

2. Move the prism into position B, and focus the *collimator* until the same line is distinctly seen.

3. Repeat the operation, always focusing the telescope when the prism is in position A, and the collimator when the prism is in position B. After three or four trials no change of focus is required; both collimator and telescope will then be adjusted for parallel rays. I find that it is by no means necessary to work much out of the position of minimum deviation in order to gain a delicate adjustment. If the adjustment is made in the centre of the field, then I usually put the telescope into such a position that the line, when the prism is placed at maximum deviation, should just be out of the field

of view; this gives quite a sufficient change of focus if the rays are not parallel on entering the prism.

The following measurements, which were purposely made without special care, will show the accuracy of which the method is capable. The sliding tube of the collimator was divided into millimetres. Two different adjustments for the sodium-line, made in the way described above, gave the readings 5.0 and 4.0. The prism was now turned round so as to deflect the ray to the other side. Two adjustments now gave 4.1 and 5.0. The mean of the four readings is 4.5. The adjustment was then made according to the well-known method of first focusing the telescope on a distant object and focusing the collimator to the telescope afterwards: the reading was 4.2. As the focal length of the collimator was 300 millimetres, the two results differ only by a thousandth part of the focal length. Whether this difference is due to errors of observation, or whether it is produced by a difference in the focus of the yellow rays and the mean visible rays, I cannot say; but I believe, with a little precaution, the method can be adapted to the study of the achromatism of a lens.

I have assumed that the faces of the prism are perfectly plane. Practically it is difficult to get a prism in which this condition is accurately fulfilled; and it may be questioned whether the curvature of the prism may not seriously interfere with the accuracy of the method. To this I reply:—

1. That a prism which is known to be good may always be set aside to do this work.

2. That the reason of having the rays strictly parallel on entering the prism is based on the supposition that the faces of the prism are plane. It is by no means evident that parallel rays will give the best definition when the faces of the prism are curved.

3. That the change in the adjustment of the collimator introduced by the curvature of the prism is very small. One prism, which I know to be exceptionally bad, gave a difference of a half per cent. in the focal length of the collimator. It is not the change of focus introduced by the curvature of the prism which makes the method inaccurate when the prism is bad, but the difference in the change of focus in the two positions of the prism. This is one of the reasons why it is

better to take the two positions of the prism not too far away from minimum deviation. The small displacement of the prism will only introduce a small variation in the focal length due to the curvature of the faces.

III. *A Condenser of Variable Capacity, and a Total-Reflexion Experiment.* By C. V. BOYS, A.R.S.M., Lecturer for the Term on Natural Science at Uppingham School.

WISHING to show my pupils the effect of condensation on the spark, I thought a condenser the capacity of which could be reduced gradually to nothing would be most suitable. So I made this simple contrivance, which answered its purpose well:—

A glass tube is sealed at one end and is covered with tinfoil for one third of its length; this forms the outer coating. The inner coating consists of a test-tube with the rim cut off, also covered with tinfoil; this is fixed to a wire, and can be drawn in and out. When it is fully in, the condenser has its maximum capacity; when drawn out as far as possible, the two coatings are too far apart to have any sensible action, and the capacity is zero.

On hanging this on the conductor of a Holtz machine the effect on the spark is well shown. Let the wire be first pushed in as far as possible, the condenser then acts to its full extent; but on gradually drawing it out the sparks are less and less bright, but follow one another more and more rapidly, till at last, when it is fully out, they have passed gradually to the almost continuous pale spark so characteristic of a Holtz machine. To show the effect best, the poles should not be more than about half an inch apart. Of course much ozone is formed inside the tube.

The total-reflexion experiment was an accident. A small condenser made of a test-tube gave way under the strain, a minute hole being pierced in the bottom, through which sparks passed almost continually. No light could be seen anywhere except on the rim of the tube, which formed a brilliant circle