Construction and Use of Reflection Echelons

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THE methods used in constructing and testing reflection echelons were briefly described. By adding auxiliary mirrors, the instrument was converted into a wave-length measuring device which, when mounted in vacuum, gave vacuum wave-lengths directly without compensation for phase change variation as is necessary with the Fabry-Perot interferometer.

A water-cooled hollow cathode discharge tube of iron was found to give lines between four and five times narrower than obtained from the standard arc. The high resolving power of the grating, consisting of 40 plates 0.69 cm thick, made it possible to determine wave-lengths to within a few units in the fourth decimal place in angstrom units.

EXTENSION OF ECHELON THEORY

(A) Line Displacement Due to Intensity Envelope of Echelon

It can be shown that the $(\sin^2 \alpha)/\alpha^2$ intensity distribution curve of the echelon produces a displacement of the center of gravity of a Doppler shaped line that is proportional to the slope of the distribution curve and the square of the line width. The interorder distances of a number of iron lines in exact double-order position were compared with the interorder distances given by sharp mercury satellites from a low current water cooled mercury arc lamp. From these data, if one takes into account the ratio of the wave-lengths and the varying magnification of the auxiliary spectrograph, it was possible to construct graphs connecting the observed fractional order (from center of intensity envelope) and the correction to be made due to line displacement. Attempts were made to verify this experimentally by varying the pressure in the echelon chamber, but since the effect was only slightly greater than the experimental error of setting, all that could be verified was the general correctness of the graph.

(B) Non-Linearity of Echelon Dispersion

In earlier measurements[1] it was assumed that the dispersion of the echelon over the small range of one order was substantially constant. A simple calculation shows that the angle between successive orders increases with order, the ratio between consecutive orders being $(1-\lambda t/s^2)$, where t is the plate thickness and s the step width. This ratio is 1.0034 for λ5000A in this instrument. The observed fractional part in consequence is always too large. A correction table for different values of the observed fractional part at various wave-lengths shows that the corrections are appreciable only for the longer wave-lengths for high values of the fractional part.

Both these corrections were applied to a further group of 103 ultraviolet iron lines measured directly in vacuum in terms of the red cadmium line. When these values are converted into air wave-lengths by means of Kösters and Lampe's formula[2] for the index of normal air the calculated air wave-lengths are appreciably higher than the values approved as secondary standards.

A possible explanation of the discrepancy becomes evident when graphs of $(\lambda_{vac}-\lambda_{air}-0.125-0.00025\lambda)$ for each formula are plotted against λ in angstrom units. This equation is chosen merely in order to have a flat open scale. The curve of Meggers and Peters[3] is very nearly parallel to that of Pérard[4] but is displaced approximately 0.003A below the latter.

The Kösters and Lampe curve, while 0.0003A higher than the Pérard curve at 6438A, is 0.0005A lower at 3300A and as much as 0.0025A lower at 2750A.

The results, which will be published in detail in the *Proceedings of the Royal Society* in association with J. W. Drinkwater, indicate that Pérard's curve (or better still, that of Meggers and Peters displaced upwards by a constant amount of 0.0032A) gives the closer approximation to the refractive index and dispersion of normal air, especially in the range 3300–2750A.

[1] Williams and Middleton, Proc. Roy. Soc. **A172**, 159 (1939).

[2] Kösters and Lampe, Physik. Zeits. **35**, 225 (1934).

[3] Meggers and Peters, Bull. Bur. Stand. **14**, 697 (1918).

[4] Pérard, Trav. et Mem. Com. Int. Pds. et Mes. **19**, 1 (1934).