



VII. On anomalous dispersion in incandescent sodium vapour

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Calculated Values of g for Tokio.

From the formula, section 222, p. 167, Thomson and Tait's 'Natural Phi- losophy,' published 1867	}	979·74	{	cent. per
				sec. per
From the formula given on p. 21 of Dr. Everett's Units & Phys. Const., published 1879	}	979·803	}	sec.
				" "
From the formula given by Major Herschel, published 1880	}	979·811	}	" "
				" "

In our paper we merely, as a rough approximation, took the first of these calculated values to the first place of decimals.

Might we again draw attention to an important point advocated in our paper, but which runs the risk of being missed altogether in this discussion. It was our simple proposal of an easy way of measuring the relative value of g over the earth. Let rigid pendulums be sold, each accompanied by a table giving the number of swings per hour at many different temperatures in London. An observer in Siberia, say, finds the number of swings per hour at an observed temperature, and from his table at once sees the value of g for the place relatively to that of London.

In conclusion might we venture to suggest that, whatever may be Major Herschel's opinion of our ability as experimenters, whatever may be the estimate he forms of the value of our results, the style and tone of his letter is hardly what is usually employed by scientific men when discussing an investigation patiently made and faithfully recorded.

We are, Gentlemen,

Faithfully yours,

W. E. AYRTON,
JOHN PERRY.

June 16th, 1880.

VII. *On Anomalous Dispersion in Incandescent Sodium Vapour.* By A. KUNDT*.

THE first observation of an anomaly in the dispersion of light was, as is well known, made by Le Roux upon iodine vapour. The vapour of iodine, which chiefly transmits only the extreme blue and red rays, shows a stronger refraction for the red than for the blue rays. As then anomalous dispersion was discovered in fuchsine by Christiansen, and I

* Translated from Wiedemann's *Annalen*, 1880, No. 6, vol. x. pp. 321-325.

found the same phenomenon in many substances, and proved the relations between anomalies of dispersion and absorption of light and superficial colours, I expressed, in my third communication on anomalous dispersion *, the conjecture that the gases also, which sometimes possess so energetic an absorption for certain kinds of rays, must exhibit anomalies of dispersion in the vicinity of these rays. I added, however:—"But whether we shall ever succeed in demonstrating the refraction-anomalies in each single absorption-band of the gases and incandescent vapours, some of which show so great a number of thin absorption-lines, must be left undecided."

I have recently in fact observed in at least one incandescent vapour, that of sodium, a dispersion-anomaly in the vicinity of those rays which this vapour absorbs and emits. What holds good for sodium vapour, will at all events take place with all other absorbing gases and vapours, and, indeed, for the maximum of absorption of each of them. Herewith my previous conjecture is verified by experiment.

I was led in the following manner to the observation on sodium vapour:—While I, with Dr. Kohlrausch, the Assistant at the Institute, was making, for a lecture, the well-known experiment of the conversion of the bright sodium-line into a dark one, it struck us both that, when the absorbing sodium vapour was very dense and the dark line in the spectrum very broad, its upper and lower margins showed a peculiar rounding-out in the vicinity of the dark line. On closer examination I soon recognized that we had to do with a dispersion-anomaly, conditioned by the dispersion in the conical sodium-flame.

The spectrum with the dark line had, on the screen upon which it was thrown, the form shown in the annexed figure.



The experiment was arranged as follows:—By means of electric light a horizontal intensely bright spectrum was projected, through a prism with the edge vertical, upon the screen. In the path of the rays a Bunsen burner was placed, and with a small iron spoon a piece of sodium introduced into

* Pogg. *Ann.* vol. cxliv, p. 132 (1871).

it. If the spoon is brought exactly into the middle of the flame of the Bunsen burner, it is easy to maintain the flame above it as a cone of intensely yellow brightness. Now this cone acts like a prism with horizontal refracting angle turned upwards. Therefore, if the incandescent sodium vapour exhibits a dispersion, this cone of rays, which pass horizontally through it, must give a vertical spectrum (impure, it is true, on account of the conical shape). If the rays pass simultaneously through a glass prism with a vertical and the sodium prism with horizontal refracting angle, a spectrum is obtained which, if dispersion is present in the vapour, must have the shape above delineated*. As the refracting angle of the sodium prism lies above, the index of refraction of the vapour must be the highest for those rays which are most deflected downwards. The drawing shows that, in accordance with my investigations on solid bodies and liquids, the index of refraction rises much as the absorption-bands of the red side of the spectrum are approached, is lower on the green side of the dark line than on the other, and then rises again rapidly.

After the phenomenon was once recognized, I very often repeated the experiment; and when a very regularly conical sodium-flame of great intensity can be obtained, the anomaly in the refraction is very considerable. I have also, instead of sketching the phenomenon objectively on a screen, observed it subjectively with the telescope.

The above experiment, however, is successful only when the intensity of the sodium-flame is very great, such as is obtained by burning metallic sodium, and that for the following reason:—While the sodium-flame obtained by introducing a salt of sodium into the flame of a Bunsen burner, examined spectrally, shows two bright lines (the two D lines), the phenomenon is changed when a piece of sodium of the size of a pea is put into the burner. At first the two D lines come out distinctly; then, when the sodium begins to be vaporized in greater quantity, these lines widen considerably; with still greater density of the vapour they blend into one; and finally, upon this broad yellow band with fainter margins, there usually appear two fine black lines corresponding to the D lines. These dark lines are produced by the absorption of the cooler sodium vapour surrounding the bright sodium-flame. These phenomena have already been observed by Hankel† and Ciamician‡, and perhaps also by others.

The absorption-power changes correspondingly to the emis-

* Pogg. *Ann.* vol. cxliv. pp. 128-137 (1871).

† *Berichte der Leipziger Akademie*, 1871, p. 307.

‡ *Wien. Ber.* lxxviii. (1878), p. 887.

sion-power of the sodium-flame with increased density of the vapour. While a flame coloured by a sodium-salt, inserted as absorbing medium in the path of the rays, gives two sharp dark lines of absorption in the yellow of the spectrum, when the density of the vapour becomes greater these absorption-lines blend into a single broad band with fainter margins. Now with these bands the dispersion-anomaly appears distinctly visible, while with the narrow absorption-lines, though at any rate present, it is not recognizable, since here it is limited to an extremely small compass in close proximity to the two sides of each absorption-line.

If we could form a real prism of incandescent sodium-vapour, we should probably be able to observe indications of anomalous dispersion in the narrow absorption-lines, even with less density of the vapour. My endeavours, however, to convert the conical flame into a prismatic one by applying plates of glass or mica to its sides, led to no result. Just as little have I hitherto observed dispersion-anomalies in other incandescent vapours by introducing salts of the metals into the Bunsen burner; the density of these vapours, and consequently their absorption, is too slight for the method of observation I employed. With improved methods and very dense vapours the same phenomenon as in sodium-vapour will doubtless be obtained.

To the foregoing I add a remark which, so far as I know, has not yet been enunciated. Those solid and liquid bodies which exhibit for certain groups of rays strong absorption, and for neighbouring groups anomalous dispersion, possess, as I have previously shown, for the same groups a strong reflecting-power*.

As it is proved that incandescent gases exhibit anomalous dispersion in the vicinity of the rays which they strongly absorb, it must be assumed, according to the analogy of experience with liquid and solid bodies, that the gases also strongly reflect those rays which they strongly absorb and, consequently, emit. A sodium-flame, therefore, would reflect much more strongly rays of the number of vibrations of the D line than any other luminous rays of the spectrum, and therefore show a yellow surface. Experiments in proof of this inference (which presumably would present considerable difficulties) I have not yet instituted.

Before such experiments are available and the strength of the selective reflections of incandescent gases is in some measure quantitatively determined, it would be precipitate to

* *Conf. Stokes, Pogg. Ann.* xci, p. 158 (1854), and xcvi, p. 522 (1855).

build further conclusions on the existence of such selective reflection. I will merely point out that if the reflecting-power of incandescent gases for certain groups of rays is considerably greater than for all others, this will not be without importance for the spectroscopic investigation of heavenly bodies which, like comets for instance, emit partly their own, partly reflected light. If the light of such a body consists of single isolated groups or shows narrower brighter bands on a continuous dark spectrum, we are accustomed, according to our present knowledge, to assume that the light of this discontinuous spectrum is entirely and exclusively emitted by the body as a self-luminous one. If the body possesses a selective reflecting-power, the above conclusion is not at once admissible. One might even imagine, as the most extreme case, a non-luminous very dense mass of gas in our solar system, possessing selective absorption, and consequently for many separate groups of rays a power of selective reflection. Such a mass, intensely illuminated by the sun, would, without being self-luminous, show a discontinuous spectrum by reflection.

Strassburg, March 1880.

VIII. *Remarks on a Simplification of the Theory of Vibratory Motions.* By C. CELLÉRIER*.

THE motions in question are the oscillations of the particles on both sides of their positions of equilibrium—that is to say, those which constitute sound and light. To find their law on the most general hypothesis, the excursions and the molecular velocities at a fixed instant called the initial instant are supposed to be given; the unknowns are the projections of those excursions upon three rectangular axes at any instant whatever: they are functions of the time and of the position of the particle.

The equations of the motion are satisfied by taking for each of them a sum of terms of the form $a \cos \rho(p-st)$, in which t is the time, p the distance of the particle from a fixed plane, and a, ρ, s constants. The motion represented by one of these terms isolated is called a simple motion.

At the initial instant each of the terms reduces to $a \cos \rho p$; and the constants and the fixed plane corresponding to each can be arranged so that their sum shall reproduce the initial

* Translated from the *Archives des Sciences Physiques et Naturelles* of the *Bibliothèque Universelle*, June 5, 1880, pp. 549–553, having been communicated to the *Société de Physique et d'Histoire naturelle* of Geneva on June 3, 1880.