

**Does the Spectrum-place of the Sodium lines vary in different Azimuths?** By the late Professor C. Piazzi Smyth, Astronomer-Royal for Scotland. *Communicated by* Professor J. G. MACGREGOR, D.Sc., F.R.S.

(Read May 5, 1902.)

The above question having been set before me by my friend Prof. P. G. Tait, and in such a guise that its practical solution, if amounting to anything sensible, might have astronomical applications, I set myself to examine it with the highest dispersion power in my possession, viz., a fine Rutherford Diffraction grating, of 17,296 lines to the inch, ruled over a surface 1.6 inch square; a telescope 52 inches long, with magnifying powers from 20 to 50; and a collimator 32 inches long, armed with a very substantial slit-apparatus by Mr Adam Hilger, and some other fittings.

These were all laid out in horizontal plane on the levelled top of a table, which revolved on three wheels below, in a circle divided to every ten degrees of astronomically determined azimuth, on the floor of an upper chamber.

Some preliminary trials were made with sodium light, derived from salt burning in a Bunsen-burner gas flame; first, by placing burners on either side of the slit, and sending their lights into that by metal reflectors placed oppositely to each other and at 45° each to the axial direction. This plan, therefore, gave two images of the salt-lines (say  $D^1$  and  $D^2$ ), one above the other in the field of view. The second plan consisted in sending the light of a single burner direct into the slit, and noting by micrometer the absolute spectrum place of one of its D lines, while the table was turned to successive steps of azimuth all round the circle.

No change of spectrum place, as depending on azimuth, could be established by either of these methods; but the images of the lines were so barbarously coarse and hazy, that it was hazardous to attempt to say from them within what fraction of the distance from  $D^1$  to  $D^2$  the negative could be considered absolutely proved. I therefore arranged a variety of the apparatus for trying the



experiment with sodium lines rendered luminous in an end-on gas-vacuum tube by electric induction sparks. The lines so produced were not quite so bright as I could have wished, chiefly owing to the small size of my galvanic battery of induction coil, whose sparks were only one inch long; but the definition of the lines was as perfect as could be desired, and fully worthy of the high fame of the Rutherford grating. The distance  $D^1$  to  $D^2$  measured, in the second order of spectrum of that grating, 266 units of the micrometer, with an average error on each occasion of not more than two of those divisions; and the final conclusion derived from three different methods of trying the experiment at eight points equally distributed round the azimuthal circle, was,—that there is no change of spectrum-place in a sodium line, depending on the spectroscope looking in any one azimuth rather than another, to the amount of  $\frac{1}{200}$  of the distance between  $D^1$  and  $D^2$ .

Wherefore, if theory continues to assert, on its own very secure grounds, that there is *some* effect of that kind, it must be so small that the next search for it must be conducted with a very much more powerful apparatus than anything I possess. That is, if I made no mistakes in trying the case; and in order that that may be fully judged of by others, I append herewith the original observations, together with the following few words on the principles followed in summing them up, viz.:—

As all the electrically illumined series herein alluded to were made by the method of absolute place on one spectral image alone, it became necessary to guard against any other source of disturbance to absolute place than the problematical one inquired about, while these observations were going on. Except when some positive change was made by hand, and in that case duly noted, to some part of the apparatus capable of altering the micrometer zero, there was nothing that occurred to the visible spectrum-place of any spectral line, except to exceedingly small amounts, and in a manner that allowed the assumption, and consequent correction in a second column, that it varied as the time. The duration, therefore, of any whole series of measures (as starting from any given azimuthal point, and returning to it again after passing through  $360^\circ$ ) was made as short as possible, viz., five to seven minutes; while continued observations, in one and the same azimuth, were



subsequently kept up through several hours, as a test that no larger and cumulative time-change existed.

Most of the observations were made with the grating in the angular position most nearly normal to the collimator, when the distance from  $D^1$  to  $D^2$  marks 266 of the micrometer on the second order of spectrum. But the negative results thence derived have been tested and confirmed by other observations made after turning the grating through its position of simple reflection, to the second order of spectrum on the opposite side thereof, where the distance of the lines is necessarily less wide, and, in fact, measured only 243 of the micrometer.

Again the poles of the induction coil have been changed, so that the direction of the illuminating current through the capillary has been made to pass straight to, or straight from, the slit, besides the light having been sent to the slit sometimes direct in the axis of the collimator and sometimes at right angles, by means of a totally-reflecting prism and an altered place of standing for the tube-holder; but none of these things have had any certainly visible effect on the absolute spectrum-place of any line in the field of view. See the following observations on May 18 and May 20, as extracted from my observing ledger.



7 May 18, 1882.—3 p.m.—Tait Experiments by C.P.S.—As to effect of change of Azimuth on Spectrum-place of Sodium lines, viewed by electric illumination of 1 inch induction sparks, in an end-on Gas-vacuum tube. 2nd order of Spectrum. Grating in position most normal to Collimator. Mag. power 20. Light sent direct into slit.

Time of Obs.	Azimuthal Direction Observed in, or	Object Observed.	Micrometer Reading.	Difference or Dist. D <sup>1</sup> to D <sup>2</sup> .		
h. m.						
3 0 p.m.	Light South of slit.	D <sup>1</sup>	417	} 266		
	" " "	D <sup>2</sup>	683			
3 1 "	Light South of slit.	D <sup>2</sup>	683	} 265		
	East	D <sup>2</sup>	684			
	North	D <sup>2</sup>	682			
	West	D <sup>2</sup>	683			
	South	D <sup>2</sup>	682			
3 7 "						
3 8 "	S. West "	D <sup>2</sup>	683	} 265		
	S. East "	D <sup>2</sup>	682			
	N. East "	D <sup>2</sup>	685			
	N. West "	D <sup>2</sup>	685			
	S. West "	D <sup>2</sup>	682			
3 15 "	S. West "	D <sup>2</sup>	682	} 265		
	" " "	D <sup>1</sup>	417			



After adjustments altering the zero reading of Micrometer, observed as follows:—

Time of Obs.	Azimuthal Direction Observed in, or	Object Observed.	Micrometer Reading.	Difference or Dist. $D^1$ to $D^2$ .	Corrected for Time Changes and Index error +45.	Combination of all four sets observed this day.
<i>h. m.</i> 3 27 1 <sup>m</sup> .	Light S.W. of slit. " S.E. " " N.E. " " N.W. " " S.W. "	$D^2$ $D^2$ $D^2$ $D^2$ $D^2$	636 637 638 637 638		683 683 684 683 683	Az. to South = 683 for place of $D^2$ . S.E. = 683 " " East = 684 " N.E. = 684 " North = 682 " N.W. = 684 " West = 683 " S.W. = 683 " South = 683 "
3 35 "	" S.W. " " " "	$D^2$ $D^1$	638 372	} 266		
3 40 "	Light S. of slit. E. N. W. S.	$D^2$ $D^2$ $D^2$ $D^2$ $D^2$	639 639 638 639 640		683 683 682 683 683	When distance from $D^1$ to $D^2$ = 266 of the same units.
3 47 "						



h May 20, 1882.—Tait Experiments by C.P.S.—Sodium line's Spectrum-place in various Azimuths as before, but now on side of grating's simple reflection where its plane is *least* Normal to Coll.; Dispersion less, though still in 2nd order of Spectrum; and colours inverted.

Time of Obs.	Azimuth Observed in, or	Object Observed.	Micrometer Reading.	Difference or Dist. D <sup>1</sup> to D <sup>2</sup> .	Temp.	Corrected for Time Change.	Combination of both sets in <i>abnormal</i> position of grating.
h. m. 2 17 p.m.	Light S. of slit.	D <sup>2</sup>	615	{ 245	63.5	618	Azim. to South = 618 for place of D <sup>2</sup> .
	" "	D <sup>1</sup>	860				
2 20 "	Light S. of slit.	D <sup>2</sup>	616				
	" W. "	D <sup>2</sup>	618			619	S. W. = 617
	" N. "	D <sup>2</sup>	618			618	West = 619
	" E. "	D <sup>2</sup>	617			616	N. W. = 621
2 32 "	" S. "	D <sup>2</sup>	620	{ 241	64.2	618	North = 618
	Light S. W. of slit.	D <sup>2</sup>	613			617	" N. E. = 620
	" N. W. "	D <sup>2</sup>	619			621	" East = 616
	" N. E. "	D <sup>2</sup>	620			620	" S. E. = 617
	" S. E. "	D <sup>2</sup>	617			615	" South = 618
2 40 "	" S. W. "	D <sup>2</sup>	621			617	"
	Light S. W. of slit.	D <sup>2</sup>	619	{ 241	64.2	617	When dist. from D <sup>2</sup> to D <sup>1</sup> = 243 of the same units; but error of obs. large.
	" "	D <sup>1</sup>	860				



After above set changed back to Normal position of Grating; also changed direct mode of sending light into slit, for a side method, by a prism (totally reflecting) of hard crown glass.

Time of Obs.	Azimuth.		Object Obs.	Micrometer Reading.	Diff. or D <sup>1</sup> to D <sup>2</sup> .	Temp.	Corrected for Changes with Time.	
	Light to Prism.	Prism to Slit.						
h. m. 3 45 p.m.	E.	S.	D <sup>1</sup>	656	} 264	64.7		
	"	"	D <sup>2</sup>	920				
3 50 "	E.	S.	D <sup>2</sup>	924			923	Combination of all three sets, in Normal Position of Grating, but with light sent to slit from one side through a Rectangular Prism.
	W.	W.	D <sup>2</sup>	925			924	
	N.	N.	D <sup>2</sup>	921			921	
	E.	E.	D <sup>2</sup>	922			923	
3 55 "	E.	S.	D <sup>2</sup>	922			923	Azim. to E. = 920 for place of D <sup>2</sup> . " S. = 921 " " " W. = 920 " " " N. = 920 " " " E. = 920 " " when Dist. from D <sup>1</sup> to D <sup>2</sup> =267 of the same units.
	E.	S.	D <sup>2</sup>	918			920	
	W.	W.	D <sup>2</sup>	920			921	
	N.	N.	D <sup>2</sup>	919			919	
4 0 "	N.	E.	D <sup>2</sup>	920			919	
	E.	S.	D <sup>2</sup>	922			920	
	E.	S.	D <sup>2</sup>	922			918	
	S.	W.	D <sup>2</sup>	920			918	
4 7 "	W.	N.	D <sup>2</sup>	920	} 270	64.5	920	
	N.	E.	D <sup>2</sup>	915			917	
	E.	S.	D <sup>2</sup>	913			918	
	E.	S.	D <sup>1</sup>	644			918	
	"	"	D <sup>2</sup>	914				



## For effect of changing Poles of Induction Coil.

Time.	Az. of Light.	Obj. Obs.	Pole.	Microm. Reading.	
h. m. 5 0 p.m.	S.	D <sup>2</sup>	Pos.	916	Therefore no sensible effect.
5 1 „	„	D <sup>2</sup>	Neg.	914	
5 2 „	„	D <sup>2</sup>	Pos.	914	

## For effect of long continued interval of Time.

Time.	Az. of Light.	Obj. Obs.	Microm. Reading.	Temp.	
h. m. 4 40 p.m.	S.	D <sup>2</sup>	915	64.7	Therefore no effect worth noticing.
5 55 „	„	D <sup>2</sup>	914	64.4	
7 0 „	„	D <sup>2</sup>	916	64.0	
8 23 „	„	D <sup>2</sup>	914	63.5	
10 13 „	„	D <sup>2</sup>	915	62.8	
12 45 „	„	D <sup>2</sup>	913	61.9	

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