

## LVIII. On the light reflected by potassium permanganate

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Jupiter), but also an accordant influence of our own planet, which is the central orb and the largest planet in the belt which is bounded by the secular perihelion of Mercury and the secular aphelion of Mars.

Herschel's modified presentation of the nebular hypothesis, and Gummere's criterion, furnish the needful grounds for a satisfactory explanation of such remarkable velocities as that of the inner moon of Mars. They also seem to require that secondary orbs, when they revolve in less time than is required for the rotation of their primaries, should be denser than the primaries. There is therefore good reason for the further prediction that, whenever the density of Phobos is ascertained, it will be found to be greater than that of the planet itself. If Mars has any other moons which have an orbital period of less than twenty-four hours, they should also be of like superior density. In these harmonies, as well as in many others, the pointing to the primeval organizing agency of light is interesting and suggestive. At the theoretical period of each of the harmonic divisions, and at all other stages of nebular condensation, the rhythmical rotation of our day-star has been repeating its unvarying confirmation of the old, old record. In the dim and distant past, in the living present, and through all coming time, from the great "Beginning," until the culmination of prophecy when "the elements shall melt with fervent heat," nothing but divine intervention has disturbed, or can disturb, the equality between the accumulated action of solar gravity for a half-rotation and the velocity of light. The harmonic hypothesis forecasts the same requirement at the surface of the central orb in every stellar system; so that the closing refrain in the hymn of each of the morning stars is, was, and ever shall be:—

"And God said, Let there be light; and there was light."

LVIII. *On the Light reflected by Potassium Permanganate.*

By Sir JOHN CONROY, *Bart., M.A.\**

THE light reflected from the surface of potassium permanganate was originally examined by Haidinger, who announced (*Sitzungsberichte der kaiserlichen Akademie der Wissenschaften*, Band viii. 1852, p. 133), that when the light reflected from the surface of the crystals and of the substance rubbed on a plate of glass was examined with a dichroscopic lens, the portion polarized in the plane of incidence was light yellow at low angles, and became white as the angle increased, whilst the portion polarized perpendicularly was light yellow, and became green and blue as the angle increased.

\* Communicated by the Physical Society.

Professor Stokes found (*Phil. Mag.* vi. 1853, p. 400) that the reflected light contained four bright bands, corresponding in position to the dark bands of the absorption spectrum of a solution of the substance, and that when the reflected light was separated into two streams polarized in, and perpendicular to, the plane of incidence, and then examined by a prism, the bands were hardly visible in the one, and the other at a certain angle consisted mainly of them.

E. Wiedemann has recently published (*Pogg. Ann.* cli. 1874, p. 625) an account of some experiments he has made on the same subject. He found that whilst the dark bands of the reflection spectrum did not even partially cover those of the absorption spectrum, they did not lie exactly intermediate between any two of them—and, further, that the position of the bands was independent of the angle of incidence, both with ordinary light, and with that polarized in the plane of incidence; but with light polarized perpendicularly to this plane, the bands occupied the same position up to a certain angle, and then with a slight increase of the angle suffered sudden displacement towards the blue, and a new band appeared near D. He also found that with light polarized perpendicularly to the plane of incidence, the position of the bands was independent of the nature of the surrounding medium, being the same when the permanganate was in air, benzene, and bisulphide of carbon; but when the light was polarized in the plane of incidence, with the increase of the refractive index of the medium the bands were more and more displaced towards the blue.

For some experiments I have made on the same subject I have used a Babinet's goniometer, which has, in addition to the ordinary horizontal stage, a vertical one so arranged that the reflecting surface can be placed over the axis of the instrument. Sunlight was used, which could be polarized in any plane by a Nicol supported by the fixed arm of the goniometer; and a small direct-vision spectroscope, by Hilger, with a "bright-point" micrometer and a reflecting prism for bringing a second spectrum into the field, was carried by the other arm of the goniometer. By placing a beaker on the horizontal stage, and, after the surface of the permanganate had been properly adjusted, filling it with the liquid and limiting the incident beam by a narrow vertical slit, the light reflected from the surface of the substance when immersed in a liquid could be examined.

The experiments were usually made with potassium permanganate crushed, and burnished with an agate on a piece of finely-ground glass; and it was found that the light reflected from the surface of crystals and from that of the substance rubbed on glass was identical; except that the blue rays were

more intense in the light reflected by the crystals, and the higher bands were more distinctly seen.

The surface-colour of potassium permanganate, and the position and intensity of the bands in the spectrum of the reflected light, are independent of the relative position of the plane of incidence to the long axis of the crystal, or to the striæ produced by rubbing, when the powdered substance burnished on glass is used.

1. *Surface-Colours*.—Freshly prepared surfaces of potassium permanganate appear of a pale yellow when light, either unpolarized or polarized in any plane, is incident upon them at low angles. But with ordinary light, and with light polarized in the plane of incidence, the amount of white light reflected is so great at high angles that the surface-colour, if any, is completely masked.

When the incident light is polarized perpendicularly to the plane of incidence, or when unpolarized light falls on the surface and a Nicol is placed between the eye and the permanganate, with its principal section in the plane of incidence, the surface-colour is seen to change as the angle increases, becoming successively green and blue, and finally white and metallic.

The surface-colours alter with the surrounding medium. The following Table gives, approximately, the colour at various incidences, (A) when the light is either unpolarized or polarized in the plane of incidence, and (B) when it is polarized perpendicularly to that plane, for potassium permanganate in air, tetrachloride and bisulphide of carbon.

Angle of incidence.		Surrounding medium.		
		Air.	Tetrachloride of carbon.	Bisulphide of carbon.
30.	{ A .....	Pale yellow.	Yellow-green.	Yellow-green.
	{ B .....	" "	" "	Green.
35.	{ A .....	Pale yellow.	Yellow-green.	Yellow-green.
	{ B .....	" "	" "	Green.
40.	{ A .....	Pale yellow.	Yellow-green.	Yellow-green.
	{ B .....	" "	Green.	Green.
45.	{ A .....	Pale yellow.	Yellow-green.	Yellow-green.
	{ B .....	" "	Green.	Blue-green.
50.	{ A .....	White.	Yellow-green.	Yellow-green.
	{ B .....	Pale yellow.	Bright green.	Blue-green.
55.	{ A .....	White.	Green.	Yellow-green.
	{ B .....	Yellow, with a green tinge.	Blue-green.	Blue-green.
60.	{ A .....	White.	Green.	Green.
	{ B .....	Brilliant green.	Blue-green.	Blue-green.
65.	{ A .....	White.	Green.	Green.
	{ B .....	Blue-green.	Blue-green.	Blue-green.
70.	{ A .....	White.	Greenish.	Greenish white.
	{ B .....	Blue.	"	" "
75.	{ A .....	White.		
	{ B .....	Metallic, with blue shade.		

2. *Reflection Spectra*.—With unpolarized light, and still more with light polarized in the plane of incidence, the dark bands in the spectrum of the reflected light are never very distinct. I was not able to observe whether the bands shifted or not as the angle of incidence increased, as the amount of white light reflected at angles of  $55^\circ$  and upwards was so great as to render the bands invisible. They appeared, however, as long as they were visible, to coincide exactly with the bright spaces in the absorption spectrum of a dilute solution of potassium permanganate, which was thrown into the field by means of the reflecting prism.

When the incident light is polarized perpendicularly to the plane of incidence, the dark bands are far more distinctly seen. At angles of less than  $40^\circ$  there are four bands, and the blue end of the spectrum is very weak. As the angle of incidence increases, the intensity of the blue rays diminishes; and then the amount of light in the red decreases; and at about  $55^\circ$  nearly the whole of the light comes from the bright bands.

As the angle of incidence increases beyond this amount, the dark bands gradually move towards the blue end of the spectrum; and at about  $60^\circ$  a new band appears near D. With any further increase of the angle more of the blue rays are reflected; and the bands fade away, those in the more refrangible part of the spectrum disappearing first. The relative intensity of the dark bands varies with the angle of incidence. When this is small, the third and fourth bands, counting from the red end, are darkest; with the increase of the angle the second, the first, and finally the new band, become successively darkest.

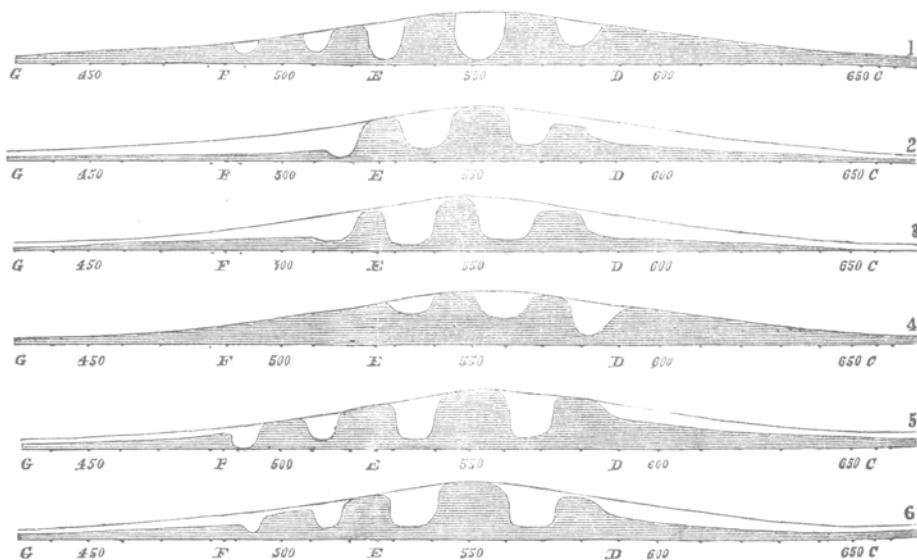
I have not been able to obtain any satisfactory measurements of the amount of the displacement of the bands, as, when a spectroscope of sufficient power to render it an easily measurable quantity is used, the bands become so ill-defined that it is impossible to measure them. Approximately the displacement amounts to about  $\cdot 006$  in "tenth-metres;" and the bands tend to coincide with the dark bands of the absorption spectrum, instead of with the bright bands as they do when the angle of incidence is about  $55^\circ$  or less.

The shaded portions of the diagrams are intended to give the relative amount of light, as determined by eye estimations, in the different portions of the absorption and reflection spectra of potassium permanganate—the ordinates being taken to represent the intensity, and the abscissæ wave-lengths. The curved line gives the intensity of the light in the different portions of the normal spectrum, as determined by Mossotti\* from Fraunhofer's measurements, neglecting the minor irregularities in the curve as given by him.

\* Pogg. *Ann.* lxxii. p. 509.

Fig. 1 is the absorption spectrum of a solution of potassium permanganate in water.

Figs. 2, 3, and 4 the reflection spectra, when the incident light is polarized perpendicularly to the plane of incidence, and falls on the surface at angles of  $50^\circ$ ,  $60^\circ$ , and  $70^\circ$ .



As has already been announced by Wiedemann, the position of the bands in the reflected light depends on the nature of the surrounding medium. From the experiments I have made, it appears that, with unpolarized light, the first dark band of the reflection spectrum corresponds in position with the first bright band of the absorption spectrum, whether the permanganate is in air, benzene, or either bisulphide or tetrachloride of carbon; these liquids, however, act on the permanganate, and after a short time the surface becomes altered, and then the bands correspond with the dark bands of the absorption spectrum.

Figs. 4 and 5 represent the distribution of light in the spectrum, with fresh surfaces of potassium permanganate in bisulphide and tetrachloride of carbon, when unpolarized light is incident upon them at an angle of about  $55^\circ$ : in both cases the bands are wider apart than in air.