LXV. On the dispersion of light

M. Rudberg

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D E C E M B E R 1827.
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LXV. *On the Dispersion of Light.* By M. RUDBERG, of Stockholm.*

IN investigating the principle, according to which, for the explanation of the dispersion of light on the system of undulations, we must suppose that when the light passes from the air into a more refractive medium, the lengths of the undulations are much contracted, in fact much shorter,—I have found that the following relation appears to exist between the length of the undulation of a certain colour in the air, and the corresponding one in any other substance :

$$L = a . l^m ;$$

l being the length of the undulation in the air, and L that in another substance ; and lastly, a, m two numbers which vary only with the nature of the substance.

I have taken the lengths of the undulations in the air as determined by M. Fraunhofer, (Gilbert's *Annals*, 1823, p. 337) viz.

In the red, $C = 0.00002422$ of an inch.

orange, $D = 0.00002175$

green, $E = 0.00001945$

blue, $F = 0.00001794$

indigo, $G = 0.00001587$

violet, $H = 0.00001464$

The lengths of the undulations in other substances being always in the inverse ratio of the indices of refraction, I have inserted them in the first column of each of the following tables, according to the indices of refraction which M. Fraunhofer has published, in his Memoir on the determination of refringent and dispersive power (Schumacher's *Astronomische Abhandlungen*, 1823).

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The comparison of the observed with the calculated lengths is shown in the following tables:

(Schumacher, *Astronom. Abhandl.* 1823. p. 31.)

Flint-glass. No. 13.

$$L = 1.044.l^{1.05}.$$

	Observed lengths.	Calculated lengths.
C	0.00001486	.....
D	0.00001330	0.00001328
E	0.00001184	0.00001181
F	0.00001088	0.00001084
G	0.00000955	0.00000953
H	0.00000876	.....

Flint-glass. No. 23.

$$L = 1.040.l^{1.0496}.$$

	Observed lengths.	Calculated lengths.
C	0.00001487	.....
D	0.00001331	0.00001328
E	0.00001185	0.00001181
F	0.00001089	0.00001085
G	0.00000956	0.00000954
H	0.00000876	.....

Flint-glass. No. 3.

$$L = 1.00218.l^{1.0446}.$$

	Observed lengths.	Calculated lengths.
C	0.00001510	.....
D	0.00001352	0.00001350
E	0.00001204	0.00001201
F	0.00001107	0.00001104
G	0.00000973	0.00000971
H	0.00000892	.....

Flint-glass. No. 30.

$$L = 1.0356.l^{1.049}.$$

	Observed lengths.	Calculated lengths.
C	0.00001490	.....
D	0.00001334	0.00001331
E	0.00001187	0.00001184
F	0.00001091	0.00001088
G	0.00000958	0.00000956
H	0.00000878	.....

Crown-glass. No. 9.

$$L = 0.87045.l^{1.0267}.$$

	Observed lengths.	Calculated lengths.
C	0.00001587	.....
D	0.00001422	0.00001420
E	0.00001268	0.00001267
F	0.00001168	0.00001166
G	0.00001029	0.00001028
H	0.00000946	.....

Oil of Turpentine.

$$L = 0.93479.l^{1.0299}.$$

	Observed lengths.	Calculated lengths.
C	0.00001646	.....
D	0.00001476	0.00001475
E	0.00001315	0.00001313
F	0.00001210	0.00001208
G	0.00001066	0.00001065
H	0.00000980	.....

Crown-glass. No. 13.

$$L = 0.85515.l^{1.025}.$$

	Observed lengths.	Calculated lengths.
C	0.00001587	.....
D	0.00001423	0.00001422
E	0.00001270	0.00001268
F	0.00001169	0.00001167
G	0.00001030	0.00001029
H	0.00000947	.....

Water.

$$L = 0.91343.l^{1.0184}.$$

	Observed lengths.	Calculated lengths.
C	0.00001818	.....
D	0.00001631	0.00001630
E	0.00001456	0.00001454
F	0.00001341	0.00001340
G	0.00001183	0.00001182
H	0.00001089	.....

Although

Although the differences between the calculated and the observed lengths are very small, they are not without influence when we wish to pass from the lengths of undulation to the indices of refraction. But the lengths of undulation in the air not being themselves certainly accurate to a thousandth, and the indices of refraction having a precision at least ten times greater, I have taken the relation between the indices such as it is derived from the supposed ratio to the lengths of undulation, and have then compared it with observation. Calling the index of refraction N , we have:

$$N = \frac{1}{a l^{m-1}}$$

in which, if N' belong to another ray:

$$\frac{N}{N'} = \left(\frac{l'}{l}\right)^{m-1}$$

In another substance, if n, n' are the indices corresponding to the same lengths l, l' , we shall have: $n = \frac{1}{b l^{p-1}}$, and also

$$\frac{n}{n'} = \left(\frac{l'}{l}\right)^{p-1}, \text{ whence, consequently, if } r = \frac{m-1}{p-1} :$$

$$\frac{N}{N'} = \left(\frac{n}{n'}\right)^r.$$

In which equation r ought to be constant. In taking for N the indices of flint-glass, No. 13, and for n the indices of water, we find, For the rays B and C : $r = 2.0430$

$$\text{B and D : } r = 2.2928$$

$$\text{B and E : } r = 2.3802$$

$$\text{B and F : } r = 2.4203$$

$$\text{B and G : } r = 2.5476$$

$$\text{B and H : } r = 2.6402.$$

These values are not precisely the same: the difference between them however has not a great influence in the present case, a small variation in the indices producing a considerable one in r ; if, for example, instead of the index of the ray C in flint-glass, which = 1.6297, 1.6298 be taken, we have $r = 2.1452$ instead of 2.0430; also in taking the mean = 2.39 of all these values, and calculating the indices of flint-glass according to those of water, according to the formula:

$$N = N' \left(\frac{n}{n'}\right)^{2.39}$$

we have the second column of this table:

Observation.	Calculation.	Observation.	Calculation.
B 1.6277	.....	F 1.6482	1.6479
C 1.6297	1.6300	G 1.6602	1.6582
D 1.6350	1.6354	H 1.6710	1.6669
E 1.6420	1.6420		A similar

A similar calculation for the same flint-glass, and the crown-glass, No. 13, gives the following values of r :

According to the rays

B and C : $r = 1.8718$	B and F : $r = 1.9140$
B and D : $r = 1.8970$	B and G : $r = 1.9475$
B and E : $r = 1.9090$	B and H : $r = 1.9748$
Mean value $r = 1.919$.	

And calculating by the formula $N = N' \left(\frac{n}{n'} \right)^{1.919}$

we have for the indices of flint-glass the following values :

C = 1.6298	F = 1.6483
D = 1.6351	G = 1.6598
E = 1.6421	H = 1.6698

Also in comparing, finally, the flint-glass, No. 13, with the crown-glass, Lett. M, we find the subjoined values of r :

According to the rays

B and C : $r = 1.5118$	B and F : $r = 1.6277$
B and D : $r = 1.5833$	B and G : $r = 1.6498$
B and E : $r = 1.6233$	B and H : $r = 1.6590$

Mean value $r = 1.609$.

And calculating the indices of flint-glass by the formula :

$$N = N' \left(\frac{n}{n'} \right)^{1.61} \quad \text{we obtain:}$$

C = 1.6297	F = 1.6480
D = 1.6351	G = 1.6595
E = 1.6419	H = 1.6697

Supplement.

If we calculate the indices of refraction of flint-glass, No. 13, according to the formula :

$$N = 1.6277 \left(\frac{n}{n'} \right)^{2.6}$$

in which the exponent 2.6 is such, that it belongs to the rays B, and the rays H, in flint-glass and in water, which rays, being the most distant from each other, afford the most certain result, we have the second column of the following table :

Observation.	Calculation.	Observation.	Calculation.
B 1.6277	.....	F 1.6482	1.6497
C 1.6297	1.6302	G 1.6602	1.6609
D 1.6350	1.6357	H 1.6710	1.6704
E 1.6420	1.6433		

In returning from flint-glass, No. 13, to water, and calculating the indices of water according to the formula :

$$n = 1.3309 \left(\frac{N}{N'} \right)^{0.39}$$

We find

Observation.	Calculation.	Observation.	Calculation.
B 1.3309	.....	F 1.3378	1.3374
C 1.3317	1.3315	G 1.3412	1.3412
D 1.3335	1.3333	H 1.3441	1.3446
E 1.3358	1.3354		

In comparing flint-glass, No. 13, and oil of turpentine, the values of r are,

According to the rays

B and C : $r = 1.806$	B and F : $r = 1.649$
B and D : $r = 1.689$	B and G : $r = 1.657$
B and E : $r = 1.653$	B and H : $r = 1.670$

And calculating the indices of flint-glass, according to the formula

$$N = 1.6277 \left(\frac{n}{n'} \right)^{1.67}$$

We have

Observation.	Calculation.	Observation.	Calculation.
B 1.6277	.....	F 1.6482	1.6481
C 1.6297	1.6295	G 1.6602	1.6605
D 1.6350	1.6349	H 1.6710	1.6710
E 1.6420	1.6421		

In comparing flint-glass, No. 13, with flint-glass, No. 3, we have the following values of r :

According to the rays

B and C : $r = 1.093$	B and F : $r = 1.120$
B and D : $r = 1.105$	B and G : $r = 1.116$
B and E : $r = 1.125$	B and H : $r = 1.111$

And calculating the indices of flint-glass, No. 13, according to the formula

$$N = 1.6277 \left(\frac{n}{n'} \right)^{1.1}$$

We have

Observation.	Calculation.	Observation.	Calculation.
B 1.6277	.....	F 1.6482	1.6478
C 1.6297	1.6297	G 1.6602	1.6599
D 1.6350	1.6349	H 1.6710	1.6706
E 1.6420	1.6417		

In comparing flint-glass, No. 13, with the solution of potash, we have for r :

According to the rays

B and C : $r = 1.910$	B and F : $r = 2.067$
B and D : $r = 1.959$	B and G : $r = 2.161$
B and E : $r = 2.045$	B and H : $r = 2.213$

And calculating the indices of flint-glass, No. 13, according to the formula

$$N = 1.6277 \left(\frac{n}{n'} \right)^{2.2}$$

We

We have

Observation.	Calculation.	Observation.	Calculation.
B 1·6277	.....	F 1·6482	1·6497
C 1·6297	1·6300	G 1·6602	1·6609
D 1·6350	1·6359	H 1·6710	1·6704
E 1·6420	1·6431		

LXVI. *Description of a Rain-gauge.*

By JOHN TAYLOR, Esq. F.R.S. &c.

[With an Engraving.]

To the Editors of the Philosophical Magazine and Annals.

Gentlemen,

THE object of this little invention was to construct an instrument by which the quantity of rain might be registered for a long period, and observed at any shorter intervals, without any manipulation which might require the attention of a person skilful in such matters.

I wished to place rain-gauges at different stations where machinery worked by water-power was employed, that I might compare the effect of various states of the weather upon the efficiency of the engines; and I was desirous of having an instrument, of which a common observer could give a correct report, and which would perform correctly, without any management or interference, for a considerable length of time, and which would thus of itself check the reports which might be made at intervals. Others may find uses for such a contrivance; and therefore as it seems to answer its purpose very well, I send you a description of it if you deem it worthy a place in your Magazine.

The instrument has been very beautifully made for me, by Mr. Henry Russell, of King's Square, Goswell-street Road, to whom I am indebted also for the arrangement of the train of wheels, and for combining all the parts into a very compact and convenient form.

As Mr. Bevan some time since gave a notice that he had constructed a self-registering rain-gauge, and promised a description of it in your Magazine, I delayed proceeding with mine until he had favoured the public with the account; and then finding that the principle of his very ingenious instrument differed from mine, and that it required so much attention as is necessary to keep the clock attached to it constantly going, I preferred my own, as being independent of any care of this sort.

The plate (Plate IV.) shows the rain-gauge in two views: fig. 1. being designed to exhibit how the water is received
and