identify the inertia of matter with the electric inertia of the electrons, if only we may assume their nuclei to be small enough, or sufficiently numerous. And the fact that these nuclei have free periods of elastic radial vibration in the fluid æther, not subject to damping by radiation, reminds us that a pulsatory theory of gravitation has been developed by Hicks and Bjerknes. There is no recognised fundamental interaction of electric and radiative phenomena with gravitation, so for present purposes we are not bound to produce a precise explanation of gravitation at all. The scope of this remark is restricted to merely showing that a rotational æther is not incompetent to include such an action among its properties.

III. "On the Refractive Index of Water at Temperatures between 0° and 10°." By Sir JOHN CONROY, Bart., F.R.S., Fellow and Bedford Lecturer of Balliol College, and Millard Lecturer of Trinity College, Oxford. Received May 16, 1895.

In 1856 Jamin ('Comptes Rendus,' vol. xliii, p. 1191) published an account of observations he had made on the refractive index of water at temperatures between 30° and 0°. He used an interference method, and found that as the water cooled the index increased.

"La masse totale de l'eau qui d'abord était à 12 degrés, se refroidissant continuellement, arriva bientôt à 4 degrés, c'est-à-dire, au point où les variations de l'indice devraient changer de signe, et où le déplacement des franges devrait être inverse. Mais rien de pareil ne se montra, et en continuant le refroidissement jusqu'à zéro, on continua d'observer une augmentation de l'indice. Il n'y a donc pas de maximum dans la valeur du coefficient de réfraction quand il y en a un dans la densité."

In another experiment the temperature of the column of water through which one of the beams of light passed was kept at 0°, whilst that of the other was gradually raised to 30°; he found by the displacement of the bands that the index decreased steadily. He did not, apparently, publish any numerical values for the indices, but states that they are accurately given by the empirical formula $K_t = K_0 - (0{\cdot}000012573)t - (0{\cdot}000001929)t^2$.

Two years later Gladstone and Dale ('Phil. Trans.,' 1858, p. 887) gave an account of observations that they had made "on the influence of temperature on the refraction of light;" they used a hollow glass prism, and determined the angles of minimum deviation for water, and several other liquids, at various temperatures. They say, "our determinations were performed repeatedly and most carefully on water near the freezing point; they confirm the observations

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of the French physicist" (Jamin) "but show at the same time that the remarkable reversion of the density at 4°, is not without its influence on the amount of sensitiveness; the change of refractive index between 10° and 5° being 0·0002, whilst that between 5° and 0° is only 0·0001."

They give a table for the values of the index to five places, for A, D, and H at eight temperatures between 0° and 11°.

In 1867 Rühlmann ('Pogg. Ann.,' vol. 132, p. 1 and 176) published an account of observations he had made of the refractive index of water at various temperatures; he also used a hollow glass prism and gives the values to five places, for lithium, sodium, and thallium light from 0° to 100°. He states, "Der Brechungsindex des Wassers nimmt stetig ab von 0° bis 80° R., ohne bei dem Dichtigkeitsmaximum irgend eine Abweichung von dem Aenderungsgesetze zu zeigen, mithin die Fortpflanzungsgeschwindigkeit des Lichtes stetig zu."

Lorenz ('Wied. Ann.,' vol. 11 [1880], p. 70) made observations by an interference method, on the refractive index of water between the temperatures of 0° and 34°; and Dufet ('Jour. de Physique' (2), vol. 4 [1885], p. 389) determined the index of water at temperatures above 17° by the minimum deviation method and by an interference method, and also calculated from the results obtained by other observers the rate of change of the index with change of temperature.

Ketteler ('Wied. Ann.,' vol. 33 [1888], pp. 353 and 506) repeated Rühlmann's determinations for temperatures above 20°, using a total reflection refractometer, but did not make any observations at lower temperatures. More recently still, B. Walter has published ('Wied. Ann.,' vol. xlvi [1892], p. 422) a short account of some determinations of the refractive index of water to five places between 0° and 30° for the D line, made, apparently, with great care by the minimum deviation method.

That the refractive index of water increases with the decrease of temperature until the freezing point is reached, appears to be proved, but as few determinations of the values of the refractive indices of water near its point of maximum density have been published, I have ventured, as the matter is one of considerable theoretical importance, to bring before the Society an account of some determinations I have recently made.

The method employed was the ordinary one, the determination of the angle of minimum deviation for a ray of definite wave-length passing through a hollow glass prism containing water at a known temperature.

The goniometer used was made by Messrs. Troughton and Simms, it has an 8-inch circle divided into 10′, and is read by means of two micrometers, directly to 10″, and by estimation to single seconds.

The prism was made by Steinheil; the value of its refracting angle, as determined by six independent measurements, was 60° 1′ 42″±0·8″.

The prism was surrounded by a water-jacket, through which a stream of brine, cooled by a freezing mixture, could be passed.

Openings in the water-jacket allowed the light which had passed through the collimater to reach the prism, and the refracted beam to reach the telescope. The temperature was ascertained by means of a thermometer with its bulb immersed in the water contained in the prism.

The prism was filled with distilled water which had been recently boiled and allowed to cool under reduced pressure.

The determinations were made exclusively with sodium light; it had been originally intended to make observations with lights of different refrangibilities, but it was found that, owing to the brilliancy and constancy of the sodium light, it was not only far easier to make observations with it, but that these observations would certainly be more accurate than those made with light of other refrangibilities.

The prism, not being in actual contact with the water-jacket, cooled very slowly, about four or five hours were usually necessary to reduce its temperature from about 9° to a little above the freezing point.

Owing to the experiments being made at temperatures different from that of the room, and to the temperature of the prism continually, though slowly, altering, it was found impossible to make the determinations by reversing the prism, and then taking half the angle between the two positions of the telescope as the angle of minimum deviation.

Several series of observations were therefore made with the prism in both positions of minimum deviation, and the differences between these readings and those made when the axes of the collimator and telescope were in the same straight line, gave the deviations.

Seven sets of observations were made, and the results are contained in Table I; which gives the deviations for both positions of the prism, and the corresponding refractive indices for the various temperatures.

The angles of deviation differ so little from each other, that any error in the determination of the refracting angle of the prism would not make any difference in the relative values of the indices; it would, of course, affect their absolute values. The probable error calculated by the ordinary formula $\left(0{\cdot}674\sqrt{\frac{\Sigma d^2}{n(n-1)}}\right)$ from the measurements made of the angle of the prism (see above) is ±0·8″. A difference of 1″ in the value of the refracting angle corresponds to two units in the sixth place in the refractive index; the probable

Table I.

Base of prism to right.			Base of prism to left.		
t.	Deviation.	Refractive index.	*t*.	Deviation.	Refractive index.
9·1	23° 39′ 58″	1·333722	8·7	23° 40′ 18″	1·333794
8·7	23 40 08	1·333758	7·8	23 40 26	1·333823
8·3	23 40 06	1·333751	7·6	23 40 25	1·333820
7·7	23 40 14	1·333780	7·3	23 40 26	1·333823
7·1	23 40 19	1·333798	6·7	23 40 35	1·333856
6·6	23 40 22	1·333809	6·3	23 40 37	1·333863
6·2	23 40 25	1·333820	6·2	23 40 34	1·333822
5·5	23 40 32	1·333845	5·6	23 40 41	1·333877
4·9	23 40 38	1·333866	5·4	23 40 47	1·333899
4·3	23 40 47	1·333905	,,	23 40 57	1·333935
3·7	23 40 46	1·333895	4·9	23 40 49	1·333907
3·6	23 40 49	1·333906	,,	23 40 48	1·333902
,,	23 40 51	1·333913	4·8	23 40 59	1·333942
3·3	23 40 51	1·333913	4·1	23 40 51	1·333913
2·9	23 40 58	1·333939	,,	23 40 55	1·333928
,,	23 40 54	1·333924	3·9	23 40 55	1·333928
2·8	23 40 55	1·333928	3·6	23 40 53	1·333890
2·7	23 40 49	1·333906	,,	23 40 54	1·333924
2·4	23 40 59	1·333942	3·2	23 41 04	1·333960
2·3	23 40 59	1·333942	,,	23 40 53	1·333920
2·1	23 40 52	1·333917	3·1	23 40 57	1·333935
2·0	23 41 0	1·333946	2·9	23 40 55	1·333928
,,	23 41 0	1·333946	2·8	23 41 02	1·333963
1·7	23 41 0	1·333946	2·5	23 40 59	1·333942
1·5	23 41 0	1·333946	2·3	23 41 08	1·333975
1·3	23 40 55	1·333928	,,	23 41 03	1·333957
1·2	23 41 07	1·333971	2·2	23 41 04	1·333960
1·0	23 41 06	1·333967	2·1	23 41 0	1·333946
0·9	23 41 19	1·334015	1·9	23 40 59	1·333942
,,	23 41 14	1·333996	1·8	23 41 04	1·333960
0·8	23 41 06	1·333967	1·7	23 40 56	1·333931
,,	23 41 05	1·333964	1·5	23 40 57	1·333935
0·7	23 41 0	1·333946	1·4	23 41 01	1·333950
0·6	23 41 20	1·334018	,,	23 41 05	1·333964
,,	23 41 16	1·334004	1·2	23 41 06	1·333967
0·3	23 41 16	1·334004	1·0	23 41 10	1·333982
,,	23 41 19	1·334015	,,	23 41 03	1·333957
,,	23 41 0	1·333946	0·6	23 41 02	1·333953
0·2	23 41 20	1·334018	,,	23 41 04	1·333960
			0·5	23 40 58	1·333939
			0·4	23 41 04	1·333960
			,,	23 41 0	1·333946
			0·2	23 41 06	1·333967

error in the refractive indices due to the measurement of the refracting angle of the prism is therefore rather less than $\pm 0{\cdot}000002''$.

A difference of 1″ in the value of the angle of minimum deviation

corresponds to 4 units in the sixth place of the refractive index; as the sets of micrometer readings were all fairly concordant, and their probable errors less than 1″, the values of the indices were calculated to six places.

The temperatures at which the observations were made not being identical for the two positions of the prism, it was thought that a graphical method, though, from its nature, somewhat "arbitrary," would give a more truthful result than any arithmetical process of taking the means. The results were therefore plotted on paper divided into squares of 1 mm., 0·2° of temperature being represented by 5 mm. on the axis of abscissæ, 0·00001 of refractive index by 4 mm. on that of the ordinates; and a curve drawn in the ordinary way.

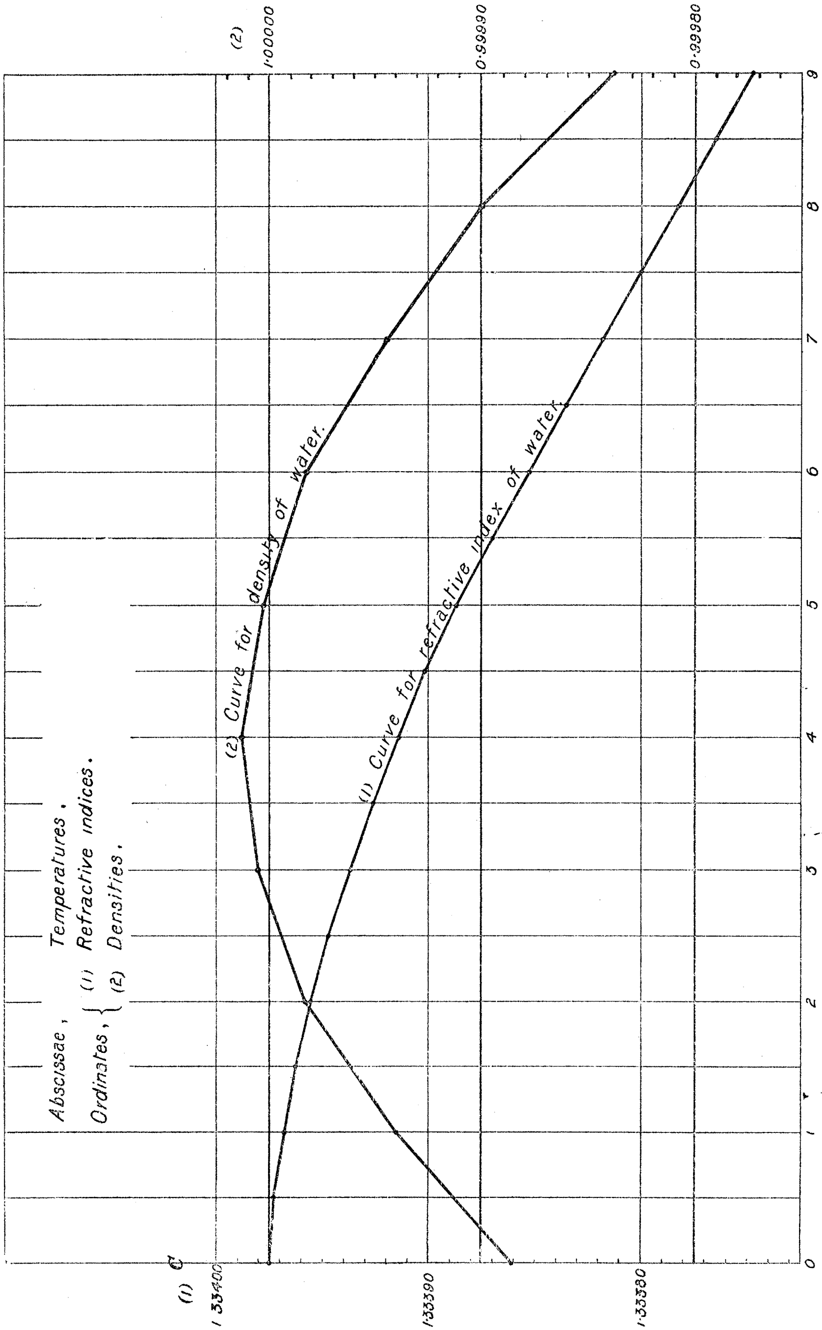
Owing to the scale on which the results were plotted, a good deal of "judgment" was necessary in drawing the curve. It was therefore thought desirable also to plot the results on a smaller scale, so far as the ordinates were concerned; this was done, one unit in the fifth place being represented by 2 mm., and another curve drawn. The values of the index for different temperatures, as given by the two curves were compared and were found to agree satisfactorily; and it therefore seemed probable that the curves were really fair representations of the observations.

In the first column of Table II the values of the refractive indices, relative to air, for each degree as deduced from the curves, are given to five places; in the second the values as found by Walter, and in the third and fourth those for sodium light, given by Gladstone and Dale, and Rühlmann.

Table II.—Refractive Indices of Water.

t.	C.	W.	*t.*	G and D.	*t.*	R.
0°	1·33397	1·33401	0·0°	1·33374	0·0°	{ 1·33375 1·33380
1	1·33397	1·33400	4·0	1·33367		
2	1·33396	1·33398	6·5	1·33356	1·5	1·33375
3	1·33394	1·33396	9·0	1·33342	4·0	1·33372
4	1·33392	1·33393	—	—	5·0	1·33371
5	1·33389	1·33390	—	—	5·8	1·33368
6	1·33385	1·33387	—	—	9·9	1·33355
7	1·33382	1·33383	—	—	10·0	1·33353
8	1·33378	1·33379	—	—	—	—
9	1·33375	1·33374	—	—	—	—

The values show that the refractive index of water, as was first announced by Jamin, increases continuously up to the freezing point, the rate of increase, however, seems to change about 4°, the temperature of maximum density, as was pointed out by Gladstone and Dale.



Abscissae, Temperatures.
Ordinates, (1) Refractive indices. (2) Densities.
(2) Curve for density of water.
(1) Curve for refractive index of water.
(2) 1·00000
0·99990
0·99980
(1) 1·33400
1·33390
1·33380
C
0
1
2
3
4
5
6
7
8
9

Curve (1) gives the values of the refractive indices at temperatures between 0° and 9°, as determined by the experiments, of which an account has been given in this paper; and curve (2) the densities of water at the same temperatures as given in Lupton's 'Numerical Tables' (p. 28).

These curves show clearly that no formula representing the variation of the refractive index of water with the temperature, as a function of the density only, can be a complete expression of the facts of the case.

IV. "On the Magnetic Rotation of the Plane of Polarisation of Light in Liquids. Part I. Carbon Bisulphide and Water."

By J. W. RODGER, Assoc.R.C.S., Demonstrator of Chemistry, and W. WATSON, B.Sc., Assoc.R.C.S., Demonstrator of Physics, Royal College of Science, London. Communicated by Professor A. W. RÜCKER, F.R.S. Received June 1, 1895.

(Abstract.)

The aim of this investigation is the determination in absolute measure of the magnetic rotation of liquids at different temperatures, the effect of the chemical nature of the liquid on this property, and its correlation with other physical properties.

The present communication contains a description of the apparatus and method of experiment, and the results obtained with the standard liquids, carbon bisulphide and water, for sodium light, in a magnetic field of constant intensity, and at different temperatures between 0° and the ordinary boiling point.

The magnetic field was produced by means of a helix consisting of two separate coils, either of which, if desired, could be used separately. During the process of winding, the dimensions of each layer were carefully determined, and every precaution was taken to ensure good insulation.

The liquid under examination was contained in a glass tube closed by very thin glass plates. This tube was surrounded by a brass jacket, which passed through the coils. Observations could be made at different temperatures, and the temperature could be kept constant while making a set of readings by causing water, or the vapour of liquids boiling under different pressures, to circulate through the jacket.

Special pains were taken to obtain monochromatic light, with the result that in the case of carbon bisulphide, where the double rotation amounted to 40°, there was no trace of coloration.