near the sea-coast of Georgia (U.S.A.). In these three-days cyclonic storms, before the rain begins and usually before the lowest strata of air are sensibly disturbed by the upper currents, the low-lying dense masses of clouds coming from the north-east scud across the skies with great rapidity. Under these circumstances, during moonless nights, the general illumination is sufficient to plainly indicate the road to the traveller, even when it is bordered by tall overhanging trees. Under ordinary circumstances, an equivalent degree of cloudiness would have compelled the traveller to abandon all attempts at guiding the horse, and to rely entirely upon the superior acuteness of the nocturnal vision of his equine companion. In such storms, the cloudiness involves the entire firmament, and there are no electrical manifestations. To the traveller, the general illumination apparently surpasses that of a starlight cloudless night.

Now the question is, What is the origin and source of this general nocturnal illumination on cloudy moonless nights? No degree of cloudiness seems to completely obliterate the faint illumination. For, as Arago intimates, even when the heavens are overcast, during moonless nights, and the stars are hidden by an unbroken mass of the most dense clouds, there is a sufficiency of diffused light in the open country to prevent the difficulty and inconvenience which would attend any attempt to walk in the Cimmerian darkness of a cavern.

It is a popular opinion that the clouds act like ground-glass lamp-shades in diffusing the aggregate starlight, so as to produce a faint illumination from all parts of the sky, and thus obliterating shadows on the surface of the earth due to the greater amount of light radiated from the more luminous regions of the celestial vault. But Arago justly maintains that when we consider the immense effect of clouds in weakening the dazzling light of the sun on particular days in winter, it is scarcely possible to admit that the faint diffused light, which, on a cloudy night, guides the steps of the traveller, comes from the stars. In other terms, in view of the loss from reflection and absorption, the amount of starlight penetrating the cloud-canopy seems to be quite inadequate to account for the degree of general illumination observed at the surface of the earth. If we exclude the stellar origin, there remains no other explanation of the nocturnal light of a clouded sky, except the admission that the clouds themselves have a luminosity of their own. This is the view taken by Arago.

But since, for all degrees of obscuration, more or less of the starlight incident upon the canopy of clouds must penetrate it, and be diffused at the surface of the earth, this source of luminosity must be looked upon as a *vera causa*. Its adequacy to explain the observed illumination in any given case will depend upon the density of the overcasting cloudy masses and upon the sensitiveness of the human organ of vision. Hence it seems to be more rational to conclude that some portion of the nocturnal luminosity of clouds may be due to the faint diffused starlight; but that, when the amount of illumination from comparatively dense noctilucous clouds surpasses that of clear moonless nights, we are warranted in assigning them self-luminous properties. This seems to have been the condition of the low, dense, and rapidly-drifting clouds observed by me during the incipient stages of north-east storms on the Atlantic coast. Moreover, the fact that an equal degree of cloudiness is not always attended with an equal amount of illumination points to the same conclusion. In other words, it seems to be reasonable that the degree of luminosity sometimes manifested in the deep winter nights, when the whole heavens are overcast with dense clouds, is vastly too great to be due to diffused stellar light, and is more probably ascribable to the greater or less self-luminous properties of the clouds themselves.

In the case of isolated clouds, augmented nocturnal brightness may be due to well-known local causes, independent of self-luminosity. For example, the source of the brightness of the clouds observed by Prof. Piazzi Smyth in 1882 and 1883, was traced by him to the reflection of the gas-lights of the city of Edinburgh, from water-drops in the clouds (NATURE, vol. xxviii. p. 239). In like manner, the bright nocturnal clouds observed by Mr. T. W. Backhouse and others in 1886 (NATURE, vol. xxxiv. pp. 239, 312, 386) were probably due to bands of lofty clouds illuminated by the lingering sunlight.

But even in cases in which the noctilucous condition of the clouds is general, it is more than possible that the starlight illumination may be reinforced by the prolonged twilights due to the reflection of sunlight from attenuated solid particles suspended in the supra-cirrus strata of the atmosphere, such as were manifested after the Krakatão eruption in the autumn of 1883. Moreover, in certain cases the stellar illumination may be strongly augmented by cloud-obscured auroral lights. These several possible sources of extra-stellar illumination of the sky during cloudy nights seem almost to preclude the necessity of the assumption of the existence of the condition of self-luminosity of clouds under any circumstances.

But, admitting the occasional self-luminous condition of clouds, the question is, What are the physical causes of their luminosity? It is customary to refer such obscure luminous phenomena to phosphorescence or to electricity. But it must be confessed that, in the absence of definite knowledge of the physical causes of the phosphorescence of clouds, on the one hand, or of distinct electrical manifestations in such clouds, on the other, such explanations, so far from enlightening us, would seem to be more akin to illustrating the obvious by the obscure.

Seafaring men must have had numerous opportunities of observing nocti'ucous clouds in various latitudes under every degree of obscuration; but I do not, at present, recollect any reference to such observations on the ocean. In "The Voyage of H.M.S. *Challenger*," in the "Memorandum of Meteorological Observations," under head "Weather," there is a record of the "visibility of distant objects"; but I have been unable to find any night-observations of visibility ("Narrative," vol. ii. p. 300 *et seq.*).

Berkeley, California, August 30. JOHN LE CONTE.

## ON BOSCOVICH'S THEORY.[1]

WITHOUT accepting Boscovich's fundamental doctrine that the ultimate atoms of matter are points endowed each with inertia and with mutual attractions or repulsions dependent on mutual distances, and that all the properties of matter are due to equilibrium of these forces, and to motions, or changes of motion produced by them when they are not balanced; we can learn something towards an understanding of the real molecular structure of matter, and of some of its thermodynamic properties, by consideration of the statical and kinetic problems which it suggests. Hooke's exhibition of the forms of crystals by piles of globes, Naviers's and Poisson's theory of the elasticity of solids, Maxwell's and Clausius's work in the kinetic theory of gases, and Tait's more recent work on the same subject—all developments of Boscovich's theory pure and simple—amply justify this statement.

Boscovich made it an essential in his theory that at the smallest distances there is repulsion, and at greater distances attraction; ending with infinite repulsion at infinitely small distance, and with attraction according to Newtonian law for all distances for which this law has been proved. He suggested numerous transitions from attraction to repulsion, which he illustrated graphically by a curve—the celebrated Boscovich curve—to explain cohesion, mutual pressure between bodies in contact, chemical affinity, and all possible properties of matter—except heat, which he regarded as a sulphureous essence or virtue. It seems now wonderful that, after so clearly stating his fundamental postulate which included inertia, he did not see inter-molecular motion as a necessary consequence of it, and so discover the kinetic theory of heat for solids, liquids, and gases; and that he only *used* his inertia of the atoms to explain the known phenomena of the inertia of palpable masses, or assemblages of very large numbers of atoms.

It is also wonderful how much towards explaining the crystallography and elasticity of solids, and the thermo-elastic properties of solids, liquids, and gases, we find without assuming more than one transition from attraction to repulsion. Suppose, for instance, the mutual force between two atoms to be repulsive when the distance between them is $< Z$; zero when it is $= Z$; and attractive when it is $> Z$: and consider the equilibrium of groups of atoms under these conditions.

[1] Abstract by the Author of a communication to Section A of the British Association, on Friday, September 13, at Newcastle.

A group of two would be in equilibrium at distance Z; and only at this distance. This equilibrium is stable.

A group of three would be in stable equilibrium at the corners of an equilateral triangle, of sides Z; and only in this configuration. There is no other configuration of equilibrium except with the three in one line. There is one, and there may be more than one, configuration of unstable equilibrium, of the three atoms in one line.

The only configuration of stable equilibrium of four atoms is at the corners of an equilateral tetrahedron of edges Z. There is one, and there may be more than one, configuration of unstable equilibrium of each of the following descriptions:—

(1) Three atoms at the corners of an equilateral triangle, and one at its centre.

(2) The four atoms at the corners of a square.

(3) The four atoms in one line.

There is no other configuration of equilibrium of four atoms, subject to the conditions stated above as to mutual force.

In the verbal communication to Section A, inportant questions as to the equilibrium of groups of five, six, or greater finite numbers, of atoms were suggested. They are considered in a communication by the author to the Royal Society of Edinburgh, of July 15, to be published in the Proceedings before the end of the year. The Boscovichian foundation for the elasticity of solids with no inter-molecular vibrations was slightly sketched, in the communication to Section A, as follows.

Every infinite homogeneous assemblage[1] of Boscovich atoms is in equilibrium. So, therefore, is every finite homogeneous assemblage, provided that extraneous forces be applied to all within influential distance of the frontier, equal to the forces which a homogeneous continuation of the assemblage through influential distance beyond the frontier, would exert on them. The investigation of these extraneous forces for any given homogeneous assemblage of single atoms—or of groups of atoms as explained below—constitutes the Boscovich equilibrium-theory of elastic solids.

To investigate the equilibrium of a homogeneous assemblage of two or more atoms, imagine, in a homogeneous assemblage of groups of $i$ atoms, all the atoms except one held fixed. This one experiences zero resultant force from all the points corresponding to it in the whole assemblage, since it and they constitute a homogeneous assemblage of single points. Hence it experiences zero resultant force also from all the other $i - 1$ assemblages of single points. This condition, fulfilled for each one of the atoms of the compound molecule, clearly suffices for the equilibrium of the assemblage, whether the constituent atoms of the compound molecule are similar or dissimilar.

When all the atoms are similar—that is to say, when the mutual force is the same for the same distance between every pair—it might be supposed that a homogeneous assemblage, to be in equilibrium, must be of single points; but this is not true, as we see synthetically, without reference to the question of stability, by the following examples, of homogeneous assemblages of symmetrical groups of points, with the condition of equilibrium for each when the mutual forces act.

*Preliminary.*—Consider an equilateral[2] homogeneous assemblage of single points, O, O′, &c. Bisect every line between nearest neighbours by a plane perpendicular to it. These planes divide space into rhombic dodekahedrons. Let $A_1OA_5$, $A_2OA_6$, $A_3OA_7$, $A_4OA_8$, be the diagonals through the eight trihedral angles of the dodekahedron inclosing O, and let $2a$ be the length of each. Place atoms $Q_1$, $Q_5$, $Q_2$, $Q_6$, $Q_3$, $Q_7$, $Q_4$, $Q_8$, on these lines, at equal distances, $r$, from O; and do likewise for every other point, O′, O″, &c., of the infinite homogeneous assemblage. We thus have, around each point A, four atoms, Q, Q′, Q″, Q‴, contributed by the four dodekahedrons of which trihedral angles are contiguous in A, and fill the space around A. The distance of each of these atoms from A is $a - r$.

Suppose, now, $r$ to be very small. Mutual repulsions of the atoms of the groups of eight around the points O will preponderate. But suppose $a - r$ to be very small: mutual repulsions of the atoms of the groups of four around the points A will preponderate. Hence for some value of $r$ between O and $a$, there will be equilibrium. There may, according to the law of force, be more than one value of $r$ between O and $a$ giving equilibrium; but whatever be the law of force, there is one value of $r$ giving *stable* equilibrium, supposing the atoms to be constrained to the lines OA, and the distances $r$ to be constrainedly equal. It is clear from the symmetries around O and around A, that neither of these constraints is necessary for mere equilibrium; but without them the equilibrium might be unstable. Thus we have found a homogeneous equilateral distribution of 8-atom groups, in equilibrium. Similarly, by placing atoms on the three diagonals, $B_1OB_4$, $B_2OB_5$, $B_3OB_6$, through the six tetrahedral angles of the dodekahedron around O, we find a homogeneous equilateral distribution of 6-atom groups, in equilibrium.

Place, now, an atom at each point O. The equilibrium will be disturbed in each case, but there will be equilibrium with a different value of $r$ (still between $o$ and $a$). Thus we have 9-atom groups and 7-atom groups.

Thus, in all, we have found homogeneous distributions of 6-atom, of 7-atom, of 8-atom, and of 9-atom groups, each in equilibrium. Without stopping to look for more complex groups, or for 5-atom or 4-atom groups, we find a homogeneous distribution of 3-atom groups in equilibrium by placing an atom at every point O, and at each of the eight points $A_1$, $A_5$, $A_2$, $A_6$, $A_3$, $A_7$, $A_4$, $A_8$. This we see by observing that each of these eight A's is common to four tetrahedrons of A's, and is in the centre of a tetrahedron of O's; because it is a common trihedral corner point of four contiguous dodekahedrons.

Lastly, choosing $A_2$, $A_3$, $A_4$, so that the angles $A_1OA_2$, $A_1OA_3$, $A_1OA_4$ are each obtuse,[1] we make a homogeneous assemblage of 2-atom groups in equilibrium by placing atoms at O, $A_1$, $A_2$, $A_3$, $A_4$. There are four obvious ways of seeing this as an assemblage of di-atomic groups, one of which is as follows:—Choose $A_1$ and O as one pair. Through $A_2$, $A_3$, $A_4$ draw lines same-wards parallel to $A_1O$, and each equal to $A_1O$. Their ends lie at the centres of neighbouring dodekahedrons, which pair with $A_2$, $A_3$, $A_4$ respectively.

For the Boscovich theory of the elasticity of solids, the consideration of this homogeneous assemblage of double atoms is very important. Remark that every O is at the centre of an equilateral tetrahedron of four A's; and every A is at the centre of an equal and similar, and same-ways oriented, tetrahedron of O's. The corners of each of these tetrahedrons are respectively A and three of its twelve nearest A neighbours; and O and three of its twelve nearest O neighbours. By aid of an illustrative model showing four of the one set of tetrahedrons with their corner atoms painted blue, and one tetrahedron of atoms in their centres, painted red, the mathematical theory which the author had communicated to the Royal Society of Edinburgh, was illustrated to Section A.

In this theory it is shown that in an elastic solid constituted by a single homogeneous assemblage of Boscovich atoms, there are in general two different rigidities, $n$, $n_1$, and

[1] "*Homogeneous assemblage of points*, or *of groups of points*, or *of bodies*, or *of systems of bodies*," is an expression which needs no definition, because it speaks for itself unambiguously. The geometrical subject of homogeneous assemblages is treated, with perfect simplicity and generality by Bravais, in the *Journal de l'École Polytechnique*, cahier xix. pp. 1–128 (Paris, 1850).

[2] This means such an assemblage as that of the centres of equal globes piled homogeneously, as in the ordinary triangular-based, or square-based, or oblong-rectangle-based, pyramids of round shot or of billiard balls.

[1] This also makes $A_2OA_3$, $A_2OA_4$, and $A_3OA_4$ each obtuse. Each of these six obtuse angles is equal to $180° - \cos^{-1}(1/3)$.

one bulk-modulus, $k$; between which there is essentially the relation

$$3k = 3n + 2n_1,$$

whatever be the law of force. The law of force may be so adjusted as to make $n_1 = n$; and in this case we have $3k = 5n$, which is Poisson's relation. But no such relation is obligatory when the elastic solid consists of a homogeneous assemblage of double, or triple, or multiple Boscovich atoms. On the contrary, any arbitrarily chosen values may be given to the bulk-modulus and to the rigidity, by proper adjustment of the law of force, even though we take nothing more complex than the homogeneous assemblage of double Boscovich atoms above described.

The most interesting and important part of the subject, the kinetic, was, for want of time, but slightly touched in the communication to Section A. The author hopes to enter on it more fully in a future communication to the Royal Society of Edinburgh. WILLIAM THOMSON.

## NOTES.

THE model of a memorial to Prjevalsky, which is to be erected on the shore of Lake Issyk-kul, is being exhibited at St. Petersburg. It represents a rock, upon which an eagle is descending, having a map of Asia in its talons, and an olive branch in its beak. The monument will have the inscription: "To the first explorer of Nature in Central Asia."

THE Durban Correspondent of the *Times* telegraphs that the Cape Government has decided to adopt Prof. Seeley's proposal for a geological survey under his charge. He believes that other eruptive diamond-bearing tracts like Kimberley exist elsewhere.

IT is understood that a sum of £2000 has been presented to the University of St. Andrews for the purpose of erecting buildings and equipping a chemical laboratory in connection with the Chemical Chair in the United College of St. Andrews.

THE late Alderman George, of Leeds, has bequeathed £10,000 to the Yorkshire College.

THE Harveian Oration will be delivered at the Royal College of Physicians by Dr. James E. Pollock, at 4 o'clock precisely, on Friday, October 18.

THE Queen has been pleased, on the recommendation of the Secretary for Scotland, to appoint Mr. R. Fitzroy Bell, advocate, to be Secretary to the Scottish University Commissioners, constituted under the Universities (Scotland) Act of last session.

ON Monday the International Congress of the Ethnographic Sciences was opened in Paris, at the Trocadéro, under the presidency of M. Jules Oppert, Member of the Institute and Professor at the College of France. In opening the proceedings M. Oppert defined the province of ethnography, and enumerated six sections into which the Committee of the Congress had divided the ethnographic sciences. These were: (1) general ethnology; (2) ethics and sociology; (3) ethnographic pyschology; (4) comparative religion, with a sub-section devoted to Buddhism; (5) philology; and (6) archæology and the fine arts.

THE Congress on Hydrology and Climatology meets in Paris to-day. After the meeting there will be an excursion to the Vosges.

AT the Colonial Exhibition in Paris, visitors may now obtain pamphlets, issued by the French Government, concerning the different colonies, their resources, and the advantages they offer to immigrants. Those relating to the Victoria and the New Zealand exhibits are very good.

AT St. Petersburg, on September 7, several Pulkova astronomers and geodesists took advantage of the ascent of a balloon, belonging to the Technical Society, to test the accuracy of barometrical measurements. The aëronauts, who reached a height of 1800 metres, took with them, besides chronometers and various meteorological instruments, a barometer, a barograph, and an aneroid; and they obtained, in addition to the curve of the barograph, the various heights at which the balloon stood during its ascent and descent for twenty-eight different moments. The heights obtained from these measurements will be compared with those found by geodetical angular measurements, which were made at five different places as far distant from one another as Cronstadt, the St. Petersburg University, Kolpino, and Pargolovo; that is, at distances of more than thirty miles between the extreme stations. The geodetical measurements thus secured are now being calculated.

THE Brussels Correspondent of the *Times* points out that the number of foreign students at the German Technical High Schools is steadily increasing, especially at Berlin, where, last year, there were thirteen English students preparing for the professions of mechanical and mining engineers, architects, and chemists.

WE regret to announce the death, at Manila, on July 28 last, of Senor Don Sebastian Vidal, Inspector-General of the Philippine Island Forests and Director of the Manila Botanic Garden. He held the post for a considerable period, and was the author of numerous important works on Philippine botany. He paid two visits to this country in his official capacity; a first of two months' duration, in the autumn of 1877, and a second of four months', in 1883–84. Both periods were spent at Kew in working up the Philippine flora; and he deposited in the Herbarium a set of no less than 4062 specimens for future reference. His published works are:—"Catalogo metódico de la Plantas Leñosas observadas en la Provincio de Manila," 1880; "Rĕsena de la Flora del Archipiélago Filipino," 1883; "Sinopsis de Familias y Generos de Plantas Leñosas de Filipinas," 1883, with an atlas of 100 folio lithographed plates; "Phanerogamæ Cumingianæ Philippinarum," 1885; and "Revision de Plantas Vasculares Filipinas," 1886. The two latter were the result of his last visit to Kew, and he was assisted in their preparation by Mr. R. A. Rolfe of that establishment. Senor Vidal was the first to investigate the Philippine flora since the time of Blanco (when geographical botany as a science was practically non-existent), and we owe to him, not merely a widely extended knowledge of its constitution, but also the establishment of the fact that the Philippine flora, though substantially Malayan in character, yet presents a number of very important peculiarities. We cannot but announce the death of so energetic and promising a worker with profound regret, and hope that his successor will carry on the work with the same amount of success.

AN Indian native paper announces that the Newab of Junagadh has communicated with the Meteorological Department of the Government of India offering to start an observatory at Verawal, and to make suitable arrangements for the exhibition of storm signals for apprising the shipping of the port of the advent of storms in the Arabian Sea. The Dewan of His Highness has offered a building for housing the meteorological instruments, and proposes to erect a shed for the reception of the thermometers on a site near the seashore of Verawal, and to assist generally the Meteorological Department to start an observatory.

MR. HOWARD CUNNINGHAM, the Honorary Curator of the Wiltshire Museum, writes complaining that the monoliths of Stonehenge are being defaced by the names and initials of visitors, and that the inclosure has become "like a pigsty," owing to the litter of broken bottles and other relics of the British holiday-maker. The state of one of the most ancient and interesting of