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Physical Theories of Gravitation

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	No. 1.	No. 2.
Weight of powder	.5882 gram.	.4559 gram.
$Si O_2$ found	95.53%	96.14%
$Al_2 O_3$ plus traces of $Fe_2 O_3$	4 59%	4.01%
Total	100.12	100 15

The force of adhesion to a wet surface was estimated at 200 grams per square centimeter, or about one-fifth of an atmosphere, but it may be much greater. If applied to a poisoned wound at once it would undoubtedly absorb some of the poison and so assist in the cure. The popular belief in its efficacy has therefore, some foundation in fact.

If more of this rock can be secured it is our intention to test the rapidity of its absorption of moisture from the air when cut in thin slices, with a view to its use as a hygrometer.

The vein in which the specimen was found is twenty feet wide, nearly vertical, and strikes westward. The contents of the vein are chiefly light and dark blue translucent quartzite, mixed with amorphous clay and iron oxide, and bordered by a thin blanket of limestone. Some of the translucent quartzite is mixed with light gray mad stone, as if the firmer portions were formed by fusion of the light gray material. The latter agrees very closely in composition, as well as in appearance, with the silicious shells already mentioned, and was probably formed from them by the internal heat of the vein.

PHYSICAL THEORIES OF GRAVITATION.

T. PROCTOR HALL.

A force which belongs to individual atoms, is independent of chemical and physical conditions, and cannot be altered or destroyed by any known means, must be closely related to the fundamental nature of the atoms. One of the most essential parts in our concept of matter is mass, and the force of gravitation of an atom is proportional to its mass. Mass and gravitation stand, therefore, either as co-effects of the same cause or as cause and effect. The force exerted by each atom at any point decreases in proportion to the increase of the expanding

spherical surface containing the point; following the law of all forces expanding in three-fold space, which may be stated thus: Force x area of distribution=a constant.

From this fact it is evident that the distribution of the force of gravitation is confined to threefold space; for, since the boundary of a fourfold sphere is a solid, a force expanding in all directions from a point in fourfold space decreases in intensity in proportion to the increase of the boundary, that is to say, in proportion to the cube of the radius, instead of following Newton's law.

Newton's law has been experimentally proved for distances that are very great compared with the diameter of an atom, and to a degree of accuracy limited by errors of experiment. It does not necessarily follow that the law holds with absolute accuracy, or that it holds at all for distances comparable with atomic dimensions. All that we can say is that for distances moderate and great the law expresses the facts as accurately as they have been experimentally determined.

Gravitation is not, like magnetism, polar. In crystals atoms have an orderly arrangement, yet no difference has been found in the weight of any crystal when it is set on end or laid on its side. This fact, along with the complete independence of electric conditions, show that gravitation is neither an electric nor a magnetic phenomenon.

The ether, so far as our knowledge goes, is a homogeneous isotropic continuum. In the conveyance of light and of electric strain it shows the properties of an elastic solid. To planetary motions and to ordinary motions on the earth it offers no appreciable resistance, and may therefore be called a fluid. Michelson and Morley have shown that the ether close to and in the earth moves with the earth, which indicates that the ether does not move among atoms without some resistance corresponding to friction. The existence of an ether strain such as that in a leyden jar also shows that there is a resistance on the part of the ether to the kind of motion that takes place in the electric discharge. Ether has mass, since it conveys energy by waves which have a finite velocity. Lord Kelvin has pointed out that the apparently inconsistent properties of the fluid-solid ether are analogous with the properties of ordinary matter. Pitch or taffy, either of which can be bent or moulded easily by a steady pressure, is shattered like glass by a quick blow from a hammer. The ether in like manner yields easily before

moving bodies whose velocity is relatively small, not exceeding a few hundred kilometers per second, but acts as a solid toward such high velocities as that of light, which is nearly 300,000 kilometers per second. Copper, again, is a familiar example of a metal having nearly perfect elasticity within a certain limit of strain. Beyond that limit it yields to pressure like a fluid. The ether shows the same combination of properties with a wider limit of strain. Ether in a vacuum will bear a very great electrical strain without yielding; so that the most perfect vacuum attainable is an all but perfect non-conductor; but if atoms be present the ether gives way to the stress and a current passes very much more readily. This indicates that there is some sort of discontinuity at or near the surface of the atoms.

One of the oldest theories of gravitation was proposed by Le Sage and elaborated by him for a lifetime. He supposed the atoms to have an open structure, something like wire models of solid figures, and to be exposed to a continuous storm of exceedingly minute "ultramundane corpuscles" which he assumed to be flying about in all directions with inconceivable velocity. Two atoms shelter each other from this storm in direct proportion to the quantity of matter in each and inversely as the square of their distance apart, and are therefore driven together in accordance with Newton's law. The ultramundane corpuscles are supposed so small that no atomic vibrations corresponding to heat or light are caused by their impact.

Le Sage's theory is unsatisfactory because it takes no account of the ether, which for such high velocities acts as a solid and would bring the little flying corpuscles to comparative rest in a small fraction of a second.

Kelvin has proposed a modification of Le Sage's theory in order to accommodate it to the existence of the ether. He first showed that vortex rings have some of the properties of elastic solids, and in a perfect fluid would be indestructible; then suggested that atoms may be vortex rings of ether, and the ultramundane corpuscles very much smaller vortex rings having high velocities of translation. In order to account for the permanence of atoms and corpuscles, this view presupposes a practically frictionless fluid ether, which does not at all correspond with the actual ether.

Maxwell, after deducing the mathematical theory of electricity from the hypothesis of ether strain, showed that gravi-

tation also could be accounted for on a similar hypothesis, and that the properties required for the propagation of gravitation are similar to those exhibited by the ether in the phenomena of light and electricity. This theory is the only one that is in harmony with what is known of both gravitation and the ether. It is simple, and makes no assumptions whatever regarding the nature of matter or of atoms. It is incomplete in that it leaves the nature of the strain undetermined.

The non-polar character of gravitation, its symmetry in every way about the atom, reduces to two the possible kinds of strain required by Maxwell's hypothesis. These are displacements of ether radially (1) outward from or (2) inward toward the atom. Assuming, as is customary, that the ether is incompressible, the radial displacement over a spherical surface about the atom is constant; and therefore the displacement and the intensity of the stress at any point varies inversely as the square of its distance from the atom. It is not necessary to suppose, either, that the atom itself is spherical or that the displacements in its immediate vicinity are directed toward or from a single point; for at the distance of a single centimeter from the atom the surface of equal displacement must be so nearly spherical that the most accurate observation now possible would fail to detect any irregularity. Possibly variations in the form of the atom or in the direction of displacement immediately around it may be the cause of the chemical properties of the atom, since these are apparent only at very small distances from it.

For the sake of clearness let us suppose that outward displacement of the ether is caused by the insertion of a quantity of matter, an atom, at any point. Draw a cone having the center of displacement for its vertex. Any small element in this cone is by its outward displacement shortened and widened; so that there is on each end of the conical element a pressure, and in all directions perpendicular to the pressure a tension due to the stretching of the expanded spherical shell containing the element.

Suppose, also, for the sake of clearness, that inward displacement is produced either by cutting out small portions of the ether and leaving holes (atoms) toward which the strain is directed, or by condensing small portions of the ether into atoms. An element of the cone is by its inward displacement lengthened and made narrower, and has a tension on each end and a pressure in all directions perpendicular to the tensions.

The strain in each case extends to infinity, or as far as the ether extends. If the displacement of ether were prevented from extending on one side by a rigid imaginary wall, the whole strain on that side would take place between the atom and the wall, and would be more intense than on the opposite side. The atom would tend to move in such direction as to decrease the intensity of the strain, namely, from the wall if the displacement were outward, toward the wall if the displacement were inward. By the same reasoning two atoms repel each other if the displacement is outward, and attract if it is inward. The law of gravitation is thus explained on the hypothesis that each atom is accompanied by an inward displacement of the surrounding ether, proportional in amount to the mass of the atom.

Minchin (Statics, fourth edition, vol. 2, p. 475,) by a course of mathematical reasoning has reached the same conclusion.

If the atoms be regarded as cavities, the mass of an atom is represented by the quantity of ether removed, which represents also the volume of the atom. Since atomic volume is not proportioned to atomic weight, the cavity-atom hypothesis must be abandoned.

On the condensation hypothesis the mass of an atom is the quantity of ether condensed, its volume the space occupied on the average by the condensed mass which may have any kind of irregularity of form.

This hypothesis implies that all atoms are built out of the same original stuff, and is in this respect similar to but not identical with Prout's hypothesis. The fact that all atoms attract with forces proportional to their masses shows that all atoms possess the same kind of mass, and are therefore likely to consist of the same sort of stuff.

Valence, selective affinity, electric and other peculiarities of atoms, must, if this hypothesis of gravitation be correct, find their explanation in the form and density of the atom, the distribution of its stuff in space, which can be expressed as a function of the three space co ordinates; together with the laws of energy, which express the relations of the atom to the ether. The field of force about an atom is also capable of representation by a function of the space co-ordinates such that when the distance r from the atom is relatively great the equipotential surfaces are very nearly spheres.

Stress in its ultimate analysis is probably dynamic. If so, the maintenance of the field of strain about an atom as it moves presents no greater difficulty than the maintenance of the field of light about a moving candle, or of the field of sound about a moving bell.

The propagation of such ether strains as occur in light, electricity and magnetism is very greatly influenced by the material substances present in the strained medium. It is not probable that the gravitational strain differs from others in this respect, and we may reasonably hope to find some inductive phenomena in connection with gravitation. A feasible plan is to surround a delicately poised mass by a thick pair of hemispheres (which may be hollow for liquids), and note with a refractometer any change of position, which, since the attraction of a sphere at a point within it is zero, will be due either to induction or to irregularities of the sphere. Errors due to irregularities may be readily eliminated by rotating the sphere.

THE LE CLAIRE LIMESTONE.

BY SAMUEL CALVIN.

The Le Claire limestone constitutes the second stage of the Niagara formation as it is developed in Iowa. The first or lower stage has been called the Delaware, from the fact that all its varying characteristics are well exhibited in Delaware county. The Delaware stage embraces many barren beds and presents a very great number of phases, but at certain horizons it abounds in characteristic fossils. The typical faunas of this lower stage embrace such forms as *Pentamerus oblongus* Sowerby, *Halysites catenulatus* Linnæus, *Favosites favosus* Goldfuss, *Strombodes gigas* Owen, *Strombodes pentagonus* Goldfuss, *Ptychophyllum expansum* Owen, and *Diphyphyllum multicaule* Hall. The beds of the Delaware stage furthermore contain large quantities of chert.

The Le Claire stage of the Niagara follows the Delaware. The exact line of separation between the two stages has not been, and probably cannot be, definitely drawn. There are