LETTERS TO THE EDITOR.

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Psychophysical Interaction.

I MUST demur to the statement of my views which Sir O. Lodge has given in his letter printed in NATURE for May 14, "that if dynamical laws are exact and irrefutable, the universe must be a completely determined mechanical system, with only one, and that a necessary, solution." In the first place, I made no statement as to the universe as a whole; as I do not know the physical universe to be finite in extent, I prefer to make statements only about finite portions of the universe, and the interactions of such finite portions. I certainly hold the view that the laws of dynamics, which are a self-consistent system of formal laws, are exact and irrefutable, but the question whether the motions of all parts of a living organism are in accordance with those laws is quite another matter, and one on which I have expressed no opinion. What I did in effect say, was that a material system upon which forces of psychical origin and of incalculable magnitude acted, traversed the laws of dynamics in the only sense in which such a system of laws can be traversed, viz. that the motions would not be in accordance with the laws, whether the supposititious forces do mechanical work or not.

Sir O. Lodge maintains that the psychical and the physical can interact without upsetting any fundamental dynamical law; he objects to the principle of Least Action as containing assumptions which beg the question at issue, and pins his faith to Newton's laws. Now, although the principle of Least Action contains nothing which is not deducible from Newton's laws, provided the same form of energy-function is taken in the two cases, I will, for the sake of argument, accept the test that Sir O. Lodge lays down. One of Newton's laws is that to every action there is always an equal and opposite reaction, or every stress has two aspects; now I suggest for Sir O. Lodge's consideration the following questions:—What are the reactions corresponding to the forces of psychical origin which act upon parts of a living organism? On what do such reactions act? It will clearly not suffice to say that the reactions are something of a different character from the actions, and are appropriate to exert an influence upon the psychical; Newton's reactions are mechanical forces acting upon material systems.

As an example of a mechanical system the motions of the parts of which are determinate through the laws of dynamics in conjunction with the law of gravitation, we may take the solar system, supposing each member of it to be treated as a whole. Let us suppose that there resided in the solar system some agency of a non-material character which was capable of applying to the planets forces of unknown magnitudes along the normals to their orbits relative to the centre of gravity of the system. The paths of the planets could then no longer be calculated; in fact, there would be an end of gravitational astronomy; both the linear and angular momenta of the system, so far from being conserved, would become absolutely indeterminate, and yet Sir O. Lodge must in consistency maintain that the laws of dynamics would not be traversed. Moreover, although the sum of the potential energy and the kinetic energy of the motions relative to the centre of gravity would be unaltered, the energy of the motion of the whole system through space would be altered to an unknown extent. If the disturbing forces acted normally to the paths relative to a point regarded as a fixed origin for the sun and stars, the energy of the system would be conserved, but in all other respects the same result as before would ensue, namely, chaos.

There are, I take it, in the main three views which may be maintained as regards the relations of the psychical and the physical in living organisms.

(1) The view known as pure naturalism, that the physical forms an independent system, and the psychical is only a *Begleiterscheinung* influenced by, or perhaps determined by, the physical, but exerting no influence on the

physical. In this case the motions of the physical are entirely determinate in accordance with mechanical laws.

(2) The view that the psychical and the physical form two systems linked together, with interaction between the two; on this view neither system is complete in itself, and the physical cannot be determined completely by any system of purely mechanical laws. This view does not exclude pure determinism as regards the whole complex, since it may be held that the psychical has a dynamics of its own, and that the interaction between the psychical and physical is determinate in accordance with some scheme of laws.

(3) Lastly, it may be held that the dualism of the physical and psychical is entirely inadequate as an ultimate formulation; in fact, that both (1) and (2) are unworkable as thorough-going hypotheses; on this monistic view, both the physical and the psychical must be regarded as manifestations of something more fundamental than either. This view, as also (2), does not exclude the partial and tentative application of mechanical laws, even to the case of living organisms; there may be a partial or practical independence of the physical in certain classes or cases, but such practical independence could never be presumed apart from proof of its existence by means of actual observation, and there must certainly be a point at which the practical independence breaks down, and at which the dualism of our ordinary mode of thinking becomes inadequate as a representation of what happens. It is this last view of the matter which I am inclined, personally, to regard as the true one.

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Christ's College, Cambridge, May 17.

WITH the help of one of Clerk Maxwell's demons a very simple illustration of change of motion in a dynamical system, without any interference with the sums of energy and momentum, can be constructed, which may perhaps be of service to Mr. McDougall.

Let the demon provide himself with some inextensible, perfectly flexible, mass-less string. (It is found abundantly in text-books of Dynamics.) Let him observe two bodies of the system, having, it may be, motions of rotation as well as of translation; and when he discovers a point on each the relative velocity of which with respect to the other point is either zero or at right angles to the straight line between them, and which also are about to recede from each other, let him, at the very instant when things are so, attach a piece of his string to these two points exactly equal in length to the distance between them. The two bodies will thus be suddenly yoked together without any shock whatever, and consequently without any loss of energy. Their subsequent motions of translation and rotation will be altered by the action of the string; but their total energy and their total momentum will remain entirely unaltered. As soon as the string slackens the demon must be careful to remove it, in order to avoid the possible shock when it again tightens.

If the string be perfectly elastic (so that no energy is dissipated in internal work when the string stretches) instead of inextensible, the demon may attach it to any two points on the surfaces of the bodies without affecting the momentum sum or the energy sum; but so long as the string is at all stretched, a portion of the energy of the two bodies will be stored up in it.

For example, let the two bodies be spheres moving with the same uniform, rectilinear, velocity; and suppose the centre of figure of each to be its centre of inertia. Let each be spinning about an axis through its centre, perpendicular to the plane in which the centres are moving. Then the demon may safely fasten his inextensible string to the two points where the straight line joining the centres cuts the surfaces. There will be no shock, and therefore no loss of energy. There will be also no change in the total momentum of the spheres, whether linear or angular, nor any change in the uniform, rectilinear, motion of their common centre of inertia; nevertheless, when the demon releases them, they may be moving in divergent instead of parallel directions, and with diminished or increased velocities of rotation.

Demoniacal guidance of this kind conflicts neither with the law of conservation of energy nor with that of the conservation of momentum, and so far would seem to contradict Prof. Ward's criticism in his "Naturalism and Agnosticism," vol. ii. p. 83.

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