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Seiden Strasse 29.
Hamburg, Feb. 5, 1895

Dear Sir

I am obliged for your criticism of a point in my paper, and will try to answer it. There is a particular condition mentioned, but which might have been emphasized and defined more precisely (in translation in *Phil Mag.* Feb. 1895).

The relative dimensions of ether particles and the gross molecule of matter require, it seems, to be something like realized; and on comparative scale a "molecule" becomes no longer such, but must be viewed (in relation to the ether) as a mass of visible dimensions immersed in a gas. For in order to allow a mean path of millions of miles combined with a large number of particles in unit of volume, the size of the ether particles must be relatively very small.

By four lines of argument according with each other in the deduction arrived at, Lord Kelvin gives the effective diameter of a molecule of matter at about $1/10,000,000$ of a centimeter. A body 100,000 times that diameter, or $1/10$ of a millimeter, is visible, and immersed in air, would represent a visible body immersed in a gas, not behaving as a molecule. It would be subject to the pressure (collective and steady) of the gas, and not be disturbed by the separate impacts.

This is the case of a molecule in the ether. To fix the ideas, we may take (to enormously exaggerate the size) an ether particle as a small perfectly elastic ring $1/100$ of a millimeter in diameter, and a gross molecule of matter as 100,000 that diameter, but otherwise a ring exactly similarly proportioned. A molecule is then represented by a

ring one meter in diameter on the above scale. But such a ring on relative scale, behaves as a mass of visible dimensions (and not as a molecule of a gas to other molecules). There is no reason for supposing that the scale may not approximately represent the truth.

For simplicity, we will consider movement of rotation only developed in particles, and neglect movement of vibration.

Then we have a very fine gas of non-spherical particles, therefore eminently capable of rotation at impact, streaming in all directions through a massive ring suspended freely in the gas - the ring being one meter in diameter.

Then since no rotation can be developed by the ring (one meter in diameter) by the equal pressure of the gas, all the rotation at impact is developed in the particles of gas, each 100 millimeter in diameter. The ether particles then receive rotation, and impart none, when they impinge against the molecules of gross matter. But when the ether particles encounter themselves, they impart as much rotation as they receive. Therefore when they encounter gross matter, they carry away a surplus of rotation, from the fact that they do not give any. This acquirement of rotation is however only at the expense of translation: or translatory motion is converted into rotatory by impact of the particles against gross molecules. Here then is, as it appears, a sufficient cause for gravitation - even independently of the vibration developed in the ether particles, which is a second phase of internal motion.

In my paper*, a gross molecule is compared to a polished steel anvil, and the ether particle to a polished steel key ring (for comparison), which when projected against the anvil, is, as a rule, thrown into rotation, while the

and is incapable of this, but behaves as a massive body immersed in a gas.

The above considerations may, I hope, go to remove the difficulty you express in your letter: the solution lying simply in the fact that an aether particle is so very small, that a molecule of gross matter may be regarded as a visible mass on comparative scale, or in relation to it, and not as another particle. The offered solution is, ^{indeed to think,} ~~definite~~ from a mechanical point of view, ~~apparent~~ and the problem is a purely mechanical one.

It might be added that the volume or extent of the gaseous aether being so infinitely greater in comparison with the extent of gross matter, fresh particles are continually impinging against gross molecules (or reversing them like a sieve) and send the same particles again: so that the above process of conversion of translation into rotation is continuously renewed.

Then when the aether particles encounter themselves, the energy of rotation is turned back into energy of translation: and you yourself proposed this in a letter of Sept 23, 1890. In fact this is a necessary and well known consequence of the kinetic theory, considered mathematically by Clausius. The whole affair is remarkably simple. It is all effective mechanical means to an end, it is deductively simple, if effective. ~~The~~ ^{one} chief purpose of the specific medium is no doubt to contain an ever available store of energy (to work the universe).

There is then no progressive cooling whatever of the aether by streaming through gross matter, but a stationary state is maintained, where the sum of energy contained in the aether undergoes no change.

Your very truly
S. Tolber Preston

my paper, of the law of Maxwell (about molecules of diverse masses all tending to assume the same energy of translatory motion) being "still disputed" in the case of molecules of "very different sizes". This statement is due to Prof. Boltzmann.

The latter also has expressed the view that "the average effect of repeated and repeated mutual collisions must be to gradually convert all the translational energy into energy of shudder and shudder vibrations of the molecule". These words are quoted from Lord Kelvin's Natural Lectures, Vol. 1, page 237.

Lord Kelvin thought this a fatal objection to the kinetic theory at first. But in an appendix to the same volume, he reverses this idea, namely he says:

"I now see that, on the contrary, that ---- the conversion of all but an infinitesimal proportion into translational and rotational energy must be the ultimate result." (p. 464).

You will probably have seen this passage.

Of course the relative masses of a molecule and an aether particle, where one is 100,000 times the diameter of the other - would be as $(100,000)^3 : 1$, or as one thousand billion is to one.

So that practically the gross molecule might be supposed rigidly fixed in the aetherial gas, so far as any effect a separate particle of the aether could have upon its inertia. Obviously, no single particle can ever act on the molecule, but only a balanced pressure due to enormous numbers.

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