REVIEW OF BENNET'S EXPERIMENT

COUNTEREVIDENCING THE CORPUSCULAR THEORY OF LIGHT

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The corpuscular theory of light, erroneously attributed to Newton, incidentally, who considered but rejected it, asserts that light is made up of massed particles that behave according to classical Newtonian mechanics. They would be gravitationally influenced and would exert pressure through exchange of momentum on any object on which they impact. It was the corpuscular theory, already discredited long since, that relativists chose to challenge in respect to the purported gravitational bending of light rays by the Sun, claiming a victory over a straw man in so doing. It is to be carefully distinguished from the ballistic theory which also regards light as made up of small particles obeying classical mechanical laws, but attributes no mass, or such insignificant mass, to them that they exert no light pressure on impinging against a target and are not subject to gravitational influences. They do, however, travel at velocities dependent on the motion of their source of emission and are reflected according to mechanical principles. The experimental findings of Bennet's paper presently being reviewed are regularly cited in all the older texts on the theory of light as conclusively negating the corpuscular theory, in favour of the undulatory theory. In truth these findings say very little about the ballistic theory but that somehow goes down with the corpuscular through guilt by association. The ballistic theory is negated by De Sitter's remark and by Michelson and others' studies of the behaviour of light on reflection, in particular from moving mirrors.

So positive are the statements made and so definite are the conclusions stated in these textbooks that before we came to actually reading this paper we had expected it to describe an experiment crucis executed with great care and pains with so much presicion that the conclusion was unambiguously indicated. That was before we went digging the paper out to read it for ourself from the old leather-bound volumes of the Transactions - now cracked with age and the hard covers falling off them, quaintly tied on with a narrow ribbon in a bow, never probably having been untied before now since it was first knotted to keep the covers from going their own ways leaving the volumes to fend for themselves.

Actually such is not the case and this experiment on which so much has depended is not one critically executed. It was but one of many Bennet did to show the sensitivity of a torsion balance he had constructed with a spider's web and he devotes only a brief paragraph to a discussion of it; most of which discussion we give below. The major point of his paper relates to the capabilities of his instrument, which are remarkable indeed and scarcely to be improved upon by replacing the spider's web with quartz fibers or anything of more modern invention as the suspending element. He reports, for instance:

Having found that a spider's thread, only two inches and a half long, when twisted 18,000 revolutions, would not cause a sensible deviation of the magnetic needle, owing to its very great tenuity, or to its glutinous quality preventing its having any tendency to untwist; and that light substances suspended by it, and enclosed in glass, were capable of being turned about by so small a degree of heat as that occasioned by a person sitting at the distance of three feet from the instrument; or by wires, or other substances, only warmed by holding in my hand; and that when the instrument was placed in a cool room, a slight touch with the end of my finger would cause the wing of a dragon-fly, or even a bit of straw, to point exactly at the side of the glass which had been touched; there could remain no doubt of the freedom with which a magnetic needle would move when thus suspended ...

Some additional comments make it quite evident that Bennet's balance was indeed ultrasensitive, perhaps not even matched by the instruments of today. However, no effort was made by him to quantify its limitations by determining, for instance, the torque corresponding to a degree of rotation of the needle. No bounds were established within which it operated. Thus, any determination made by means of it was but qualitative; and that within unknown ranges.

The experiment in question may be reported here in his own words, consituting the full extent of what he had to say:

To the end of a fine gold wire, three inches long, and suspended by a spider's thread in a cylindrical glass, was fastened a small circular bit of writing paper; light was admitted through a small hole, and also the focus of a large lens was thrown upon the paper, with the intention of observing whether it would be moved by the impulse of light: but though these experiments were often repeated, and once with the paper suspended in an exhausted receiver, yet I could not perceive any motion distinguishable from the effects of heat. Perhaps sensible heat and light may not be caused by the influx or rectilinear projections of fine particles: but by the vibrations made in the universally diffused caloric or matter of heat, or fluid of light. I think modern discoveries, especially those of electricity, favour the latter hypothesis.

That is the unabridged full report of the experiment, # 10 in a long list of experiments Bennet performed with his balance.

We comment that no indication is provided of the intensity of the light beam brought to bear upon the undimensioned bit of writing paper. How did he distinguish between the effect of heat and that of light except by intuition? He did not even state the diameter of the small hole which admitted light from what:- the sun, or a candle? All we may conclude is that if there were any effect due to light pressure, it was small by comparison, say, to moving a chair; maybe small by comparison with knocking the scrap of paper with a pencil; an elephant pushing a log would achieve much more, we might believe.

In other experiments Bennet mentions that the readings made by him were terribly influenced by the convective disturbances of the air in the vicinity of the moving parts of his instrument, as well as by what we recognize today as being the effects of electric charges brought into its vicinity. To isolate the anvil against which the impinging photons or corpuscles are supposed to strike, from the effects of radiant heat or charges, while permitting a light beam to impinge on it, is a difficult matter to accomplish. It is the bugbear that other experimentalists have encountered since Bennet's time. It is considered overcome by replacing Bennet's bit of paper with gold metallic foil beaten so thin as to be transparent, so that the amount of heat convection in the evacuated chamber remaining the balance in whatever residual gases there be left in it, is considered equal on both sides of the foil. This is a risky procedure, in our opinion, and are we to believe that photons passing through a transparent object (and illuminating something placed back of it) exert the same forces as would those which were totally reflected from a mirrored surface? Is this not equivalent to asserting that a projectile fired through air encounters the same resistance and exerts the same force against air as it does when hitting a brick wall?

A better approach might be to employ a large **light beam of known area** and intensity, concentrated by a lens of known focal length to a point source of emission, at a wavelength well out of the infrared and let it play for a measured period of time on a target in an evacuated chamber, sensed for thermal and electric effects. The light might be brought into the chamber through a filter opaque to the infrared. If we could then be assured that neither the effects of heat- or light-induced charge occurred, or only to some negligible extent, then greater confidence, on repeating Bennet's experiment, could be placed in an assertion that light pressures do or do not arise and within what quantitative limitations, measured per lumen, and consequently per photon, if one believes in photons.

Laser beams induce disintegration of the surfaces on which they are brought to bear, more through excitation of the molecules than through a blasting of them with photon projectiles. The recoil energy of the detritus of the molecules reflected backwards into the free space on one side of the anvil more than on its dark side can obscure any definite conclusion in measuring so weak an effect.

It is just the major, significant objection to a corpuscular hypothesis: i.e., that the radiation from millions, if not billions, of independent sources of illumination through any one cubic centimeter of space, traverse that space from all directions simultaneously without the least evidence of interactions occurring between them (except when the carrying ability of the medium is saturated as, for instance, at the solar photosphere, through which region other weaker sources of light cannot progress). If two laser beams in vacuo were directed one against the other and the change in the degree of their individual scattering were measured as the hypothesized photons collided, we might find it convincing.

Returning to Bennet's modest experiment, it is unamusing to see how one textbook writer draws on an earlier textbook, and that from a third, etc., each consolidating and firming up the contentions of his predecessor, until an experiment crucis is created and a cult of belief results. None of them except the very first, in his grand display of erudition derived from other textbooks, ever has returned to the fountainhead of awareness to drink from the source of knowledge. What grand conclusions the pedagogues force their disciples to believe!

The real conclusions to be drawn from Bennet's paper are simply that if light pressures are exerted, they are not comparable in magnitude with those of an elephant pushing a log, or even a puff of convected gases blown against a delicately suspended vane. The last is what Bennet proved; the first we know already.