siderable, but that within the limits of error the existence of the light pressure of Maxwell and Bartoli are *quantitatively* confirmed.

This result is of importance to astrophysics as furnishing a much simpler explanation of the repulsive force of the Sun than the hypothetical ones of electrical charges. A firm basis, amenable to computation and assured by experiment, is thus given to the view expressed by Kepler.

PETER LEBEDEW.

PHYSICAL INSTITUTE, MOSCOW,
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PRESSURE DUE TO LIGHT AND HEAT RADIATION.[1]

ALTHOUGH the idea of a pressure due to radiation is at least three centuries old, and definite experiments directed toward its measurement were made a century and a half ago, yet Maxwell[2] was the first to accurately state the theory of a radiation pressure, in the form in which it is now held. In astrophysics the problem is interesting, not alone for its bearing upon the repulsion of comets' tails by the Sun[3] but also for its possible effect upon the Solar Corona and the Aurora Borealis.[4]

The present experiments were of two kinds: (1) The determination of the light pressure by observing the deflection, either static or ballistic, of a torsion balance when one vane of the balance was exposed to light, and (2) the determination, in ergs per second, of the intensity of the light falling upon the vanes. The image of an aperture, upon which the rays from an arc lamp were concentrated by two condensing lenses, was focused in the plane of the glass vanes placed symmetrically with regard to a rotation axis held by a quartz fiber of known torsion coefficient. The torsion balance was covered by a bell jar connected to pressure gauges and a mercury pump. To eliminate the disturbing action due to the residual gas in the receiver, the following devices were used: (1) The vanes were silvered and highly polished,

[1] An abstract of a paper read in Denver, August 29, 1901, before a joint session of the American Physical Society and Section B of the American Association for the Advancement of Science.

[2] J. C. MAXWELL, *Electricity and Magnetism*, 1st ed., Oxford, 1873, 2, 391.

[3] P. LEBEDEW, *Wied. Ann.*, 45, 292, 1892.

[4] S. ARRHENIUS, *Konig. Vetenskaps-Akademiens Förhandlingar*, 1900; also ASTROPHYSICAL JOURNAL, 13, 344, 1901.

thus making the absorption small and the reflecting percentage large. (2) The silver surface of one vane was turned towards, and of the other, from the light, thus making the effect of the gas action and light pressure in the same direction on one vane, and in opposite directions on the other. (3) The pressure of the air in the bell jar was varied, and pressures were chosen in the vicinity of that pressure at which the gas action was very small. (4) The length of exposure of light on the vane in most of the observations was only six seconds. The gas action, which begins at zero and increases with the length of exposure, was thus reduced in comparison with the instantaneous action of the radiation pressure. By means of an inclined glass plate placed in front of the aperture, a portion of the incident light was thrown on a thermopile. The deflection of a galvanometer connected with the latter gave the *relative* light intensities.

Two methods of determining radiation pressure were used:

(1) The vane was exposed continuously to the light until the turning points of the vibration of the balance showed that static conditions had been reached. The other vane was then exposed. Finally the whole suspended system was turned through 180°, and the vanes were exposed in turn. The mean of the angles of deflection, multiplied by the torsion coefficient of the fiber and divided by the lever arm, gave the force in dynes acting on the vane. (2) The vanes were exposed in the same order as before, but only for a quarter of the period of the suspended system. The period, damping coefficient, torsion coefficient, and lever arm being known, the value of the radiation pressure could be found. The two methods gave practically the same result except for the air pressures for which the gas action was large.

Measurements of the radiation pressure were made with eight different gas pressures in the bell jar. A comparison of the static with the ballistic deflections, within this range, showed that the pressure due to gas action varied from $\frac{1}{10}$ of, to 6 or 7 times, the radiation pressure. The radiation pressures observed by the ballistic method and reduced to constant radiant intensity, are given in the accompanying table:

Gas pressures in millimeters of mercury	Radiation pressures in 10^{-4} dynes
96.3	0.9
67.7	1.0
37.9	1.0
36.5	1.0
33.4	1.0
1.2	1.0
0.13	1.3
0.06	1.1

Mean 1.04×10^{-4} dynes.

The energy falling upon the vanes was measured by means of a bolometer consisting of a thin disk of platinum, about the size of the vanes, covered with platinum black. The bolometer, occupying exactly the position which the glass vane had previously occupied, was made one of the arms of a Wheatstone bridge. The bridge was balanced, the bolometer exposed to the light, and the throw of the bridge galvanometer read. Later the disk was heated by an electric current which entered and left at two equipotential points on the bridge current, and the galvanometer throw was read again. The current strength and the resistance of the disk being known, the energy developed in the disk is $i^2 R \times 10^7$ ergs per second. The reading of the thermopile before mentioned made it possible to reduce all observations to a constant light intensity. If $E =$ energy per second falling upon a surface, $a =$ the percentage of the radiation reflected from the silvered vane, $v =$ the velocity of light, then, theoretically, the value of the radiation pressure is $\frac{(1+a)E}{v}$.

In the experiment, $R = 0.278$ ohm; the current causing the same resistance changes in the platinum disk as the light source, was $i=0.75$ amp.; $a = 0.92$, and $v = 3 \times 10^{10}$. We have thus

$$\frac{1.92 \times 0.278 \times 0.75 \times 10^7}{3 \times 10^{10}} = 1.34 \times 10^{-4} \text{ dynes}.$$

The observed value of the radiation pressure is thus seen to be about 80 per cent. of the theoretical value as computed from the heat measurements. Unfortunately there were certain systematic errors in the energy measurements due to the construction of the bolometer and which could not be eliminated. The writers have therefore greater confidence in the accuracy of the observed radiation pressures than in the theoretical values computed from the heat measurements.

E. F. NICHOLS and G. F. HULL.

DARTMOUTH COLLEGE,
Hanover, N. H.

SPECTROSCOPIC BINARIES: A SUGGESTION.

THE spectroscopic binaries are naturally divisible into two chief classes, which may be conveniently distinguished by the Roman numerals I and II. Class I comprises those systems in which one component only yields a perceptible spectrum; in Class II the spectra of both components are visibly superposed. Stars of the first class — so far as our present knowledge extends — are distinctly more numerous than those of the second. But the latter are in general more interesting, since the study of such systems must lead frequently to conclusions of special value to the astrophysicist.

As an illustration, I may point out that it will be possible to deduce the *average* mass[1] for stars of Class II; to compare the mean masses for stars of different spectral types, or those comprised in different orders of magnitude, etc. By combining such results with photometric, parallactic, and other data, we may further investigate the relation between mass and intrinsic brightness, which is one of the fundamental problems of stellar physics.

The preponderance in numbers of Class I, as noted above, may prove to be illusory. In other words, a careful examination, by special methods of these star-spectra would doubtless often reveal the supposed absent secondary spectrum. Such is my suggestion, and it now remains to point out the nature of the special methods referred to.

In general, a marked disparity in brightness between the components of a binary star is accompanied by dissimilarity of the spectra. Thus, if the primary spectrum be of the solar type (or some closely-related sub-type), the secondary spectrum is almost invariably of the type of Sirius.

[1] If m_0 denote the required mean mass (the Sun's mass being taken as unity), I find

$$m_0 = [\bar{7}.24630] \frac{1}{n} \Sigma UV^3,$$

where n is the number of binaries, U the period of revolution in *days*, and V cosec, i the relative mean orbital velocity in kilometers per second. It is here assumed that n is very large, and that the orbit-poles are distributed equally in all directions.