LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

*On the Mechanism of "Atomization"

So far as the writer knows no adequate explanation has been offered of the phenomenon of liquid "atomization." Scheubel[1] has, indeed, given some interesting and instructive spark pictures of the process as it occurs in the carburetor throat, but not much direct information can be derived from them except at fairly low air speeds. The fact, however, that the phenomenon can be used with confidence in the design of many machine elements,—that certain results may be expected to attend certain conditions,—is tacit declaration that the process has a definite physical background.

If, given a quantity of liquid which at one time exists as a single comparatively large mass, and a moment later is observed to be in the form of a very great number of very small discrete drops, we merely make the assumption that there must be an intermediate stage in which fine ligaments are formed, of such diameter that they will disintegrate into drops of the observed size, we can account for this phenomenon on the basis of Rayleigh's theory of jet disintegration and certain recent observations of the size of the drops formed when a liquid is atomized. This assumption seems reasonable, since time and temperature considerations exclude the possibility of evaporation and subsequent recondensation; it seems necessary, since it will appear very improbable that the existence of such fine ligaments can ever be directly demonstrated; and it is hoped to show that it is sufficient.

Rayleigh[2] thus explained the disintegration of a jet which we shall identify with the ligament mentioned in the preceding paragraph: He considered the jet as an infinitely long cylinder of liquid initially in equilibrium under the influence of the tension of its envelope, and investigated the efficiency of various types of disturbance in upsetting this equilibrium. He found that

$$\alpha = \alpha_0 e^{qt} \tag{1}$$

where α and α_0 are amplitudes, at times t and 0, respectively, of a disturbance symmetrical with reference to the cylinder axis; e is the Napierian base; and

$$q = \left(\frac{8T}{\rho D^3}\right)^{\frac{1}{2}} \cdot F \tag{2}$$

In Eq. (2), T and ρ represent the liquid's surface tension and density, respectively:

D is the diameter of the undisturbed filament; and F is a (dimensionless) function of Z, the ratio length/diameter. The denominator of this fraction is the same as D above, while its numerator is the distance along the jet between two adjacent points in the same phase of vibration.

When α grows to $D/2$ the filament breaks.

The function F has been investigated by Rayleigh[2] and by the present writer.[3] As a result it follows that the effective value of F may be taken as about 0.34 at $Z=4.5$. For this value of Z it also follows that the diameter d of a spherical drop will be about twice D, the diameter of the cylindrical segment from which the drop is formed.

Hausser and Strobl[4] and Sauter[5] found,

* Publication approved by the Director of the Bureau of Standards of the U.S. Department of Commerce.

[1] F. N. Scheubel, Jahrbuch der W. G. L. p. 140 (1927).

[2] Rayleigh, Proc. Lon. Math. Soc. **10,** 4, (1879).

[3] Castleman, Nature **114,** 857, (1924).

[4] Hausser and Strobl, Zeits. tech. Phys. **5,** 154 (1924).

[5] J. Sauter, Zeits. V.D.I. **72,** 1572 (1928).

for water atomized in a high speed air stream, a mean value of d of about 6×10^{-4} cm, while Woltjen[6] found about the same for oil atomized by "airless" injection into a high pressure bomb. Taking 10^{-3} cm as an upper limit, we have 5×10^{-4} cm for D, so that Eq. (2) gives $q=740{,}000$ sec.$^{-1}$ for water atomized in a high speed air stream.

Now, it is very difficult, if not impossible, to estimate the value of α_0 precisely. The molecular diameter is, however, of the order of 10^{-7} cm[7] so it seems legitimate to place about 10^{-8} cm as a lower limit. To cut through a ligament 5×10^{-4} cm in diameter, α must grow to $D/2=2.5\times10^{-4}$ cm. The necessary time is, by Eq. (1), $t=(1/q)\ln\alpha/\alpha_0=(1/M_q)\log_{10}\alpha/\alpha_0=1/73{,}000$ sec. (approx.). This would correspond to a motion of about 2 millimeters of the *air* stream in the throat of the carburetor of an automobile engine turning over at high speed; or of about 1 mm of the spray 0.0005 sec. after injection at 8000 lbs/in², into a chamber held at 200 lbs/in² (N.A.C.A. Report #268).

The above gives *upper* limits of the possible lengths of these fine ligaments. Small wonder that they have never been observed!

R. A. Castleman, Jr.

Bureau of Standards,
March 15, 1930.

[6] Woltjen, Dissertation, Tech. H.S. at Darmstadt (1925) (Data taken from N.A.C.A. Tech. Memo. #403, pp. 19–22).

[7] Rayleigh, Phil. Mag. **48**, 331 (1899).

The Atomic Weights of Hydrogen and Helium.

Eddington (Proc. Roy. Soc. **A126**, 696, 1930) has obtained a new theoretical value of 1/137 for the fine structure constant α. This agrees much better with observational data than his previous value of 1/136. He also reaches the very interesting conclusion that in a *rigid system* of protons and electrons, there should be a proportional loss of mass equal to α. The most rigid system of this kind now known is the alpha-particle, and the loss of mass, assuming the alpha-particle to be absolutely rigid, agrees more closely with the theory than is indicated in Eddington's paper. In fact, on this assumption, an atomic weight of 1.00777 ± 0.00002 for hydrogen (see Birge, Phys. Rev. Suppl. **1**, 1, 1929) leads to 4.00166 as the calculated atomic weight of helium. As I have noted (footnote 12a, page 21, loc. cit.) the best chemical value for this latter quantity is now 4.0018. Because of the newly discovered isotopes of oxygen, Aston's mass spectrograph value of 4.0022 should be lowered about one part in 10,000 (page 69, loc. cit.) and then agrees precisely with the chemical value. Hence the observed and calculated values of the atomic weight of helium differ by only one part in 30,000, and this may be taken to indicate that the alpha-particle is in fact very nearly "rigid."

This correlation of the fine structure constant with the "packing effect" in an alpha-particle has already been suggested, on a purely empirical basis, by Lunn (Phys. Rev. **20**, 1, 1922) and has been revived by Witmer (Nature **124**, 180, 1929). In this earlier work, the predicted decrease in mass was given as $\alpha/(1+\alpha)$, but this differs by an entirely negligible amount from the present predicted decrease of α.

If the nucleus of the isotope oxygen "16" is a non-rigid system composed of four such "rigid" alpha-particles, the mass of this nucleus should be four times the mass of an alpha-particle, diminished by the mass-equivalent of the binding energy of the four alpha-particles. The atomic weight of the isotope oxygen "16" is 15.9984 (one part in 10,000 less than 16.0000), and one thus obtains 0.0082 atomic weight units (or one part in 1950 of the total mass) as the mass-equivalent of the binding energy. This seems to be a reasonable value.

Raymond T. Birge

University of California,
March 25, 1930.

A New Unified Field Theory and Wave Mechanics

In your issue of January 1st 1930, you published a preliminary notice of a paper on the above subject by the present writer. A few more words of explanation thereof, not included in the paper itself seem called for.

The fundamental postulate is that the unobservable is non-existent. This is familiar in wave mechanics, but is now applied for the first time to relativity.

Since the metric tensor of space time is