Evidence for the Enrichment of Carbon in the Heavier Isotope by Diffusion

An apparatus similar to that described by Hertz[1] for the separation of gaseous isotopes by diffusion has been constructed by one of us (D.E.W.) and used to produce methane gas in which the relative abundance of C^{13} is several times its value in normal methane.

The diffusion apparatus[2] consists of thirty-five "separation members," each involving its own circulating mercury diffusion pump and auxiliary porous tubing. Starting with twenty-five liters of pure methane gas at a pressure of 8 mm of mercury, twelve hours of circulating the gas suffices to establish an isotopic concentration equilibrium in the apparatus, at which time the enriched sample (200 cc at 6 mm pressure) may be removed for analysis. Calculations, based upon mass spectrometer measurements of the concentration factor achieved with the isotopes of neon, indicate that, under favorable conditions, this end-product might be expected to contain as high as fifteen or twenty atomic percent of C^{13}. For the abundance in ordinary carbon Jenkins and Ornstein[3] obtained 0.95 ± 0.1 percent by intensity measurements on the band spectrum, while Aston[4] obtained 0.71 ± 0.07 with the mass spectrograph.

Spectroscopic observation, on the diffused sample were made by the second author (F.A.J.) and gave evidence for a considerable enrichment in C^{13}. About $\frac{1}{2}$ mm of the methane was introduced into a small discharge tube containing 10 mm of purified argon. This gave an intense source of the Swan system of C_2 bands. Fig. 1 shows a comparison of the C_2 bands from ordinary methane (upper) and from the enriched sample (lower). The head marked by a single dot is the 1,0 band, λ4737, of $C^{12}C^{12}$. The corresponding head of $C^{12}C^{13}$ at λ4744, marked by two dots, is considerably more intense in the lower spectrum. Three measurements of the relative intensity of λ4744 to λ4737 were made from different exposures by means of density marks photographed on the same plate, and gave the values 0.143, 0.139 and 0.143. Adopting 0.142, this corresponds to an abundance of 6.6 atomic percent of C^{13}, or an enrichment by a factor of at least 7. That this is considerably less than the calculated value given above is not to be taken as significant, however, since the conditions for the diffusion in which this sample was obtained were not such as to give the most efficient separation. Furthermore, although precautions were taken to exclude ordinary carbon from the discharge tube, a small amount of it would considerably affect the result.

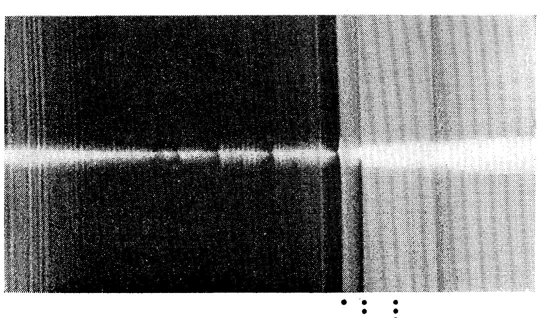

FIG. 1.

An interesting confirmation of this determination is the appearance on the spectrogram of a faint head (marked by three dots) in the calculated position for $C^{13}C^{13}$. In ordinary carbon, this has an intensity less than one ten-thousandth of that of the main band, and is not observable in emission. In stellar absorption spectra, however, it has been identified by Sanford.[5] If the above measurement is correct, its intensity for the enriched sample should be one two-hundredth, and this is enough to make it barely visible. There can be no doubt of its identity here, since it does not appear in the spectrum of ordinary carbon.

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[1] G. Hertz, Zeits. f. Physik **79**, 108 (1932); Naturwiss. **21**, 884 (1933).
[2] To be more fully described in a later paper.
[3] F. A. Jenkins and L. S. Ornstein, Proc. Amst. Acad. Sci. **35**, 3 (1932).
[4] F. W. Aston, Proc. Roy. Soc. **A149**, 400 (1935).
[5] R. F. Sanford, Publ. Astronom. Soc. Pacific **41**, 271 (1929).

Two-Body Problem in General Relativity Theory

In a recent paper,[1] Silberstein attempts to show the incorrectness of the general theory of relativity. His reasoning is as follows:

a. I set up a static solution of the gravitational equations which has two singular points and is everywhere else free from singularities.
b. The two particles so represented are not accelerated in each other's gravitational field, in contradiction with experience. Hence the gravitational equations of the general relativity theory are incorrect.

We should like to point out the following. Even if (a) were the case the conclusion (b) would not be justified. For in a field theory only a representation of masses which is free from singularities can be accepted, since at a singularity the laws of the field are violated. However the assertion (a) is not correct. We shall show that the solution given by Silberstein has singularities outside of the two points. This we did not notice in our recent paper, where we referred to this solution, which had been previously communicated to one of us.

In order that a line element of the form (1) (cf. Silberstein's paper) represent a regular gravitational field outside

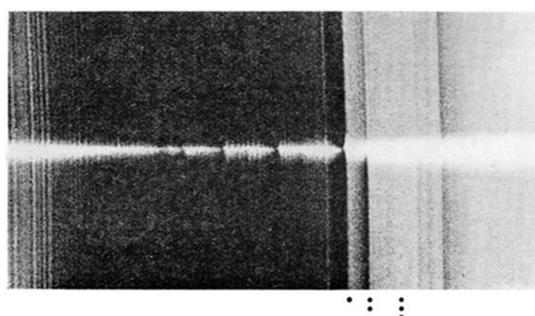

FIG. 1.