PHYSICS

Sequel to a Scientific Detective Adventure

Clue to Heavy Hydrogen's Discovery Proves Wrong But Hidden Twin Was Found Just the Same

By WATSON DAVIS

IN ADVENTURES of police and detectives, it sometimes happens that a false clue leads to the guilty person.

Science has a parallel case, for the clue that started the successful search for heavy-weight or mass two hydrogen (deuterium as this twin to ordinary hydrogen is now called) is now shown to be not in accord with the latest facts and figures.

This scientific detective story can be picked up when Dr. Raymond T. Birge and Dr. Donald H. Menzel, computing the relationships of weights of atoms, came to the conclusion in 1931 that there existed an undiscovered hydrogen twin, twice the weight of ordinary hydrogen, existing in nature with an abundance of about one in 4,500 hydrogen atoms.

It is history that the research trio of Prof. Harold C. Urey, Dr. F. G. Brickwedde, and Dr. G. M. Murphy of Columbia University and the National Bureau of Standards discovered deuterium in 1931, and that the 1934 Nobel prize for chemistry to Prof. Urey crowned the achievement. Such a burst of research as science has seldom seen followed the discovery. It was the first good chance to see how varieties of the same element, isotopes they are called, differed from each other. Heavy water, a strange kind of H_2O in which all or most of the hydrogen was the heavy variety, was made and used in experiments.

New Determination

Now four years after, there comes from England a new determination of the atomic weight of hydrogen which was used by Drs. Birge and Menzel in the computations that gave the original clue to deuterium.

Experimenters in Cavendish Laboratory, Cambridge, measuring and interpreting the range of the particles flung off by artificially radioactive atoms, politely suggested that Dr. F. W. Aston erred by one part in 4000 when in 1926 he determined the ratio of the weights of the helium and oxygen atoms, a determination that led to the weight of 1.0078 for hydrogen. The new weight suggested is 1.0081, and Dr. Aston, making new observations with an improved mass spectrograph, confirmed this value.

If Drs. Birge and Menzel had used this atomic weight there would not have resulted the discrepancy in figures that resulted in deuterium's discovery.

No more complex than the evidence in many detective stories are the scientific details of the "Hydrogen Case" or "Found Through a False Clue." Dr. Raymond T. Birge of the University of California, who makes critical studies of physical constants, has assembled for *Science Service* a record of this interesting case.

Oxygen the Basis

Oxygen is the basis for all atomic weights, Dr. Birge explains, and since we now know that oxygen has isotopes, one must say that the atomic weight of the average mixture of oxygen isotopes is taken as exactly 16 by definition. The great majority of atomic weights are determined by direct comparison with silver. For that reason particular effort has been made to determine, as accurately as possible, the silver-oxygen ratio. The present accepted atomic weight of silver is 107.880, and since exactly this figure has been obtained in several quite independent ways, it is believed to be correct to one part in 100,000. This is by far the most accurately known atomic weight. On the other hand, because of the importance of hydrogen, a special effort has been made to obtain its atomic weight with accuracy, and the value adopted in Dr. Birge's reports on general constants, etc., is 1.00777. These atomic weights are all on what can be called the chemical scale.

There is now an entirely independent scale of atomic weights, generally called the physical scale and based on the assumption that the mass of the mass sixteen isotope is exactly 16 by definition. All masses on this scale are determined by the mass spectograph, or now, more recently, by the disintegration work at Cambridge University. Aston found 1.0078 for the mass of hydrogen. More recently Bainbridge found 1.00778. Now if neither hydrogen nor oxygen had isotopes, the chemical value just given should agree exactly with the mass spectograph value. As soon, however, as the oxygen isotopes were discovered, this brought about, necessarily, a predicted discrepancy in the two results for hydrogen.

Prediction Made

On the basis of this discrepancy, Drs. Birge and Menzel predicted (*Physical Review*, 37, 1669, 1931) that there should exist an isotope of hydrogen of mass 2 with a relative abundance of one part in 4500. This was based on the assumption that the abundance of the oxygen isotopes was such as to require a reduction of 2.2 parts per 10,000 in reducing from the physical to the chemical scale. More recent work on the abundance of the oxygen isotopes indicate that the true correction factor is more nearly 2.5 per 10,000. As a result of this prediction a number of persons immediately began active work for this isotope, and Dr. Urey was fortunate enough to be the first one to find it. Moreover, he found it with an abundance of one part in 4000, almost exactly that predicted by Drs. Birge and Menzel.

A Good Check

The best work on this subject by Bleakney, gives one part in 5000 for the abundance. This, in itself, indicates a very good check. In other words, one would conclude that the relative abundance of the oxygen isotopes, and of the hydrogen isotopes, just cancelled in such a way that the observed mass of mass one hydrogen on the physical scale should be practically equal to the observed atomic weight of the mixture of the hydrogen isotopes in the chemical scale, the value in both cases being practically 1.0078. Unfortunately, the agreement is quite deceptive, for it has been pointed out by Dr. Urey, and others, that the best determinations of the atomic weight of hydrogen have been made with electrolytic hydrogen, and in this, as is well known, the abundance of the heavy isotope is very much less than normal. In fact it is probably not more than one part in 40,000, or one in 30,000, at the most. Hence the discrepancy, on the basis of which Drs. Birge and Menzel made their prediction, apparently is not explained by the facts.

Now, however, the Cavendish experimenters have found that both Aston and Bainbridge are wrong in the value of the mass of the mass one hydrogen isotope on the physical scale. It should be 1.0081 in place of 1.0078. Assume, for the sake of argument, that this new figure is correct. On reducing it to the chemical scale, we then get 1.00785 as the predicted value of mass one hydrogen. If there is an abundance of one part in 30,000 in the experiments made on the atomic weight of hydrogen, then, for this mixture, the atomic weight should have a value, on the chemical scale, of 1.00788 in order to agree with the new Cavendish value. This value of 1.00788 agrees very well with the observed chemical value of 1.00777 previously quoted. Hence the Cavendish work practically clears up the discrepancy between the atomic weight of hydrogen and the mass spectograph values. For the first time, it gives independent evidence of the essential correctness of the present accepted atomic weight of hydrogen, and clears up a serious discrepancy of several years' standing.

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New Atom Weighings Show Masses Need Corrections

NEW weighings of the atoms just completed at Cambridge, England, by Dr. F. W. Aston, Nobelist and authority on atomic weight, give confirmation of the announcement made to the Royal Society about a fortnight ago by Lord Rutherford and his colleagues that some of the weights of common elements need revision. (*SNL, March* 23, *p.* 180)

Using a partially completed mass spectrograph or atom weigher, Dr. Aston announces in a letter to *Nature,* the following masses: For hydrogen, 1.0081; for deuterium or hydrogen of mass two, 2.0148; for helium, 4.0041; for carbon, 12.0048.

The famous Aston value for light-weight hydrogen determined by him in 1926 was 1.0078, contrasted with the new value of 1.0081.

Inaccurate Standard

What has happened now is as though the official pound weight of a nation were found to be slightly inaccurate. The weights of atoms are referred to the weight of oxygen taken as 16, either as it occurs on the average in nature or as the lightest of the three varieties, depending upon whether the determination is by chemical or physical methods.

The team of Cavendish Laboratory researchers, Prof. M. L. E. Oliphant, A. E. Kempton and Lord Rutherford, first suggested the need of revision as a result of the energies with which bombarded atoms artificially disintegrated. The distances the atom particles shoot out from the exploding atoms allow calculations of the masses of the atoms.

Dr. Aston admits that these disintegration experiments as atom weighers are "much more delicate but less direct." Dr. Aston's new atomic weights are as yet provisional and in no case does he claim greater accuracy than one in 10,000.

Scientists are interested in the slight differences in atomic weights discovered because they are of large importance in computing the energy within atoms and developing theories as to the existence of isotopes or varieties of atoms.

"I am never likely to regret the underestimate of hydrogen's atomic weight that I made in 1926," Dr. Aston said, "however serious it may ultimately turn out to be, because of the fundamental part it played in encouraging the search for heavy weight hydrogen (called deuterium) which was discovered in America."

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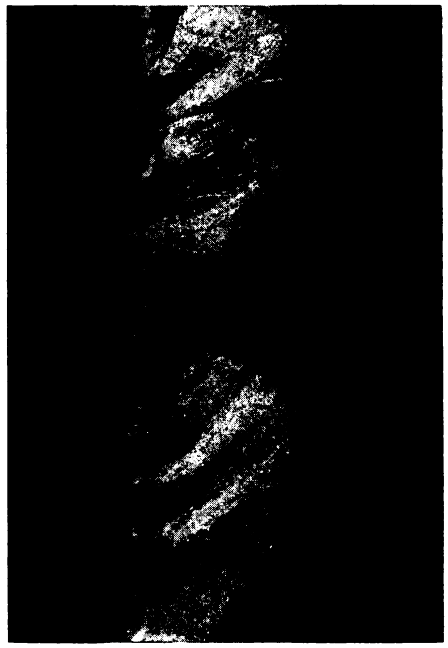

SAVER OF GOLD

Corduroy similar to that used in a lady's lounging pajamas or a boy's school knickerbockers, but having wider cords, is used to entrap gold from the gold ore "pulp" stream which is caused to flow over it. The photograph, showing an enlarged vertical section of the corduroy is used through courtesy of Engineering and Mining Journal.

PHYSICS

Einstein Proved Right Again By Light From Hottest Stars

EINSTEIN is again proved right, this time by light from the universe's hottest, most luminous and most massive stars, observed by Dr. Robert J. Trumpler of the University of California's Lick Observatory, on Mt. Hamilton, Calif., who told the National Academy of Sciences about it at its opening meeting.

One of the three famous tests of Einstein's general theory of relativity was proof of what astronomers call "red-shift," which means that a large mass like the sun or another star pulls back on the light energy it radiates and increases its wavelength. The famous heavy-weight dwarf star companion of brilliant Sirius, whose matter is 4000 times as dense as on earth, showed this predicted effect in observations at Mt. Wilson and Lick Observatories about a decade ago, but later observations indicated that this heavy-weight bantam star may be brighter in light than suspected and also that it may be twins. Some felt this spoiled its support of Einstein.

Dr. Trumpler searched for and found the Einstein shift effect in light from what are called the class O stars in the great star clusters of our Milky Way.

The astronomer's study is complicated by the fact that stars often rush away from or toward the earth at such tremendous speeds that this also changes wavelengths, a phenomenon called the Doppler shift. Dr. Trumpler got around this difficulty by comparing small and large stars of the same cluster so that their motions could be ignored.

The class O stars showed such greater redshifts of their light that Dr. Trumpler is confident that they uphold relativity. Using the theoretical value of the relation of red-shift to mass, he then used the red-shift to determine that the hot and luminous class O stars are on the average 180 times as massive as the sun.

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