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Olga Kosheleva
The University of Texas at El Paso, olgak@utep.edu

Vladik Kreinovich
The University of Texas at El Paso, vladik@utep.edu

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Why Was Nicholson's Theory So Successful: An Explanation of a Mysterious Episode in 20 Century Atomic Physics

Olga Kosheleva and Vladik Kreinovich
University of Texas at El Paso
500 W. University
El Paso, TX 79968, USA
olgak@utep.edu, vladik@utep.edu

Abstract

In the early 1910s, John Nicholson suggested that all atoms are formed by four basic elementary particles. This theory had a spectacular match with observations: it explained, with an unbelievable accuracy of 0.1, the atomic weights of all 92 elements known at that time. Specifically, it was shown that every atomic weight can be represented, with this accuracy, as an integer combination of four basic atomic weights. However, in a few years, this theory turned out to be completely wrong: atoms consist of protons, neutrons, and electrons, not of Nicholson's particles. This mysterious episode seems to contradict the usual development of science, when an experimental confirmation means that the corresponding theory is true. In this paper, we explain this mystery by showing that, in fact, there was no experimental confirmation, Namely, we prove that any real number larger than 3.03 can be represented, with accuracy 0.1, as a linear combination of four Nicholson's basic weights. So, this past "experimental confirmation" has nothing to do with atomic weights or any experimental data at all – it is simply an easy-to-prove general mathematical result.

1 Nicholson's Theory: A Mysterious Episode of 20 Century Atomic Physics

Atomic ideas: a brief reminder. At first glance, most macro-objects are continuous. You can divide water from a glass into smaller and smaller parts, and each part, no matter how small, will exhibit all the properties of water. Jewelers routinely divide gold and silver objects into smaller and smaller pieces, and each piece have all the properties of gold and silver.

Can we divide indefinitely – or eventually we will reach some limit? Some properties do change as the objects get smaller: e.g.:

- while a big amount of water, when spilled on the table, spreads around (do not check this in the vicinity of your computer!),
- a small amount of water stays as a drop.

Because of this, starting with the ancient Greeks, many researchers conjectured that there are limits to cutting, that matter consists of small pieces which cannot be cut further. The ancient Greek researchers called such parts *atoms* – which means not-divisible in ancient Greek.

Until the 19 century, atoms were an interesting hypothesis, sometimes helpful in physical analysis, but there was no experimental confirmation that some quantities can have non-divisible values corresponding to non-divisible pieces. In the early 19 century, John Dalton noticed that in a chemical reaction, the rate of the masses of substances involved in the reaction is usually equal to a ratio of two integers. A similar observation was later made about the volumes of gases involved in chemical reactions. These observations lead to the notion of atomic weight: it turned out that the atomic weights of all the elements are proportional to the atomic weight of the Hydrogen H.

Other similar observations appeared. For example, the 1909 Millikan's experiments showed that electric charge cannot be arbitrarily small: there is the smallest possible charge q_0, and every value of electric charge is proportional to q_0: we can only have charges q_0, $2q_0$, $3q_0$, etc. This made physicists conclude that electric current is not continuous, it consists of discrete ("atomic") particles – which were called *electrons*.

Atomic weights turned out to be a challenge. While more accurate experiments confirmed that all the electric charges are exactly proportional to the smallest value q_0, for atomic weights, the proportionality turned to be only approximate.

Nicholson's idea. If all the atomic weights were exactly proportional to the atomic weight of the Hydrogen H, we could conclude – similar to the conclusion about electric current – that all the matter consists of identical particles – H atoms. However, the weights are only approximately proportional. So, John Nicholson made a natural suggestion: since we cannot explain all elements by using only *one* type of atoms, maybe there are *several* different types of atoms?

By combining different physical ideas with trial-and-error, he came up with four types of what we would now call elementary particles:

A *Coronium*, with atomic weight 0.51282;

B *Proto-Hydrogen*, with atomic weight 1.008;

C *Nebulium*, with atomic weight 1.6281; and

D *Protofluorine*, with atomic weight 2.3615.

It turned out that the atomic weights of all elements known at this moment – up to Uranium – can be represented, with inaccuracy at most 0.1, as integer combinations of these weights [1]; see also [2].

Why this is a mystery. On the one hand, you have a theory that is in perfect agreement with experiment – actually, in sensationally good agreement with the observations. But we know how it all ended: we now know that atoms are built out of protons, neutrons, and electrons, and this has nothing to do with Nicholson's idea. How come?

We are accustomed to the more usual situation, when experimental confirmation means that a theory is right. But here, the theory is perfectly matching the observational data, and still it turned out that this theory is completely wrong. How can it be?

What we do in this paper. In this paper, we explain that there is actually no mystery: because there was actually no spectacular match with observations. True, all atomic weights could be represented as integer combinations of the basic weights A-D with accuracy 0.1, but what we will show is that *any* real number larger than 3.03 can be thus represented. So, what was perceived as empirical confirmation has nothing to do with atomic weights or any other experimental data – it is simply a curious (and rather easy to prove) property of four Nicholson's real numbers.

2 Our Explanation of This Perceived "Mystery"

Analysis of the problem and the resulting explanation. Since we are interested in representations with accuracy 0.1, let us keep only two digits after the decimal point in the atomic weights A-D, i.e., let us take

$$A = 0.51, \quad B = 1.01, \quad C = 1.63, \text{ and } D = 2.36.$$

Then, the following numbers from 3.03 to 4.04 can be represented as integer combinations of these four basic weights:

$$3.03 = 3B;$$

$$3.15 = A + B + C;$$

$$3.26 = 3C;$$

$$3.37 = B + D;$$

$$3.54 = A + 3B;$$

$$3.66 = 2A + B + C;$$

$$3.77 = A + 3C;$$

$$3.88 = A + B + D;$$

$$4.04 = 4B.$$

The interval between every two consequent numbers $\underline{a}$ and $\overline{a}$ in this sequence of numbers is smaller than 0.2. So any number a is between $\underline{a}$ and $\overline{a}$ is 0.1-close to one of these two numbers:

- If $a \le \dfrac{\underline{a}+\overline{a}}{2}$, then

$$|a-\underline{a}| \le \frac{\overline{a}-\underline{a}}{2} \le \frac{0.2}{2} = 0.1.$$

- If $a \ge \dfrac{\underline{a}+\overline{a}}{2}$, then

$$|a-\overline{a}| \le \frac{\overline{a}-\underline{a}}{2} \le \frac{0.2}{2} = 0.1.$$

By adding $B = 1.01$ to all the numbers from the above sequence, we get a similar sequence which is 0.1-covering all the numbers from 4.04 to 5.05, etc. In other words, indeed every real number which is greater than or equal to 3.03 is 0.1-close to some integer combination of the original four weights A-D.

Since *all* real numbers can be this represented, the fact that all atomic weights can be thus represented has nothing to do with observed atomic weights – and is, thus, *not* at all a confirmation of Nicholson's idea.

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