WHY IS THE PERIODIC TABLE ASKEW?

It has been suggested that the new arrangement of the periodic table proposed in Dewey B. Larson's *Nothing But Motion* entails some fundamental shortcomings in its representation of the relationships among the elements.[1] The following remarks are intended to clarify the issue with the aid of some historical considerations.

Larson describes the main innovation of his table in the following terms:

> In the light of the new information now available, it can be seen that Mendeleeff based his arrangement on the relations existing in the 8-element rotational groups... and forced the elements of the larger groups into conformity with this 8-element pattern. The modern revisers have made a partial correction by setting up their tables on the basis of the 18-element rotational groups... But these tables still retain part of the original distortion, as they force members of the 32-element groups into the 18-element pattern. To construct a complete and accurate table, it is only necessary to carry the revision procedure one step farther, and set up the table on the basis of... the 32-element groups.[2]

At the time that he wrote these words in 1979, Larson seems not to have been aware of the periodic table proposed

[1] D. Maurice Gilroy, "The Old and the New Periodic Tables," *Reciprocity* Vol. XIII, No. 3 (Winter 1985).

[2] *Nothing But Motion,* North Pacific Publishers, Portland, Oregon, 1979, pp. 135–138.

by the Swedish physicist Johannes Robert Rydberg in 1914. Rydberg was then at the pinnacle of his fame, having two major discoveries to his credit—in 1890 he had established the existence of the fundamental frequency that now goes by his name, and in 1897 he had recognized the significance of atomic numbers, as distinct from atomic weights, in determining the true sequence of the elements. In his paper of 1914,[3] Rydberg tried to go a step farther, and integrate this knowledge in devising a new periodic table that would overcome the evident inadequacies of the original one proposed by Mendeleeff in 1869. Rydberg formulated a simple arithmetical rule, which he called the rule of "quadratic groups," based on the formula $2n^2$—an expression that will be familiar to a student of the Reciprocal System, since it appears on page 129 of *Nothing But Motion*, where it is derived from the fundamental postulates. Rydberg calculated as follows: 2 x 12, 2 x 22, 2 x 32 and 2 x 4z. Hence, he postulated two periods of 2, two of 8, two of 18 and two of 32 elements. However, in trying to accommodate the first two periods of two elements, Rydberg was led to assume that there had to be two undiscovered elements between hydrogen and helium.

Once scientists were able to prove that no such elements existed, Rydberg's rule of "quadratic groups" and his 32-member periods fell into disrepute. In light of the Reciprocal System, however, we can fill in the two missing "elements" whose non-existence derailed Rydberg's theory—they are the subatomic particles known as the neutrino (a particle with one unit of negative one-dimensional displacement, like

[3] *Phil. Mag.* [6] 28, 144.

hydrogen) and the massless neutron (a particle with zero one-dimensional displacement, like the noble gas series that begins with helium). Rydberg was right in his mathematical formula, and right in his deduction that the periodic table would start with two 2-element periods. What he did not realize is that the first of these periods was not made up of elements, but rather of subatomic particles.

Rydberg's table was not rejected in its entirely, however, and some of its features survive in the currently-accepted one. The separation of the lanthanide and actinide rare earth series from the main body of the table is a remnant of his dual 32-member periods. This separation also constitutes the major difference between the currently-accepted periodic table and that proposed by Larson. In the currently-accepted table two 15-element groups, the lanthanides (57–71) and actinides (89–103) occupy but a single space each. I.e., the element lanthanum, number 57, and the 14 elements that follow it, together occupy position 57 in the table; only with element 72 does the progression resume. Similarly actinium, number 89, and the 14 elements that follow it, together occupy position 89 in the table; only with element 104 does the progression resume. In other words, element 72 occupies the place where element 58 would be expected to appear, were it not for the anomalous properties of the lanthanides, and element 104 occupies the place where element 90 would be expected to appear, were it not for the anomalous properties of the actinides. In Larson's table the lanthanides and actinides enjoy no special position; instead two different 1 S-element groups are given a special place—europium (63) to iridium (77), and americum (95) to what we might term "eka-iridium," or element 109. We could

term them the "europeanide" and the "americanides"—as in the case of the lanthanides and actinides, each of these groups of 15 elements could be said to occupy a single position in the table. In both arrangements, two groups of 15 elements are separated from the main body; these groups overlap in part (9 out of 15 of the elements in each of the groups are identical). Larson refers to the situation as follows (*Nothing But Motion*, p. 136): "The particular elements that are thus separated on the basis of the electric displacement are not the same ones that are treated separately in the conventional tables, but the general effect is much the same." One would like to concur with this opinion; the fact that exactly two groups of 15 elements need to be treated separately in both systems is highly suggestive. A common explanation ought to be available; yet the fact remains that the lanthanide and actinide series do not coincide with the two groups treated separately in Larson's table; in terms of Larson's table, the lanthanide and actinide series begin and end 6 positions too early. That the lanthanides are not arbitrarily chosen and cannot be arbitrarily shifted up by 6 positions, is underscored by the history of the discovery of hafnium, element 72.

In the spring of 1922 Niels Bohr predicted that element 72, which had not yet been discovered, would not belong to the rare earth series, as most chemists were then assuming,[4] but would be a metal related to element 40, or zirconium. In fact, when the new element was found later the same year, it was identified in zirconium deposits, and closely

[4]See Helge Kragh, "Anatomy of Priority Conflict: The Case of Element 72," Centaurus 23 (1980), 275–301.

resembled zirconium in its properties—it was named hafnium after the ancient name for Copenhagen, where the discovery was predicted and made. Bohr, who received his Nobel Prize that same year, included the notice of the discovery in his Nobel lecture—it was seen by him and by scientists at large as a vindication of his understanding of the atom. Whether or not this was really so—that is whether Bohr reached the conclusion that element 72 would not be a rare earth on the basis of his own recondite concepts of backfilling of the electron shells within the atom, or on the basis of a simple deduction from the structure of the periodic table as it stood at the time—the close affinity of zirconium and hafnium clinched the special position of the lanthanides. By the time Bohr made his deduction, element 73, or tantalum was known to be closely related to element 41, or niobium. Likewise element 74, or tungsten, was known to be closely related to element 42, or molybdenum. While the identities of elements 75 and 43 were not yet known, further down the table, the affinity of platinum (78) to palladium (46) was well known, as was that of gold (79) to silver (47). The question that Bohr successfully answered could be rephrased as follows:

> If element 79 is similar to element 47, and element 78 is similar to element 46, and element 74 is similar to element 42, and element 73 is similar to element 41, then what will element 72 be similar to?

Of course Bohr not only answered the question but posed it as well, which is the more difficult part. If the great Bohr stooped to such crude numerology in making his prediction, he did not make it known, and I will leave this delicate issue to the judgment of the reader. But we can learn

something about Bohr's methodology from Hendrik Kramers, his closest associate at the time:

> It is interesting to recollect how many physicists abroad thought, at the time of the appearance of Bohr's theory of the periodic system, that it was extensively supported by unpublished calculations which dealt in detail with the structure of the individual atoms, whereas the truth was, in fact, that Bohr had created and elaborated with a divine glance a synthesis between the results of a spectroscopic nature and of a chemical nature.[5]

If we recall that Bohr adapted for his own use a version of the periodic table based on that of Julius Thomsen, in which the elements are placed in a sort of genealogical chart, and in which the link between zirconium (40) and element 72 is clearly indicated, we are left to wonder why a mere mortal glance would not have sufficed. Be that as it may, in the volume celebrating the centenary of Bohr's birth this prediction is hailed as his crowning achievement, the one that established his reputation in Germany. To an unprejudiced eye, Bohr simply made a clever deduction of the kind Mendeleeff had made fifty years earlier when he forecast the properties of eka-aluminum (gallium) and eka-boron (scandium). The reason for my insisting on this point, however, is that Bohr would not have been able to make his prediction of the nature of hafnium had he been using Larson's periodic table. Larson does caution us that his

[5]Quoted in Helge Kragh, "The Theory of the Periodic System," in Niels Bohr: A Centenary Volume, ed. by A. P. French & P. J. Kennedy (Harvard Univ. Press: Cambridge, 1985), p. 60.

table is meant merely as a convenient way of presenting the information about the magnetic and electric displacements; yet one must wonder why we need to forego useful chemical information in the process.

I should caution, before proceeding, that the chemical information is not *unequivocally* in favor of the currently—accepted arrangement. For instance, the table currently in use does not contain any hint of the evident chemical similarity of thorium (element 90) and zirconium (element 40), while Larson's proposed table puts those two elements in the same group. Even more striking is the relationship of molybdenum (element 42) and uranium (element 92), two elements that are brought together in the same group in Larson's table but are completely unrelated in the one currently in use. However, as was pointed out by Gilroy, molybdenum has a remarkable similarity to tungsten (element 74), a relationship that is lost in Larson's arrangement, but exists in the current one. It would seem, then, that no single table can adequately represent all of the relationships among the elements. This being so, our goal ought to be the more modest one of constructing a table based on the correct double periods of 2, 8, 18 and 32 elements, while taking into account the most salient observed physical properties of the elements, most especially the anomalous position of the lanthanide and actinide series.

Before making an attempt at constructing such a table, let us consider another difference between the old and new periodic tables—the position of boron (5) and aluminum (13). In the table as it is accepted currently, boron and aluminum are part of a group that continues with gallium (31). In Larson's table boron and aluminum are part of a

group that continues with scandium (21). As with the lanthanides and actinides, the present arrangement is preferable from the point of view of physical properties—of all the elements, gallium is most similar to aluminum. In fact, Mendeleeff's prediction of the properties of element 31, which he termed "eka-aluminum," proved uncannily accurate when gallium was discovered a few years later, and this prediction was instrumental in gaining acceptance of Mendeleeff's table. Here is another instance in which Larson's table sacrifices useful chemical information in favor of symmetry. But not even here is the situation unequivocally in favor of the currently-accepted arrangement: A lesser set of chemical properties does link boron and aluminum to scandium and yttrium, as in Larson's arrangement, a fact that has been recognized for many decades. Not only did Mendeleeff's "eka-boron" turn out to be scandium, but in the above-mentioned "genealogical" chart devised by Julius Thomsen, boron and aluminum could be made to precede either scandium, as in Larson's table, or gallium, as in the one currently accepted. In 1923 the British chemist Gilbert Newton Lewis proposed a periodic table in which boron and aluminum precede scandium and yttrium.[6] But the two arrangements are mutually exclusive: Larson's table does not account for the close relationship of aluminum and gallium, while the standard table neglects the common features of aluminum and scandium.

[6] Gilbert Newton Lewis, *Valence and the Structure of Atoms and Molecules* (The Chemical Catalog Company, 1923), p. 28.

To sum up, there are two major differences between the currently-accepted table and the one proposed by Larson, which give rise to all the rest: (1) the two 15-member groups of elements that must be separated from the rest do not coincide (though they partly overlap); (2) boron and aluminum are in different and mutually exclusive groups. Could there be a common solution to the two anomalies? One circumstance that points to a solution is that in Larson's table boron and aluminum are part of the same group as lanthanum and actinium. The two anomalies could be explained if it could be shown that there is a strong bias toward the electronegative type rotation on the electric axis, such that *positive one-dimensional rotational displacement does not exceed two units*. Thus boron (5) instead of having the configuration 2-1-3, would instead have the electronegative configuration 2-2-(5). Similarly, aluminum (13), instead of having the configuration 2-2-3 would be configured as 3-2-(5). In this fashion the lanthanides would begin with 4-4-(29) and end with 4-4-(15), while the actinides would begin with 5-4-(29) and end with 5-4-(15). In both cases there is what we might term "excess electronegativity," caused by the postulated inability to maintain electropositive rotation greater than 2 on the electric axis. Once electronegativity enters the normal range, the observed properties of the elements change accordingly, and the special rare-earth series is ended.

A glance at the table attached herewith, in which the elements are arranged according to the principles just stated, allows us to recognize at once the point at which the rare-earth elements begin—one-dimensional space displacement in excess of 14 units. Hence, scandium, with displacements

of 3-2-(15) and yttrium, with displacements of 3-3-(15) belong to the rare earth series; they are, in fact, *the only non-lanthanide and non-actinide rare earth elements*. The exact reason why one-dimensional space displacement in excess of 14 units gives rise to rare-earth characteristics is not yet completely clear; the improbability of such a large number of units of space displacement accumulating on the electric axis is evidently the determining factor. What remains to be established is why the dividing line should be at exactly this point.

The perceptive reader will notice that so far in this paper I have turned the usual deductive process on its head and used inductive reasoning. In other words, up to this point I have not deduced my conclusions directly from the postulates, but took them from empirical data, and then searched for the simplest rules, consistent with the postulates, that would account for the observed situation. Now the postulates will be called upon to accomplish two things—(1) supply a reason why the probability of one-dimensional positive rotation within the atomic structure becomes negligible beyond 2 units and (2) provide an explanation of how electronegativity greater than 14 produces elements with the special characteristics known as “rare earth.”

Once the strong bias of the elements toward the electro-negative type of rotation is revealed, its cause becomes almost self-evident. Previous deductions from the postulates made by Larson have established the ubiquity of uncharged electrons in the material sector of the universe. Uncharged electrons are simply rotating units of space, being made up of a material rotational base, a time structure, with a single unit of one-dimensional space displacement. For our present

purposes, we might describe them as units of electronegative one-dimensional rotation. Material atoms are continuously exposed to a massive flux of these rotations—or, more accurately, atoms are constantly entering and leaving the space of the uncharged electrons.

In *Nothing but Motion* (p. 141), Larson makes the following statement about one-dimensional displacements in the material sector:

> ...Electrons are plentiful in the material environment whereas positrons are extremely rare.... We can regard the positron as essentially a rotating unit of time. As such it is readily absorbed into the material system of combinations, the constituents of which are *predominantly* time structures; that is, rotational motions with net positive displacement.... The opportunities for utilizing the negative displacement of the electrons in these structures, on the contrary, are very *limited.*

The words I have italicized in the above quotation are the key to the solution of the material atoms' observed bias towards the electronegative type of arrangement. As Larson explains, one-dimensional time displacement is easily absorbed by the atoms of matter, because both of the magnetic axes of the double rotating system have net displacement in time. The transfer of positive one dimensional displacement to the atoms is facilitated by the fact that the orientation that results in absorption can occur in any one of three dimensions, whereas in the case of the negative one dimensional displacement the orientation must occur along the electric axis if absorption is to take place. Hence positrons are rare. However, as Larson points out, the material atoms can carry space displacement along the

electric (one-dimensional) axis of rotation. The opportunities for utilizing the negative displacement of the electrons in material atoms may be "very limited," but they are not non-existent.

We have seen that the transfer of one-dimensional space displacement to the material atom can only take place when the orientation of the electron in relation to it is along the electric axis; the opportunities for transfer of the displacement are further limited by the circumstance that while electrons are standing still in the natural reference system, the atoms of matter are moving inward in three dimensions at the full speed of the space—time progression. The atoms that happen to enter the one-dimensional space of the electron on their inward journey do not spend more than a single unit of time in this combination. It is during this single unit of time that the space displacement must be transferred to the three-dimensional material structure, if the transfer is to take place at all. The situation in relation to positrons is similar, but not identical. Like the electrons, the positrons are motionless in the natural system of reference, and are exposed to a constant flux of material atoms traveling inward in three dimensions. However, the material atom cannot exist in the time of the positron's time displacement, as it does momentarily in the space of the electron's space displacement. The reason is that the physical universe is one of motion, defined as a reciprocal relation between space and time. The relation of the combination of one-dimensional and three-dimensional time displacement is not motion. It is additive, not reciprocal. Thus, once the three-dimensional time displacement comes into contact with one-dimensional time displacement, and the axes of

rotation are congruent in any one of three dimensions, a combination necessarily takes place. Probability considerations indicate that in most instances the positron's time displacement will be absorbed by one of the two principal (two-dimensional) axes of rotation; in a relatively small number of cases the absorption will be along the electric axis. But whereas the absorption of time displacement along the two magnetic axes is permanent, time displacement absorbed along the electric axis is continuously subject to modification by the prevalent one-dimensional units of space displacement (electrons).

The observed situation—in which one-dimensional time displacement of the material atoms is limited to two units—appears to be one of equilibrium, the net result of the balance of probabilities. While positrons are more readily absorbed by the material atoms than electrons, the absorption is seldom along the electric axis. The absorption of electrons is more difficult, but it is *always* along the electric axis.

The effect of this situation is to effectively neutralize all electropositive one-dimensional rotations of the material atoms greater than two units, so that if the higher elements are to be formed at all, they must be formed on the "excess electronegative" basis. This configuration is rather improbable to begin with, but the unavailability of the positive alternative eventually results in the formation of the higher elements on the electronegative basis, according to the principles outlined in chapter 26 of Larson's *Basic Properties of Matter*. The electronegative alternative is aided by the same preponderance of electronegative rotations that discourages the positive configuration—one-dimensional

space displacement is plentiful in the material environment, and under the right conditions will be transferred to the material atoms. Hence the "force" that is skewing the periodic table to the electronegative side acts both to decrease the probability of the electropositive configuration and increase the likelihood of the electronegative one. The only remaining question is whether the observed limitation of one-dimensional time displacement to exactly two units is simply the result of the balance of probabilities outlined above, resulting in the establishment of an equilibrium at this level, or whether some other factor is at work that makes the two-unit one-dimensional time displacement configuration in the material atoms unusually stable. The first solution has the advantage of simplicity, but the relative probabilities need to be worked out mathematically to determine whether or not an equilibrium at precisely this level is predicted by the postulates.

In the light of the solution presented above, we are led to conclude that while the most salient of the properties of the elements are due to number of units of displacement along the electric axis, there are other properties that are a function of total displacement, regardless of how it is constituted. In the table presented by Larson, which is perfectly symmetrical along the axis formed by the noble gases, the electric displacements are effectively cancelled out; they merely fortify the structure constructed on the basis of total displacement alone. As a result the table shows only the relationships due to total displacement. The table being proposed in this paper stresses the effects of electric displacement, which is strongly skewed in favor of the negative one-dimensional arrangement. Both tables have

some features to recommend them, but since the electric displacement is the major determinant of the properties of the elements, the new table proposed here is the more useful one for chemists.

The conclusion that there are two mutually exclusive criteria for arranging the periodic table—i.e., displacement along the electric axis and total displacement may help in explaining why the rare-earth series of elements should begin with one-dimensional space displacement of 15 units. We must visualize the two tables as co-existing in some sense, since both arrangements have certain advantages in the way they represent the observed properties of the elements. In nature, as distinct from any table we can devise, each element occupies one position by virtue of its electric displacement, and another position by virtue of its total displacement. On the basis of total displacement, however, the elements do not range beyond 15 positions from the neutral axis (the noble gas series). Elements are forced into positions that are beyond this range only with difficulty, due to the relentless pressure of the electron flux, which skews the periodic table away from its ideal, symmetrical arrangement.