argon, and, while this evidence was later vitiated by the discovery of impurities, the question is by no means as yet settled in the negative. Compounds with excited helium or argon are at least not unthinkable, and this is probably the most promising way of forming them.

A word of caution may not be out of place as to the use of this method of synthesis. Metals ordinarily contain a great deal of absorbed gas and while the usual baking (at say 500°) may remove the bulk of such impurity adsorbed on the surface, it will probably take little from the interior. Then as layer after layer of atoms is removed from the cathode in the sputtering process, fresh supplies of gaseous impurity are released, so when purity of product is a main factor some provision must be made to eliminate this source of trouble. It may be possible to secure nearly gas-free metal for the cathode, or to outgas it effectively by having it in the form of a thin strip which can be heated electrically to a high temperature, but probably the most feasible method is to dilute the impurity to a point where it becomes negligible by a continuous flow of fresh gas through the chamber during the sputtering.

DEPARTMENT OF PHYSICS
UNIVERSITY OF WISCONSIN
MADISON, WISCONSIN
L. R. INGERSOLL
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A RELATION CONCERNING ATOMIC NUCLEI

Sir:

An interesting numerical relation of known atomic species is to be found in the helium–thorium series. The atomic nuclei of this series have a composition represented by the general equation

$$a_{(Z/2+n/4)} + (e_2)_{n/4}$$

in which e is an electron, a represents a group of 4 protons and 2 electrons, Z is the atomic, and n, the isotopic number. For thorium Z is 90 and n is 26, so the specific formula is $a_{58}e_{26}$. In a recent paper Latimer develops a model for the nuclei of this series. He bases his model not only on the general hydrogen–helium theory[1] developed in 1915 by the writer, but he also makes use of the very specific features of this theory, such as the pairing of the nuclear electrons,[2] the introduction of the first pair of extra or cementing electrons in the argon nucleus[3] of mass 40, and the later addition of still other pairs of electrons as the atomic number increases.[4]

Latimer also uses the idea that the abundance of an atomic species is

[1] Harkins and Wilson, THIS JOURNAL, **37**, 1367–1396 (1915).

[2] Harkins, *ibid.*, **39**, 859 (1917); **42**, 1958, 1963–1964, 1991–1993 (1920).

[3] Harkins, *ibid.*, **39**, 859, Table II (1917); *Phil. Mag.*, **43**, 305 (1921).

[4] Harkins, *Phil. Mag.*, **42**, 1976 (1920).

related to its stability,[5] and considers that the stability is related to the intranuclear spins,[6] which are supposed to be due to the protons.

It is of interest to see if any known relations, other than those upon which the model is based, agree with the interesting tetrahedral model. Figure 1 gives a representation of the helium–thorium series, taken largely from

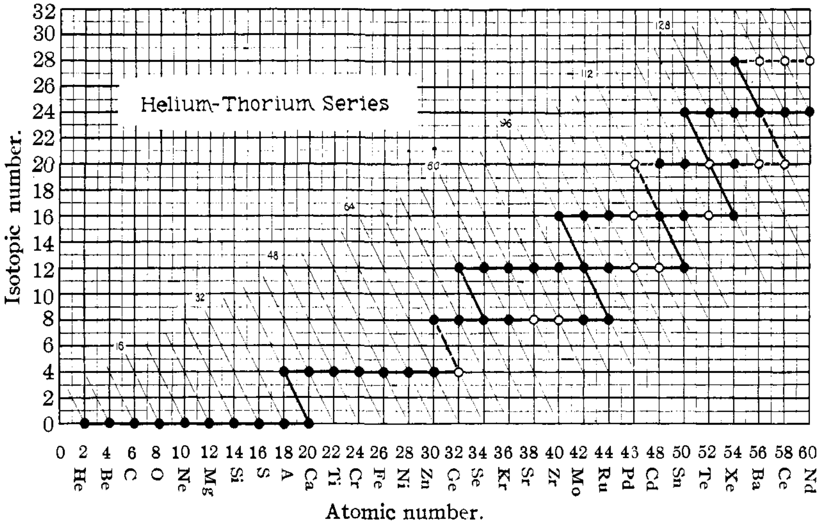

Fig. 1.—Open circles represent species as yet undiscovered.

an early paper,[7] but extended to fit the most recent data of Aston.[8] It may be noted that this series is found only on levels 0, 4, 8, 12, etc., which correspond to 0, 1, 2, 3, etc., pairs of extra or cementing electrons. The length of the series at any level will be considered to be given by the number of places for members of the series beginning and ending with known species. The values are collected in Table I.

TABLE I

1 Isotopic number, n	2 Number of cementing electrons, $n/2$	3 Number of species in known series	4 Number of species in Fig. 1
0	0	10	10
4	2	7	8
8	4	8	8
12	6	10	10
16	8	8	8

In explanation of Column 4 it may be said that Fig. 1 represents undiscovered species by open, and known species by black, circles.

[5] Harkins, THIS JOURNAL, **39**, 856 (1917); *Proc. Nat. Acad. Sci.*, **2**, 216 (1916).

[6] Harkins, *Phys. Rev.*, **35**, 434 (1930).

[7] Harkins, *J. Franklin Inst.*, **195**, 554 (1923).

[8] Aston, *Nature*, **127**, 233 (1931).

Thus the number of species is 10 for either zero or three pairs of cementing electrons, and eight (possibly seven for one pair) for one, two, or four pairs. This agrees with the writer's early idea that the zero level should be a long one, and with Latimer's idea that the level for three pairs of cementing electrons should also be long. While later discoveries may change these limits, they will probably not destroy the validity of the general relations.

It may be noted that Latimer[9] makes no attempt to explain the most fundamental relation which concerns nuclear stability, the pairing of electrons in the nucleus. Also Dirac's principle of superposition, mentioned by Rodebush,[10] has not been developed to the extent necessary to explain this phenomenon. It is not improbable that the two electrons in an alpha particle move through the whole volume of the particle, but the distribution of electron density is entirely unknown. It is not intended to imply that the electron pairing cannot later be treated in terms of an overlapping of the eigenfunctions of the single electrons.

DEPARTMENT OF CHEMISTRY
UNIVERSITY OF CHICAGO
CHICAGO, ILLINOIS
WILLIAM D. HARKINS

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THE STRUCTURE OF THE α-PARTICLE

Sir:

In the March number of THIS JOURNAL, W. M. Latimer has written an article in which he refers to a suggestion of mine. Inasmuch as one might infer therefrom that I considered the idea of the tetrahedral form of α-particle to be original with me, may I state that this was not the case. What I did suggest and discuss with Professor Latimer and others was the orientation of the spins of the proton, as used by Latimer, in which the spin of each proton was supposed to point out from the center of the tetrahedron. This was some time ago, and Professor Latimer writes me that our discussion was only recalled to him by our correspondence after this article was in manuscript form.

In view of this paper of Latimer's and recent discussions of nuclear spin [Bartlett, *Phys. Rev.*, **37**, 327 (1931); Gibbs and Kruger, *ibid.*, **37**, 656 (1931)], a word as to my reason for making this suggestion may not be out of place. I wished to have the resultant spin for one, two or three protons the same (and the same as that of the electron, equal to $^1/_2$ unit), and the spin for four protons equal to zero. This is a natural result of the tetrahedral structure though requiring some "distortion" of the angle (if such language has any meaning) between two protons in the case of two. This would explain the anomalous spin in the case of nitrogen (3 α-particles, 2 extra protons, 1 extra electron, resultant spin

[9] Latimer, THIS JOURNAL, **53**, 987 (1931).

[10] Rodebush, *ibid.*, **53**, 1611 (1931).