LETTERS TO THE EDITOR

Prompt publication of brief reports of important discoveries in physics may be secured by addressing them to this department. Closing dates for this department are, for the first issue of the month, the twenty-eighth of the preceding month; for the second issue, the thirteenth of the month. The Board of Editors does not hold itself responsible for the opinions expressed by the correspondents.

Nuclear Spin

On the basis of measurements by Rasetti[1] of the Raman effect in N_2, Heitler and Herzberg[2] have suggested that the electron in the nucleus has lost not only its spin, but also its power to determine what the statistics of the nucleus shall be. (One could say, perhaps, that the electrons in the nucleus behave as if they had no spin and obey, therefore, the Bose-Einstein statistics, just as photons do.) The purpose of the present note is to point out that *the assumption that the protons alone contribute to the resultant spin is sufficient to explain all the known facts*. Furthermore, it may be that there is a building-up principle analogous to that of the outer electrons, although the evidence[3,4] is insufficient to show exactly what this would be.

TABLE I. *Building-up process.*

Element	P	Z	I	Protons added	Spins added
H	1	1	1/2		
He	4	2	0	3	$(+-)-$
Li	7	3	3/2	3	$+++$
C	12	6	0	5	$---(+-)$
N	14	7	1	2	$++$
O	16	8	0	2	$--$
F	19	9	1/2	3	$(+-)+$

The table gives in the last two columns the number of protons and spins, respectively, which must be added to the element in the row above to give the element in the row itself.

Thus, if we suppose that each additional proton contributes a spin of $\pm 1/2$ to the resultant (which is the simplest assumption), the elements may be ordered as shown. Starting with He^4, $I=0$, three parallel spins will produce Li^7, $I=3/2$, and five more, two forming a pair, can result in C^{12}, $I=0$. Two additional parallel spins give N^{14}, $I=1$; two more, opposite in direction to the first two, O^{16}, $I=0$; and three more, two forming a pair, can yield $I=1/2$ for F^{19}. The value of nuclear spin for Na^{23} is in doubt, but if we assume $I=5/2$, then, by interpolation, Ne^{20} should have $I=1$ and Ne^{22}, $I=2$. One would also expect, since $I=0$ for C^{12} and S^{32}, a value of $I=1/2$ for B^{11} and P^{31}.

The difficulty mentioned by Goudsmit for the cadmium spectrum also disappears, if one adopts the above hypotheses. The value of $I=1/2$ may be attributed to Cd^{111} or Cd^{113}, but there exist no criteria for choosing between the two isotopes. (Perhaps both give a hyperfine structure.)

It seems, therefore, that the experimental evidence to date indicates the validity of the rule that even numbers of protons imply integral values for I, and odd numbers half-integral values. This is true for Mn, Br, Pr and Bi.

One would expect aluminium, phosphorus, chlorine, potassium, scandium, vanadium, cobalt, copper, gallium, arsenic, and other elements with isotopes having only odd numbers of protons to have half-integral values for the nuclear spin.

It remains an open question as to whether or not the orbital angular momentum of the protons plays a rôle, and also whether or not closed shells of protons exist, as do closed shells of extra-nuclear electrons. If there are such closed shells of protons, then this might provide the explanation of inverted hyperfine structure, the inversion being due to the absence of a proton from such a shell.

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[1] F. Rasetti, Proc. Nat. Acad. Sci. **15**, 515 (1929).
[2] Heitler and Herzberg, Naturwiss. **17**, 673 (1929).
[3] R. S. Mulliken, Trans. Faraday Soc. **25**, 634 (1929).
[4] Pauling and Goudsmit, Line Spectra (1930).