CONCLUSIONS

The changes in these secondary masses, though larger than might first be expected from the magnitude of the quoted errors, are small when reflected into calculated atomic masses. Changes of the order of magnitude observed here have no significant effect on either the atomic masses derived from doublets measured on our instrument or the various conclusions drawn from the mass data.

The recent work of Smith gives a value for the C^{12} mass of 12.003 814 58±11 amu.[9] This value is in disagreement with our value by more than two errors, yet using either of the two together with the published doublet results to obtain atomic masses leads to the same conclusions regarding neutron and proton separation energies and pairing energies.

[9] L. G. Smith, Bull. Am. Phys. Soc. Ser. II, 2, 223 (1957).

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Search for Monopole Pairs from the Second Excited State of C^{12}

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A thorough search for monopole pairs from the second excited state in C^{12} is described. No pairs could be detected and it is concluded that the question of the angular momentum and parity of this state cannot yet be considered as solved.

INTRODUCTION

THE second excited state of C^{12} at 7.68-Mev decays primarily by α emission leading to the ground state of Be^8 [1]; a cascade γ transition through the first excited state of C^{12} at 4.43 Mev has also been reported.[2,3] No direct γ transition to the ground state of C^{12} has been observed and an upper limit for the high-energy radiation is put at 4×10^{-4} of the cascade transitions.[2] In addition evidence was found[4] for electron-positron pair emission in a direct transition from the 7.68-Mev level to the ground state. The author investigated internally converted pairs from the 4.43-Mev level excited in the $Be^9(\alpha_{Po},n)C^{12}$ reaction[5] in a cloud chamber, and together with 70 pairs from the 4.43-Mev transition he found 7 pairs of about 6 Mev which he interpreted as pair radiation from the 7.68-Mev level. From the upper limit for γ emission in this transition as quoted above, the pair conversion coefficient would have to be of the order of unity or bigger to account for those pairs. This can only be the case if the transition is of the monopole type (the conversion coefficient would then be ∞). The 7.68-Mev state was therefore assigned zero angular momentum and even parity—the same as the ground state.

This is the only definite information one has, to date, on the angular momentum and parity of this state and the evidence in this work could not be considered conclusive. It was therefore thought desirable to look for these high-energy pairs with a counter system which could be expected to give a much greater yield of pairs than the cloud chamber procedure. An experiment of this nature is reported in this paper. The main results of this investigation have been presented at a meeting of the Israel Physical Society.[6]

[1] Miller, Rasmussen, and Sampson, Phys. Rev. 95, 649 (1954).
[2] Beghian, Halban, Husain, and Sanders, Phys. Rev. 90, 1129 (1953).
[3] R. G. Uebergang, Australian J. Phys. 7, 279 (1954).
[4] G. Harries, Proc. Phys. Soc. (London) A67, 153 (1954).
[5] α_{Po} indicates α particles from a Po source, i.e., at energy 5.3 Mev.

APPARATUS AND EXPERIMENTAL PROCEDURE

In order not to complicate the apparatus unduly, it was decided to look just for electron (or positron) emissions, and not more specifically for pairs of given total energy.

The experimental arrangement is shown in Fig. 1. The source consisted of 50 mC of Po deposited on a Pt foil of 7 mg/cm², facing a piece of Be of 23 mg/cm². The energy of the electrons was measured in a NaI crystal which was covered by an Al foil 0.09 mm thick. The height of the pulses from the crystal was measured in a single-channel pulse-height analyzer and the output of the analyzer was gated by pulses from a thin-walled G.M. counter which was placed between the source and the crystal. In this way counts due to electrons produced inside the crystal were largely eliminated. A 0.05-mm brass absorber had to be placed in front of the counter to reduce the intense x-ray radiation from the source.

[6] Goldring, Wiener, and Wolfson, Bull. Research Council Israel 5A, No. 1, 87 (1955).

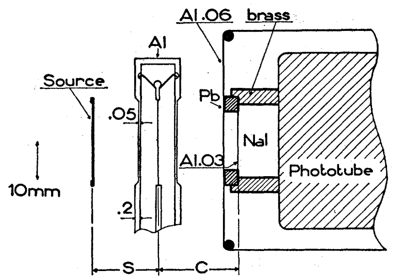

FIG. 1. Source and counter arrangement. Distances are given in mm. In "geometry (a)" $s=17$ mm, $c=20$ mm. In "geometry (b)" $s=8$ mm, $c=9$ mm.

The spectrum of the single counts in the crystal was found to exhibit three well-pronounced peaks which were attributed to the photopeak of the 803-kev line in Po and to the pair peak and pair+one annihilation quantum peak of the 4.47-Mev line. These peaks served as energy standards.

Coincidences between the crystal and the G.M. counter in the arrangement of "geometry (a)" in Fig. 1 were registered for pulses corresponding to electrons of 3.4 Mev or less. Such counts could conceivably come from three sources: (a) electrons from C^{12*}, (b) electrons produced in the source or the wall of the counter by γ rays or neutrons, and (c) electrons produced inside the crystal which leave the crystal and penetrate into the counter. To evaluate the relative number of electrons from these sources, measurements were made under the following conditions: (i) the front wall of the counter and the source material were exactly duplicated [thus doubling (b)]; (ii) the source and the counter were interchanged [in this position only (c) is counted]. It was found that approximately 50% of all coincidence counts were due to spurious effects [(b) and (c)].

The number of internal pairs emitted in the 4.43-Mev transition was determined as $N_\pi=66\pm20$ per sec. This number could also be deduced from the number of γ rays (determined both by counting and from the strength of the source). In this way N_π was found to be 55 ± 20 per second in good agreement with the direct measurement.

SEARCH FOR HIGH-ENERGY ELECTRONS

After it was established that it was possible to detect electrons from excited C^{12} nuclei with the counter-crystal telescope, the discriminator was set to record electrons of energy above 4.8 Mev, and the source, counter, and crystal were all brought close together ["geometry (b)" in Fig. 1] in order to increase the solid angle.

The number of electrons of energy above 4.8 Mev was found to be 6.8 ± 0.8 per minute, and after applying corrections as in (i) and (ii) above: 3 ± 0.8 per minute. If these counts were all due to electrons from monopole pairs in the 7.68-Mev transition, one would get for $\bar{N}_\pi$, the number of high-energy pairs, $\bar{N}_\pi=10\pm2$ per minute (since the spectral region above 4.8 Mev comprises about $\frac{1}{6}$ of the electrons). This is 1/400 of the number of low-energy pairs.

Actually the fact that measurements (i) and (ii) gave nonvanishing results made it clear that there were some other processes involved. To test this point further, absorbers were introduced between the two counters and the counts were found to rise very slightly with absorber thickness whereas they would drop sharply if a large fraction of the high-energy counts were due to electrons emitted from the source. It is therefore very likely that most if not all high-energy counts are due to some other processes (presumably involving neutrons), and we estimate that certainly not more than 60% of the observed counts are due to monopole pair electrons. This puts the upper limit for $\bar{N}_\pi/N_\pi$ at approximately 1/600.

CONCLUSION

The number of monopole pairs in the reaction $Be^9(\alpha_{Po},n)C^{12}$ is less than 1/600 of the number of pairs from the 4.43-Mev transition. This means that the pairs observed by Harries, which were about 60 times as prolific, must have been due to other causes, and the conclusion that the second excited level of C^{12} is of the type 0^+ is not justified on these grounds. An upper limit for pair emission of the same order has recently been reported by Kruse, Bent, and Eklund.[7]

We would further like to point out that the absence of high-energy electrons also implies the absence of a γ transition the pair conversion of which should have yielded electrons. The lower limit on electron emission reported here places a lower limit on the γ emission which is larger by a factor of approximately 4 than the limit arrived at by γ spectroscopy.

[7] Kruse, Bent, and Eklund, Bull. Am. Phys. Soc. Ser. II, **2**, 29 (1957).