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The theoretical estimates /1-3/ as well as the extrapolation of the available experimental data /4/ do not solve the question of particle-stability of extremely neutron-rich isotopes of light elements.

In particular, according to Garvey and Kelson /1/ the neutron binding energy in ^{13}Be is equal to -2.7 MeV and the binding energy of two neutrons in ^{14}Be is equal to -2.4 MeV. According to Vorobiev et al. /4/ these quantities are -0.1 MeV and +1.9 MeV, respectively. Also the shell model estimates of Vinogradov and Nemirovsky /3/ do not exclude the possibility of particle stability of ^{14}Be. Some years ago Poskanzer et al. /5/ reported their experimental results which suggested that ^{13}Be is probably particle-unstable.

In the present work the problem of particle stability of ^{13}Be and ^{14}Be was experimentally studied. This was possible because we could estimate the expected cross sections for production of these isotopes from the cross section systematics for multi-nucleon transfer reactions. Such systematics shows /6/ that the cross sections for the nucleon stripping- and nucleon exchange reactions (projectile - x protons ± y neutrons) depend exponentially on the Q-values, calculated for the ground state masses of the reaction products.

The experiment was performed with the 310-cm heavy ion cyclotron of Nuclear Reaction Laboratory, JINR in Dubna. A metallic ^{232}Th target of 20 mg/cm^2 thickness was bombarded with 145 MeV ^{15}N ions.

The reaction products emitted from the target at 40° with respect to the incident beam passed the magnetic spectrometer and were detected in a particle telescope consisting of two semiconductor detectors, placed in the focal plane of the spectrometer. For more detailed information concerning the experimental method we refer to ref./7/.

Energy spectra of the reaction products were obtained by measuring the yields at different values of magnetic rigidity BR. Fig. 1 shows the energy spectra of ^{14,15,16}C, ^{13,14,15}B and ^{12}Be produced in the (^{15}N - 1 proton + y neutrons), (^{15}N - 2 protons + y neutrons) and (^{15}N - 3 protons) reactions, respectively. As can be seen from this figure, at a fixed number of the stripped protons the average excitation energy does not change significantly with the increasing number of picked up neutrons. Therefore, measuring the energy spectrum of ^{12}Be we could estimate the energies at which the maxima of ^{13}Be and ^{14}Be energy spectra should be situated. The predicted shapes of these energy spectra are marked by the dashed curves in fig. 1.

The search for ^{13}Be and ^{14}Be was performed at magnetic rigidity BR = 10.85 kG$s.m, at which the ^{12}Be, ^{13}Be and ^{14}Be ions could be detected within narrow energy intervals shown in fig. 1 by the dashed areas. Large width of the maxima in the energy spectra ensures that the error in our estimation of their positions even of a few MeV would not change significantly the yields of ^{13}Be and ^{14}Be .

The expected yields of ^{13}Be and ^{14}Be were estimated from the cross section systematics shown in fig. 2. In this figure the differential cross sections $(d\sigma/d\Omega)_{40^\circ}$ for a formation of Li , Be , B and C isotopes in ^{15}N + ^{232}Th reaction are plotted as function of Q_{gg} . The values of $(d\sigma/d\Omega)_{40^\circ}$ were obtained by integrating the measured energy spectra over the whole energy range. As can be seen from fig. 2, the experimental points for isotopes of given element lie close to the $(d\sigma/d\Omega)_{40^\circ} = \mathrm{const}\, Q_{gg}$ lines. This regularity seems to be quite general/6/ and, therefore, it can be used for estimation of the cross sections. The extrapolation of the line for beryllium isotopes (shown in fig. 2) should not give significant error, since the neighbouring lines are almost parallel and fit well the experimental points in a wide range of the cross section values.

In the experiment at BR = 10.85 kGs.m about 20000 events of ^{12}Be were detected, whereas no effect due to the ^{13}Be and ^{14}Be ions was observed. The background, defining the upper limit of the ^{13}Be and ^{14}Be yields, was about 3 events. Assuming that ^{13}Be and ^{14}Be are extremely weakly bound the expected yields of ^{13}Be and ^{14}Be should be about 550 events and 30 events, respectively. In the case of the binding energy of two neutrons in ^{14}Be equal to 1.9 MeV, as suggested by Vorobiev et al./4/, the expected yield of ^{14}Be should be even larger (about 70 events).

To exclude the possibility of some unexpected anomalies in the energy spectra of ^{13}Be and ^{14}Be ions we were looking for, additional measurements at BR = 11.53 kGs.m and BR = 10.00 kGs.m were performed. Also in these cases no effect due to the ^{13}Be and ^{14}Be ions was observed.

Fig. 2 shows that even so weakly bound nuclei as ^{14}B and ^{11}Li are produced with yields consistent with our systematics. Therefore, we can conclude that in all probability the ^{13}Be and ^{14}Be nuclei are particle unstable.

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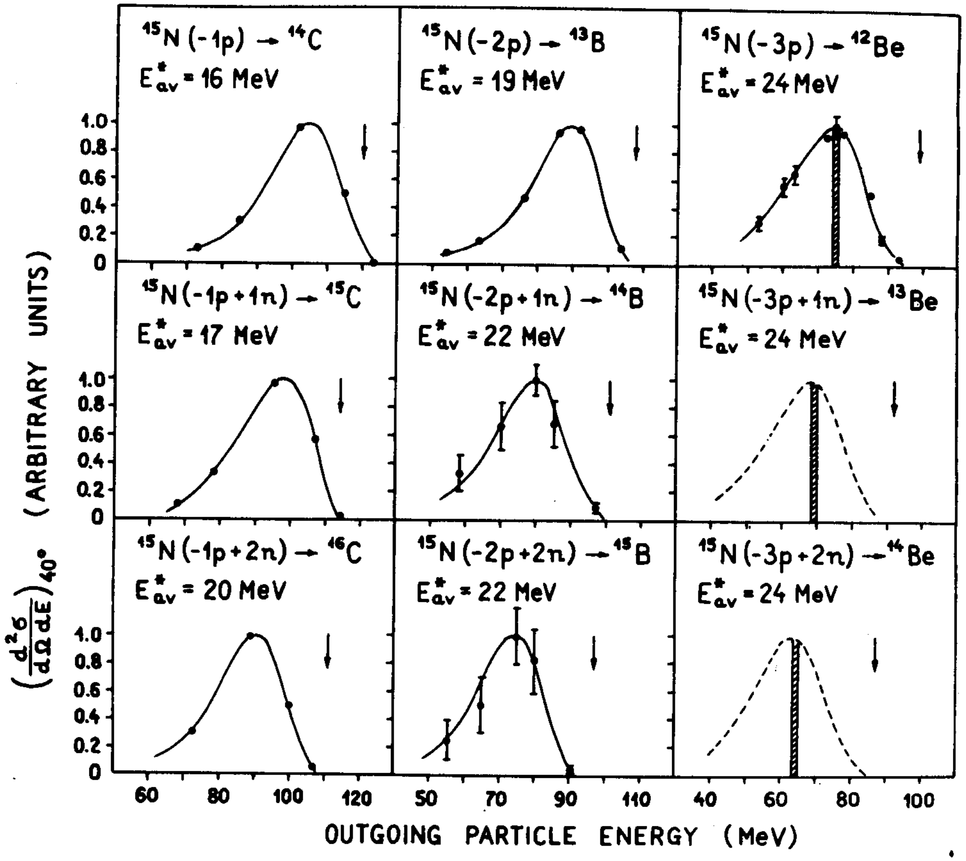

Fig. 1. Energy spectra of $^{14,15,16}C$, $^{13,14,15}B$ and ^{12}Be produced in the nucleon exchange reactions (projectile - x protons + y neutrons) in bombardment of ^{232}Th target with 145 MeV ^{15}N ions. The dashed curves show the predicted spectra of ^{13}Be and ^{14}Be. The arrows denote the energy values corresponding to the formation of both reaction products in the ground states.

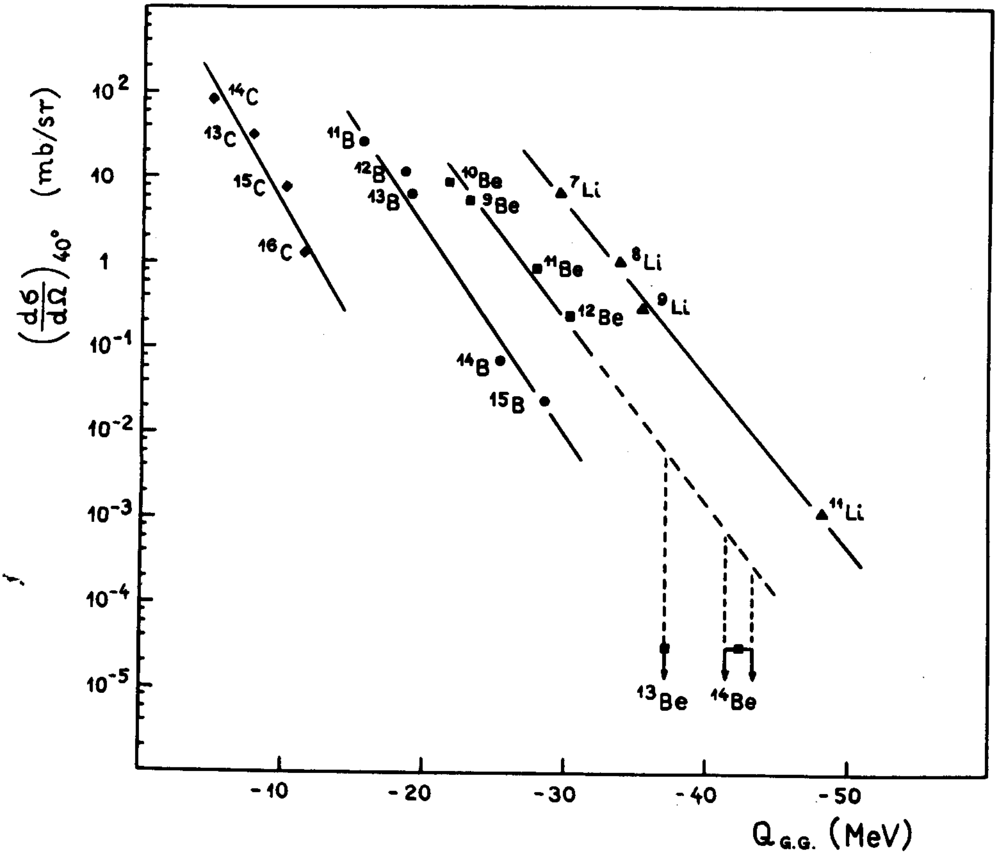

Fig. 2. The differential cross sections $(d\sigma/d\Omega)_{40°}$ for production of carbon, boron, beryllium and lithium isotopes in the $^{15}N + ^{232}Th$ reaction as a function of Q_{gg}. The Q_{gg}-value for ^{18}Be corresponds to the particle-stability threshold $E_n = 0$. For ^{14}Be the left and right arrows indicate the Q_{gg}-values for $E_{2n} = 1.9$ MeV and $E_{2n} = 0$, respectively.