Study of the ^{14}Be Continuum *

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The nuclide ^{14}Be has been studied in a radioactive-beam experiment performed at ALADIN-LAND setup. There was till now only scarce information about its detailed structure.

In this report we present new experimental data on inelastic scattering of an energetic (304 MeV/u) ^{14}Be beam in a liquid hydrogen target [1]. The details about the data reduction and treatment are given in Refs. [2]. The distribution of internal energy in the ^{12}Be+n+n system, $d\sigma/dE_{fnn}$, obtained from the present data is shown in Fig. 1. The spectrum was decomposed into three Breit-Wigner shaped resonances and a contribution from unresolved resonances. The collected statistics made it impossible to perform a least-square fit with all parameters free. By a stepwise analysis this problem could be overcome and the parameters arrived at in the final fit, with χ^2/N=27.9/35, are given in Table 1.

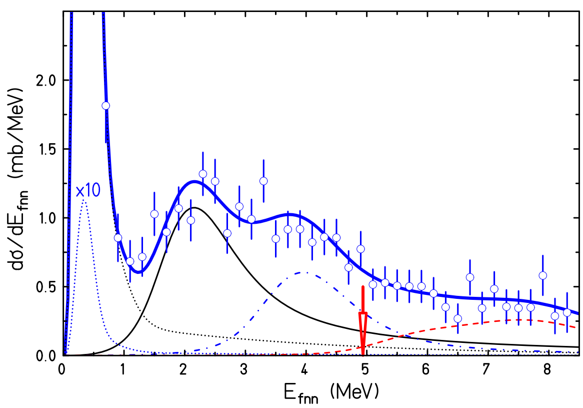

Fig. 1: The distribution of internal energy in the ^{12}Be+n+n system ($d\sigma/dE_{fnn}$). Curves show the decomposition of the spectrum into Breit-Wigner shaped resonances. The arrow indicates the four-neutron decay threshold.

The analysis of distributions on fractional energies, $\epsilon_{nn} = E_{nn}/E_{fnn}$ and $\epsilon_{fn} = E_{fn}/E_{fnn}$, were performed to determine spin and parities on the resonances. The $W(\epsilon_{fn})$ and $W(\epsilon_{nn})$ distributions, derived from events belonging to the energy regions $0.5 < E_{fnn} < 1$ MeV and $2 < E_{fnn} < 3$ MeV, are analyzed with the assumption of a democratic decay. Correlations between the decay products in democratic decays may generally be described as superpositions of different partial waves in the binary subsystems. The measured $W(\epsilon_{fn})$ and $W(\epsilon_{nn})$ can contain thus contributions from all possible waves, including cross terms. But at low energy only terms with the lowest possible angular momenta, consistent with selection rules, are needed [4]:

Table 1: Resonance parameters for excited states in ^{14}Be. The fit results to $\chi^2/N = 27.9/35$.

I^π	E_r MeV	E_{exc} MeV	Γ MeV	σ mb
2_1^+	$0.28^{a,b}$	$1.54(13)^b$	0.025^a	5.07(58)
2_2^+	2.28(9)	3.54(16)	1.5^a	2.57(19)
(3^-)	3.99(14)	5.25(19)	1.0^a	1.35(16)

^{a} parameters were fixed
^{b} taken from Ref.[3]

$$W(\epsilon) = \sum_i \frac{\Gamma(3 + l_1^i + l_2^i)}{\Gamma(\frac{3}{2} + l_1^i)\Gamma(\frac{3}{2} + l_2^i)} A_i^2 \epsilon^{l_1^i + \frac{1}{2}} (1 - \epsilon)^{l_2^i + \frac{1}{2}}.$$

Here $\Gamma(z)$ is the Euler gamma function, l_1 is the angular momentum between two neutrons or between one neutron and the fragment, l_2 is the angular momentum between one neutron or the fragment and the centre-of-mass of the remaining two-body system. A_i is the decay amplitude of a particular configuration i, ($\sum_i A_i^2 = 1$). Different components, A_{02}, A_{20}, A_{11} and A_{22}, were obtained from the fit to $W(\epsilon_{fn})$ and $W(\epsilon_{nn})$ distributions.

The analysis of the energy correlations between decay products shows that the 2_1^+ resonance contains two neutrons mainly in the $(0d_{5/2})^2$ configuration. Also a strict evidence was obtained, that the state at $E_r = 2.28(9)$ MeV is a 2_2^+ state with predominantly $(1s_{1/2}0d_{5/2})$ structure.

Strong similarity exists between the level schemes of N=10 isotones. Thus the first excited state (2_1^+) of ^{14}Be, E_{exc} = 1.54 MeV, is a close analogy to the 1.77 MeV state in ^{16}C and to the 1.98 MeV state in ^{18}O. Also excitation energies of the second 2_2^+ states for the members of N=10 isotone chain do not differ much, . The state at $E_r = 3.99(14)$ can be an analog of the 3^- state in ^{18}O and ^{16}C.

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References

[1] Yu. Aksyutina *et al.*, Phys.Rev.Lett. **111**, 242501 (2013).
[2] Yu. Aksyutina *et al.*, Phys.Lett. **B 666**, 430 (2008).
[3] T. Sugimoto *et al.*, Phys. Lett. **B 654**, 160 (2007).
[4] L.M. Delves, Nucl. Phys. **20**, 275 (1960).

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