Study of the ^{14}Be Continuum *

Yu. Aksyutina[1,2], *T. Aumann*[2,3], *L. Chulkov*[3,4], *B. Jonson*[5], *H. Simon*[3], *and the R ^{3}B Collaboration*

[1]Institut für Energie- und Klimaforschung, Jülich; [2]Nuclear Reactions and Astrophysics @ GSI; [3]Technische Universität Darmstadt; [4]NRC Kurchatov Institute, Moscow; [5]Chalmers Tekniska Högskola, Göteborg

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

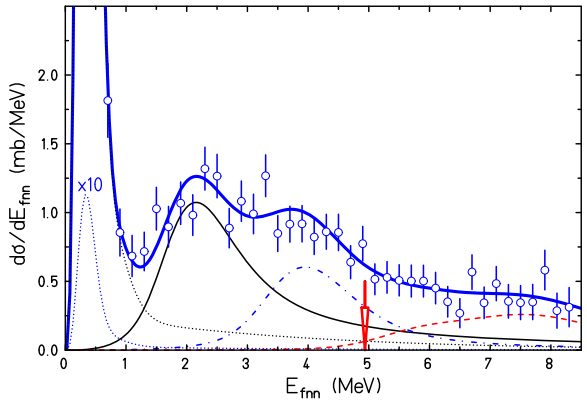

Fig. 1: The distribution of internal energy in the ^{12}Be+n+n system ($d\sigma/dE_{fnn}$). Curves show the decomposition of the spectrum into Breit-Wigner shaped resonances. The arrow indicates the four-neutron decay threshold.

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.

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

* Work supported by the Helmholtz International Center for FAIR within the framework of the LOEWE program, by the BMBF (Project No. 05P12RDFN8), by the Helmholtz Alliance EMMI, by Swedish Research Council, and the Spanish Ministry (Grant No. FPA2009-07387).

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]

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]:

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

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.

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).