Statistical decay of excited $\Lambda\Lambda$ Hypernuclei and γ–Spectroscopy at PANDA*

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Hypernuclear Physics is currently attracting renewed attention. Thanks to the use of stored $\overline{\mathrm{p}}$ beams, copious production of double Λ hypernuclei is expected at the PANDA experiment which will enable high precision γ spectroscopy of such nuclei for the first time.

The simultaneous production and implementation of two Λ particles into a nucleus is not feasible. The conversion of a Ξ^- and a proton into two Λ particles releases – ignoring binding energy effects – only 28 MeV/c^2. Accordingly, there is a chance of typically a few percent that both Λ hyperons stick to the same nucleus. Because of this two-step process, spectroscopic studies, based on the analysis of two-body reactions like in single hypernuclei reactions, cannot be performed and spectroscopic information on double hypernuclei can only be obtained via their decay products. Except for the case of very light hypernuclei also neutral particles are emitted unfortunately. Therefore, a unique identification of the double hypernuclei can only be reached via the emitted γ-rays from excited, particle stable states.

For light nuclei with mass numbers $A_0 \leq 13$ even a relatively small excitation energy may be comparable to their binding energy. In the following we therefore assume that the principal mechanism of de-excitation is the explosive decay of the excited nucleus into several smaller clusters. To describe this break-up process and in order to estimate the population of individual excited states in double hyper nuclei after the conversion of the Ξ^-, we have developed a statistical decay model which is reminiscent of the famous Fermi model for particle production in nuclear reactions [1]. We assume that the nucleus break-ups simultaneously into cold and slightly excited fragments [2]. In the case of conventional nuclear fragments, we adopt their experimental masses in ground states, and take into account their excited states, which are stable respective to emission of nucleons. For hypernuclei with single Λ particle, we use the experimental masses and excited states also. For double hypernuclei we adopt theoretically predicted masses and excited states [3, 4].

In the model we consider all possible break-up channels, which satisfy the mass number, hyperon number (i.e. strangeness), charge, energy and momenta conservations, and take into account the competition between these channels. Since the excitation energy of the initially produced double hypernuclei is not exactly known, we performed the

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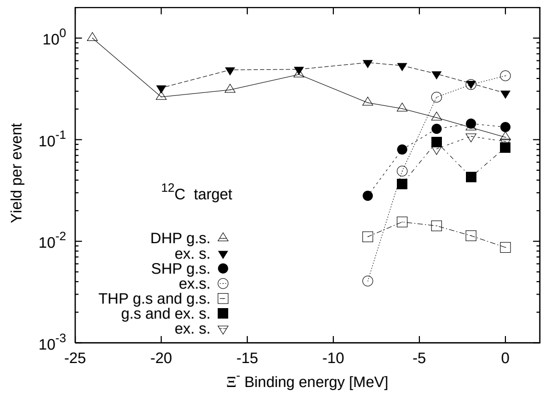

Figure 1: Predicted relative yield for ground states (g.s.) and excited states (ex.s.) in double (DH), single (SH), and and twin hypernuclei (TH) as a function of the Ξ binding energy for a secondary target of ^{12}C .

calculations as a function of the binding energy of the captured Ξ^-. Calculations were performed for all stable secondary targets (^{9}Be, ^{10}B, ^{11}B, ^{12}C, and ^{13}C) which lead to the production of excited states in double hypernuclei. Fig. 1 suggests that a significant fraction of the converted Ξ^- lead to the production of a γ-unstable double hypernuclei. Comparing the expected yields for various target nuclei we are presently developing a strategy to uniquely assign observable transition to the corresponding hypernuclei.

In the present work we have studied the population of particle stable, excited states in double hypernuclei after the capture of a Ξ within a statistical decay model. In order to check the feasibility of producing and performing γ spectroscopy of double hypernuclei at PANDA, an event generator based on these calculations has been implemented in the mark of the PANDA simulation framework Pandaroot.

The results of this simulation[5] fullfill very well our expectations of planning future experiments for searching double hypernuclei.

References

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