Studies of ^{12}C using β-decays and reactions

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The nuclear structure of ^{12}C has been dicussed since the early days of nuclear physics, but experimentally there are today still open questions about the spectroscopy of this nucleus, which hamper a clear understanding of this issue. In particular the properties of broad states just above the 3α-threshold are presently being elucidated by both theory and experiments. The decays of unbound states in ^{12}C into three α-particles is also not well measured, although this observable could provide extra information about the structure of the states.

Since 2001 we have used the β-decays of the shortlived isotopes ^{12}N and ^{12}B to provide new information on the 0^+, 1^+, and 2^+ states in ^{12}C. The main results from our first series of experiments peformed at IGISOL–Jyväskylä in 2001 and ISOLDE–CERN in 2002, published in [1,2,3], are :

1. The Spin-parity of the so-called 10.3 MeV state is 0^+ and its shape is strongly influenced by interference with the 7.654 MeV 0^+ state.
2. The breakup mechanism of the 10.3 MeV state is mainly through the ^{8}Be ground-state, but higher energies in ^{8}Be also contribute.
3. A (most likely) 2^+ state above the socalled 10.3 MeV state is populated in the β-decay of ^{12}N.
4. A good description of the breakup spectrum of the 12.71 MeV state can be made using an R-matrix formalism taking into account the symmetrisation of the three α-particles in the final state aswell as the properties of the ^{8}Be 2^+ state.
5. The consequences for the astrophysical reaction rate of the triple-α reaction has been explored.

In 2004 (in Jyväskylä) and again in 2006 (at the KVI, The Netherlands) we have revisited these decays for the following reasons. Our first set of experiments had a poor coverage for decays where the three α-particles share the breakup energy more or less equally, and hence the extend that such channels contribute could not be accurately extracted. Also, we were unable to extract the branching ratios with which the observed states were populated from the first set of data.

Preliminary results from our new experiments can be found in [4] (Jyväskylä) and [5] (KVI data). In the ongoing analysis it has become clear that some of the interpretations from our first set of experiments will have to change to describe the new data. In this contribution I will present the status of the analysis.

To study the decay properties of ^{12}C resonances we have also initiated studies of the reactions ^{10}B(^3He,p)^{12}C and ^{11}B(^3He,d)^{12}C. First results will be presented.

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