Accurate characterization of the β -decay of ^{8}B to ^{8}Be

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The study of the β^+/ EC decay of the 1-proton halo nucleus ^{8}B into the excited states of ^{8}Be. is of interest to both astrophysics and nuclear structure. In the former case, the decay of ^{8}B is the main source of high-energy solar neutrinos above 2 MeV and thus a key component of the "solar neutrino problem" [1], while in the latter, this decay offers a unique probe to explore the structure of ^{8}Be which includes the best predicted case of full isospin mixing between nuclear states [2]: a 2^+ isospin doublet formed by two narrow excitation levels at 16.6 MeV (^{7}Li+p) and 16.9 MeV (^{7}Be+n) excitation energy in ^{8}Be.

Within the Q_{EC} window (Q_{EC} = 17,9798(1) MeV), there are three 2^+ states in ^{8}Be that are fed through allowed beta transitions and a 1^+ state. A board 2^+ state at 3 MeV [2], fed through β^+ decay, is the dominant (>88%) decay mode and the primary source of high-energy solar neutrinos [1]. The 2^+ isospin doublet formed by the 16.6 and 16.9 MeV resonances, fed through β^+/EC decay. This process is modelled assuming that Fermi strength only goes to the T=1 component and Gamow-Teller strength only to T= 0. A 1^+ level at 17,640 MeV can possibly be fed through EC, this process will be followed by a 337 keV proton and the recoiling ^{7}Li ion. Assuming that the wave function of halo nuclei can be factorised [3] into a core and a halo (^{8}Be = ^{7}Li + p), the EC-decay can be modelled as occurring in the core with the halo proton as a spectator. The strength of this branch is estimated [4] from the decay of ^{7}Li giving a $\Gamma=2{,}3\cdot10^{-8}$.

^{8}Be is an unbound nucleus, therefore, the 2^+ ^{8}Be states fed through the previously discussed decays will break up into two α particles, giving rise to a $\alpha + \alpha$ continuum spectrum extending up to 17 MeV. Theoretically, this spectrum is dominated by the Gamow Teller contribution up to 15 MeV, however, experimentally this has only been proven up to 8 MeV. The decay of ^{8}B into the 16.626(3) MeV state has been observed by several groups, but the (mainly EC) decay into the 16.922(3) MeV state was hinted by 5 events in a previous JYFL experiment [5].

The MAGISOL (Madrid-Aarhus-Goteborg-ISOLDE) collaboration, has conducted multiple experiments to study the structure of the ^{8}Be nucleus in different facilities [5,6], the most recent one is experiment IS633, which took place at the ISOLDE facility at CERN in Switzerland aiming to resolve the β-feeding to the doublet and determine the level of isospin mixing. The experimental setup consisted of four compact particle telescopes, with each telescope comprising a Double-Sided Silicon Strip Detector (DSSD) with a thickness of 40 resp. 60 µm stacked with a 1500 µm thick Si-PAD detector. At the centre of the setup, a 30 mg/cm^2 carbon foil catcher was placed to stop the mass-separated 50 keV $^8BF_2$ beam. An additional 500 µm thick DSSD was placed below the implantation foil to maximize b-detection. The implanted ^{8}B nucleus decays via an EC/β^+ process, feeding the previously mentioned states of ^{8}Be, which in turn breaks up into two α particles that were detected in the setup, allowing for reconstruction of the excitation spectra.

The high statistics obtained during the experiment allowed for an accurate characterization of the ^{8}B to ^{8}Be decay. The two orders of magnitude higher statistics compared to the previous JYFL experiment, allowed for the observation of the separated feeding to the two members of the doublet for the first time in a beta-decay work. The feeding to the 2^+ states in ^{8}Be was studied through an R-Matrix analysis of the $\alpha + \alpha$ spectrum. Additionally, the effect of the β-recoil in the ^{8}B decay was studied employing a prescription given in [7] to fit the $\alpha - \alpha$ spectrum at different total energy values. This study has allowed us to for the first time experimentally confirm the dominance of the Gamow-Teller contribution in the decay up to 14 MeV. In this contribution, we will discuss this precise investigation in detail.

References

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