Parity-violating α-decay of the 3.56 MeV 0^+ state of ^{6}Li in a microscopic α+p+n model

Attila Csótó[a] and Karlheinz Langanke[b]

[a]Theoretical Division, Los Alamos National Laboratory, Los Alamos, NM 87545, USA
[b]Institute of Physics and Astronomy, University of Aarhus, Denmark
(csoto@qmc.lanl.gov, langanke@dfi.aau.dk)

We study the parity-forbidden α-decay of the lowest 0^+ state of ^{6}Li into the 0^- $\alpha + d$ scattering state [1]. The parity-nonconserving (PNC) nucleon-nucleon potential of Desplanques, Donoghue and Holstein (DDH) [2] is used, and the parity-violating decay width is calculated perturbatively. In ^{6}Li the few-body dynamics seems to be under much better control than in some heavier nuclei, where parity-violation was studied. Our main purpose is to study whether this is really the case, and thus whether theory can provide an estimate for the decay width with small uncertainty.

The initial bound and final scattering states are calculated in a six-body $\alpha + p + n$ Resonating Group Model. In order to test the sensitivity of the decay width on dynamical degrees of freedom, which are beyond our model, we additionally studied the influence of α distortions and breakup in increasingly sophisticated model spaces. We expected the effects of these model space extensions to be small, because $\alpha + p + n$ models with structureless α-particles give already a good description of the low-energy properties of the six-nucleon systems. However, it turns out, as Table 1 shows, that the PNC matrix elements converge slowly with the model space extension, and are probably still not fully converged in our most sophisticated model. Thus, dynamical degrees of freedom beyond $\alpha + p + n$ play an important role in the PNC decay width of the 0^+ state of ^{6}Li.

In our best model the total decay width is given by $\Gamma = (55.2F_\pi + 9.26F_1 + 6.59G_1)^2$ eV, in terms of the pion-, rho-, and omega weak coupling constants F_π, F_1 and G_1. Thus, the pion term strongly dominates. Our result is in reasonabe agreement with a shell-model [3]. The prediction of our best model with the DDH coupling constants is $\Gamma = 3.97 \times 10^{-9}$ eV, much smaller than the experimental upper limit $\Gamma \leq 6.5 \times 10^{-7}$ eV [4].

Table 1: *Contribution of the* $(L, S) = (0, 0)$ *and* $(1, 1)$ *components to the pion term of the PNC matrix element,* $M_{LS} = -i\sqrt{(2\pi\varrho(E_f))}\langle\Psi^{^6\mathrm{Li}}_{LS}|\widehat{V}^{PNC}_\pi|\Psi^{\alpha d}\rangle/F_\pi$*. The* ^{6}*Li wave function is* $\Psi^{^6\mathrm{Li}} = \Psi^{^6\mathrm{Li}}_{00} + \Psi^{^6\mathrm{Li}}_{11}$ *in various model spaces (*α_3 *denotes model spaces with* α *distortions).*

Model	M_{00} ($\sqrt{eV}$)	M_{11} ($\sqrt{eV}$)
$\{\alpha_1 + p + n\}$	–14.5	44.6
$\{\alpha_1 + p + n; t + h\}$	–12.8	33.4
$\{\alpha_3 + p + n\}$	16.0	27.0
$\{\alpha_3 + p + n; t + h\}$	32.1	23.1

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