2 - 17 Isospin-forbidden Proton Emission of *sd*-shell Proton-rich Nuclei *

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The study of exotic decay modes of nuclei near the proton drip line is pivotal for nuclear-structure physics in understanding the role of isospin impurity in the states of outermost imbalance of the proton and neutron numbers with respect to stable nuclei. In recent years, advancements in experimental technique permit us to reveal the structure of these nuclei by researching β-delayed one- and two-proton radioactivity[1]. The β-delayed three-proton decay had even been discovered, see Ref. [2]. The mechanism of a β-delayed decay involves first a β decay, with the highest probability for a superallowed β decay to the isobaric analogue state (IAS), followed by a proton or multi-particle emission. This second-stage proton (or multi-particle) emission from the high-lying IAS is isospin-forbidden, while decay from Gamow-Teller populated states may proceed according to the isospin-symmetry limit. A precisely measured exotic decay scheme and branching ratios (BRs) for an isospin-forbidden and/or allowed particle emission provide a stringent test and constraint for a microscopic approach that takes into account of isospin non-conservation (INC) consistently in all considered physics processes, *i.e.*, β decay, proton emission and electromagnetic de-excitation.

With our recently constructed INC Hamiltonians of *sd*-shell nuclei, which is a composition of isospin conserving (IC) Hamiltonian, Coulomb force, isovector single particle energies (IVSPEs), and isospin symmetry breaking (ISB) force of nuclear origin[3], we calculated the partial decay schemes of precursors: ^{25}Si, ^{29}S, ^{33}Ar, and ^{37}Ca with large-scale shell model method using ANTOINE code[4]. Meanwhile, we have also developed a simplified INC Hamiltonians of *pf*-shell nuclei for our collaborative research work in describing the decay of ^{53}Ni[5]. The proton decay widths are calculated as $\Gamma_p = \sum_{nlj} C^2S(nlj)\Gamma_{sp}(nlj)$[6], where $C^2S(nlj)$ are spectroscopic factors and $\Gamma_{sp}(nlj)$ is the single-proton width for an emission of a proton from an (nlj) quantum orbital. We obtained Γ_{sp} values from a penetrability estimation as in Refs. [7-9]. Table 1 shows our recent result of the spectroscopic factors, proton widths, and branching ratios of ^{25}Al→^{24}Mg β-delayed decay[9].

Table 1 Properties of β-delayed one-proton emission from precursor ^{25}Si.

J^π	$E_{\rm exp}$/MeV		$E_{\rm c.m.}$/MeV	θ^2		Γ_p/keV	Branching ratios/%	
	$E_{\rm exp}$	$E_{\rm theo}$		$l=0$	$l=2$		cd-USDB[a]	Exp.[10]
^{24}Mg								
0^+	0.000	0.000 (0)	5.624 (3)		0.0595 (37)	11.28 (71)	10.05 (56)	18.60
2_1^+	1.369	1.495 (1)	4.252 (2)	0.0421 (100)	0.8220 (583)	94.19 (1178)	83.03 (153)	74.40
4_1^+	4.123	4.347 (4)	1.489 (7)		0.0955 (85)	0.07 (1)	0.06 (0)	3.74
2_2^+	4.238	4.116 (5)	1.377 (6)	0.2333 (188)	0.0326 (43)	7.58 (61)	6.85 (100)	3.20
3_1^+	5.235	5.060 (5)	0.389 (5)	0.0850 (50)	0.2708 (282)	0.00 (0)	0.00 (0)	—

[a]The INC Hamiltonians composed of USDB[11], $V_{\rm coul}$, and V_0(USDB), c.f. Ref.[3].
[b]The error bars are provided from the standard deviation based on different short-range-correlation schemes, c.f. Ref. [3].
[c]The $E_{\rm exp}$ of 3_1^+ is cited from Ref.[12].

Fig. 1 illustrates a typical preliminary result of β-delayed one-proton emission partial decay scheme. This instance shows the partial decay of ^{25}Si→^{25}Al→^{24}Mg. The comparison of BRs deduced from shell-model approach based on INC Hamiltonians of Ref. [3] (cd-USDB), of Ref. [13] (OB-USD), and of Ref. [14] (OB-USDB) is shown at the left-inset table of Fig. 1. Only have the BRs derived from cd-USDB showed the best agreement with experimental BRs. This indicates that isospin-forbidden proton emission manifests its sensitivity on theoretical models which produces isospin mixing states influencing the proton-emission spectroscopic factors. Presently, we are analysing other precursors of *sd*-shell nuclei, and results will be published elsewhere.

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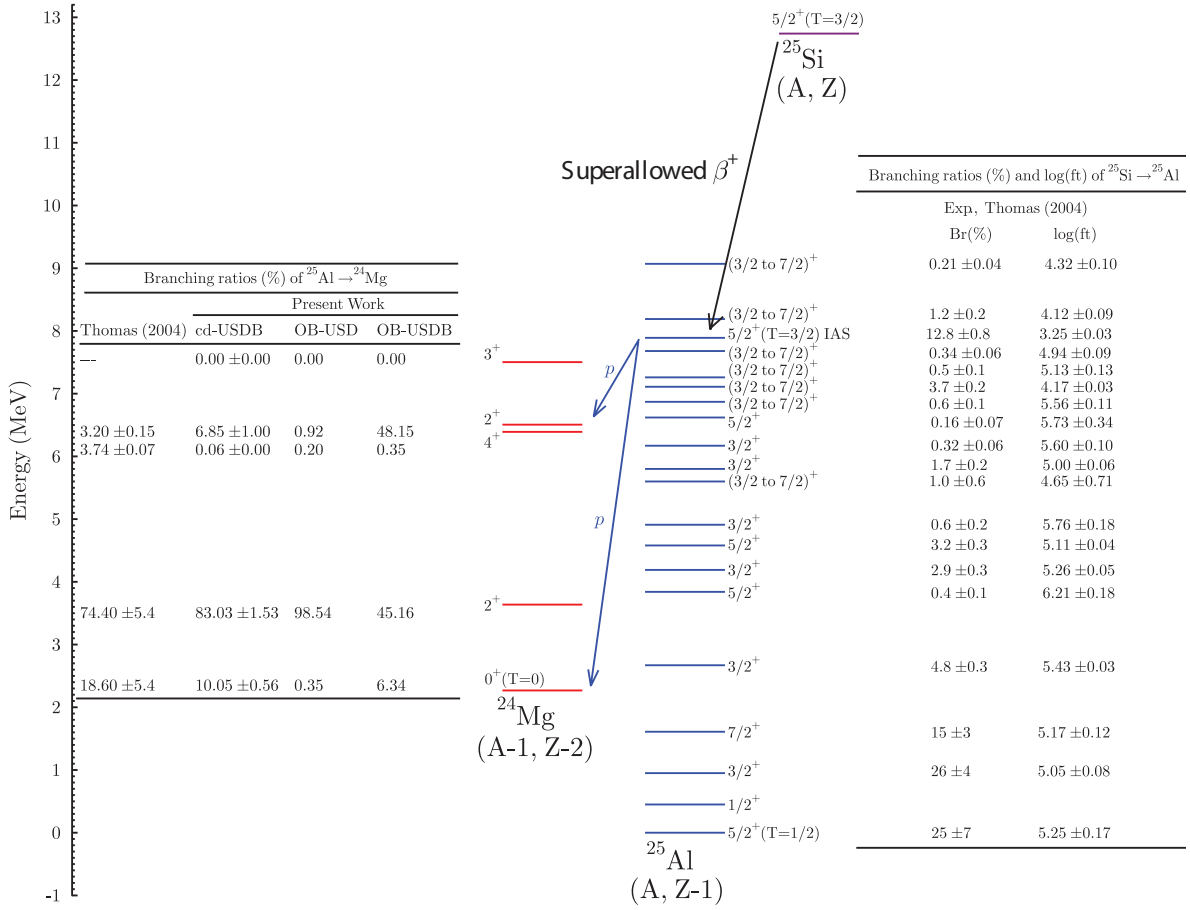

Fig. 1 (color online) The ^{25}Si decay scheme deduced from Ref. [10] and present work. The branching ratios of ^{25}Si→^{25}Al and ^{25}Al→^{24}Mg are presented in the inset-right and -left tables, respectively.

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