Isomer production studied with simultaneous decay curve analysis for alpha-particle induced reactions on natural platinum up to 29 MeV[†]

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The cross-section for production of a nuclide measured by activation method may be cumulative if the nuclide has a decay precursor nuclide. One has to subtract the precursor decay contribution from the measured cumulative cross-section to obtain the production cross-section corresponding to direct production of the product nuclide (independent cross-section).

When the half-life of the precursor nuclide (decay constant λ_2) is shorter than the half-life of the product nuclide of interest (decay constant λ_1), the cumulative cross-section of the product nuclide $\sigma_1^{\rm cum}$ is related with the corresponding independent cross-section σ_1 and the production cross-section of the precursor nuclide σ_2 by

$$\sigma_1^{\rm cum} = \sigma_1 + p\,\frac{\lambda_2}{\lambda_2 - \lambda_1}\sigma_2 \qquad (1)$$

(p is the branching ratio for decay from the precursor nuclide to the product nuclide) if the measurement was done after "complete" decay of the precursor nuclide. This relation is further approximated to

$$\sigma_1^{\rm cum} = \sigma_1 + p\,\sigma_2 \qquad (2)$$

if $T_{1/2}$ of the precursor nuclide is significantly shorter than the half-life of the product nuclide of interest.

Some experiments in the literature likely derived σ_1 by subtraction of the precursor decay contribution from the directly measured $\sigma_1^{\rm cum}$ by applying Eq. (2) to the pair of nuclides not satisfying $\lambda_2 \gg \lambda_1$, and overestimated σ_1. Irradiation of a Pt foil by alpha particle beam may produce three pairs of the ground state (g.s.) and metastable state (m.s.) without satisfying this condition: ^{198}Au (g.s. 2.69 h, m.s. 2.27 h), ^{197}Hg (g.s. 64.9 h, m.s. 23.8 h) and ^{195}Hg (g.s. 10.7 h, m.s. 41.6 h). We are studying if the independent cross-sections for production of these states, derived by decay curve analysis of the gamma peaks measured by us (*i.e.*, no approximation on timing condition), are consistent with those in the literature.

We irradiated a target stack for 60 min by a 29.0 ± 0.1 MeV alpha particle beam at 199 nA extracted from the RIKEN AVF cyclotron. The target stack consisted of thin metallic foils of ^{nat}Pt (12.4 mg/cm^2), ^{nat}Ti (2.3 mg/cm^2) and ^{27}Al (1.5 mg/cm^2). The Ti foils were inserted to validate the beam flux by comparison with the flux estimated with the well established ^{nat}Ti$(\alpha,x)^{51}$Cr monitor reaction cross-section, while the Al foils were inserted to catch recoiled reaction products. Seven Pt and Ti foils and fourteen Al foils were arranged in a stack of seven sets of Pt-Al-Ti-Al, which was followed by four additional Ti foils. The foil stack was installed in a target folder with the first Pt foil placed at the upstream side. We started counting of the activities of the front Pt foil about 1 hour after irradiation by an HPGe detector.

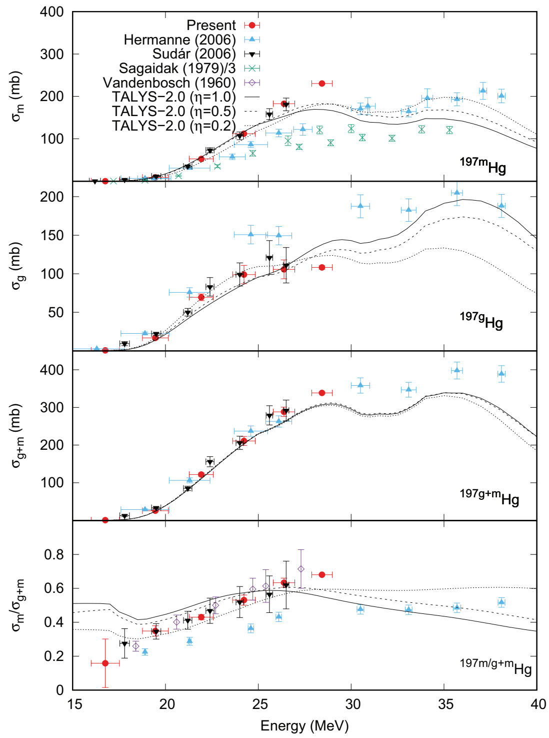

Fig. 1. ^{nat}Pt$(\alpha,x)^{197}$Hg independent cross-sections and their ratio compared with the literature data.[1–4] η gives the spin cutoff parameter.

Figure 1 shows comparison of the newly measured ^{nat}Pt$(\alpha,x)^{197}$Hg independent cross-sections and their ratio with those in the literature and simulated by the TALYS code.

References

1) R. Vandenbosch *et al.*, Phys. Rev. **120**, 1313 (1960).
2) R. N. Sagaidak *et al.*, Report P7-12734, JINR (1979).
3) A. Hermanne *et al.*, Nucl. Instrum. Methods Phys. Res. B **251**, 333 (2006).
4) S. Sudár *et al.*, Phys. Rev. C. **73**, 034613 (2006).

† Condensed from the article in Eur. Phys. J. A **60**, 195 (2024)

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DOI:10.34448/RIKEN.APR.58-008