Q-Value Determination of (d,α) Reactions ◇

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The $(\vec{\mathrm{d}},\alpha)$ reaction turned out to be a powerful tool for the spin and parity determination of odd-odd nuclei, because the target then has a 0^+ ground state and the angular distributions of the cross section and the analyzing power get quite easy to interpret via DWBA calculations [1].

After $^{198}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{196}\mathrm{Au}$ we decided also to study $^{204}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{202}\mathrm{Au}$ and $^{202}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{200}\mathrm{Au}$, because the heavy Au isotopes are not accessible in other transfer reactions and the knowledge of their level scheme is very poor [2].

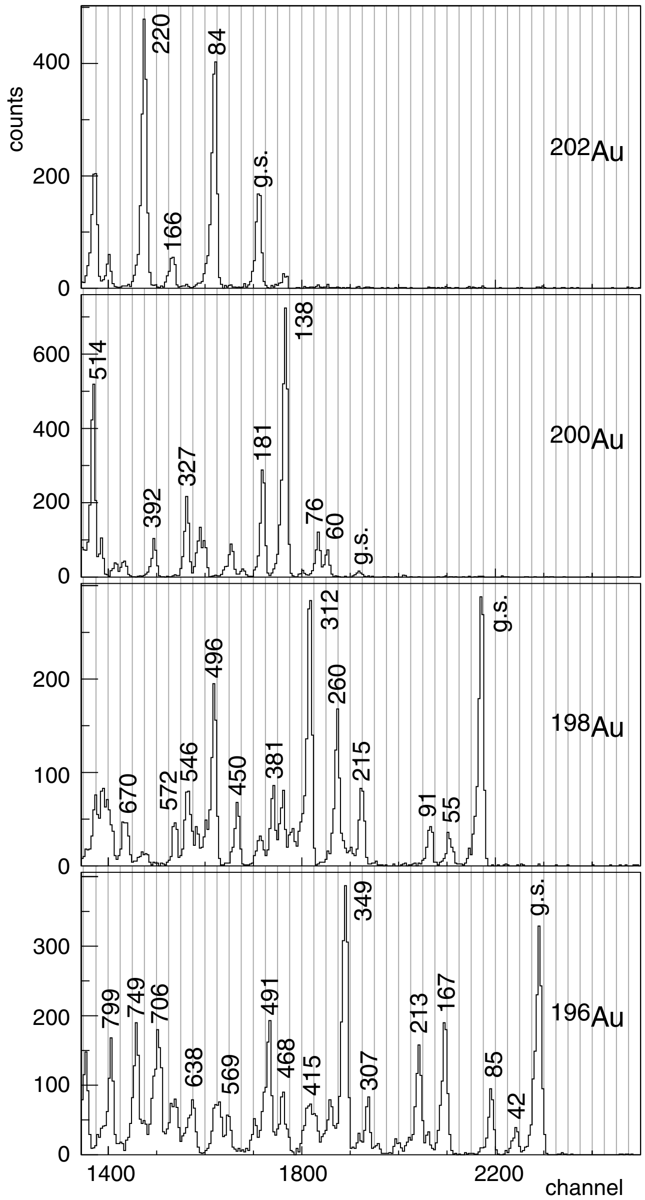

Fig. 1: Spectra of $(\vec{\mathrm{d}},\alpha)$ reactions to heavy odd-odd Au isotopes. All spectra were taken with the same magnetic setting of the Q3D at $E_\mathrm{d} = 18\,\mathrm{MeV}$ and $\theta_\mathrm{lab} = 15°$. Some peaks are labeled with their energy in keV.

Because the target material ^{204}Hg had an enrichment of only 92.64 % (4.85 % ^{202}Hg) and the Q-value of the reaction $^{204}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{202}\mathrm{Au}$ was only known with a precision of ± 166 keV, the ground state of ^{202}Au was hard to determine.

But since we had also the targets ^{204}Hg, ^{204}Hg, and ^{204}Hg we took $(\vec{\mathrm{d}},\alpha)$ spectra on all Hg targets with the same magnetic setting of the spectrograph to see the influence of isotopic impurities in each other. Figure 1 shows the spectra.

One sees clearly that the strongest line of ^{200}Au (138 keV) appears at the same position in the ^{202}Au spectrum. Since both show the same angular distributions we assume that this is not the ground state of ^{202}Au, but the line left of it.

The isotopic enrichment of the targets ^{198}Hg, ^{200}Hg, and ^{202}Hg is higher ($\geq 96\,\%$) and thus the influence of other isotopes in the spectra much lower.

We were able to make reliable energy calibrations for the $(\vec{\mathrm{d}},\alpha)$ spectra, because the nuclei ^{196}Au and ^{198}Au are well known. That made it possible to determine more precise Q-values for the reactions $^{204}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{202}\mathrm{Au}$, $^{202}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{200}\mathrm{Au}$, and $^{198}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{196}\mathrm{Au}$, than they were reported so far.

The results are summarized in the following Table:

Table 1: Q-value differences relative to $^{200}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{198}\mathrm{Au}$ and absolute Q-values for the measured $\mathrm{Hg}(\vec{\mathrm{d}},\alpha)\mathrm{Au}$ reactions.

Reaction	ΔQ (MeV) Firestone [3]	ΔQ (MeV) This Work*
$^{204}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{202}\mathrm{Au}$	+0.369(166)	+0.409(3)
$^{202}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{200}\mathrm{Au}$	+0.161(51)	+0.220(3)
$^{200}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{198}\mathrm{Au}$	+0.000	+0.000
$^{198}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{196}\mathrm{Au}$	−0.110(5)	−0.102(3)
Reaction	Q-value (MeV) Firestone [3]	Q-value (MeV) This Work*
$^{204}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{202}\mathrm{Au}$	10.419(166)	10.379(5)
$^{202}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{200}\mathrm{Au}$	10.625(51)	10.568(5)
$^{200}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{198}\mathrm{Au}$	10.788(3)	–
$^{198}\mathrm{Hg}(\vec{\mathrm{d}},\alpha)^{196}\mathrm{Au}$	10.898(5)	10.890(5)

*Preliminary results.

References

[1] H.-F. Wirth *et al.*, Annual report 2001, p. 14
[2] H.-F. Wirth *et al.*, Study of ^{200}Au and ^{202}Au via the (d,α) reaction, this report p. 16.
[3] R.B. Firestone, Table of Isotopes, ed. V.S. Shirley (John Wiley and Sons, New York, 1996).

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