

Conversion Coefficients Measurements for ^{195}Au

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Abstract: The existence of Nuclear “SuperSymmetry” has been shown for the $^{194,195}\text{Pt}$, $^{195,196}\text{Au}$ quartet. Nuclear SUSY allows to do structure predictions for odd-odd nucleus using excited levels of other members. The following work shows the ^{195}Au level structure studies with internal Conversion Coefficients (ICC) measurements. ICC plays a key role on identifying excited levels, spin and polarity. In this work, conversion coefficients measurements are shown for ^{195}Au excited levels transition. $^{195}\text{Pt}(p,n)$ and $^{196}\text{Pt}(p,2n)$ reactions were used to populate ^{195}Au excited levels. The beam energy was 7.75 MeV and 12 MeV.

Keywords: Nuclear SuperSymmetry (SUSY), Internal Conversion Coefficient (ICC), Interacting Boson Model (IBM), Interacting Boson-Fermion Model (IBFM)

1. Introduction

Odd-odd nuclei structure prediction remains challenging to nuclear structure models. Dynamical symmetries via Lie algebra were introduced in the IBM (Interacting Boson Model) [1-5] to explain the structure of even-even nuclei structure. Later model was modified to IBFM (Interacting Boson-Fermion Model) [6] to include fermions interaction as well to explain odd-A nuclei structure. Finally, the extension of the IBFM was Nuclear “SuperSymmetry”, which can describe collective properties of the quartet and do predictions for the odd-odd nuclei. Many experiments were done to study Nuclear SUSY, and the best example of the quartet that can be described with the model is $^{194,195}\text{Pt}$ and $^{195,196}\text{Au}$. The prediction of ^{196}Au excited levels [1,8] can be done with the use of other members excited states. Due to better knowledge of other members, excited levels are important to have. The (p,n) and (p,2n) reactions were used to study the structure of ^{195}Au .

2. Internal Conversion

Nuclei can de-excitation with multiple ways. They can emit γ -rays, electron or positron, but it is possible that for same excited level they will emit either γ -ray or electron. The electron is one of the atomic electrons in the K, L ... shells. The nuclei passes the energy to the electron, which is more than binding energy of the electron in the atom and electron will break out from an atom. This process is called internal conversion and the electron that breaks out is internal conversion electron.

The relation between the numbers of internal conversion electrons and the γ -rays from the same excited level shows the internal conversion coefficient. Eq. 1 shows the way to calculate ICC.

$$\alpha = \frac{N_e / \varepsilon_e}{N_\gamma / \varepsilon_\gamma} \quad (1)$$

where N_e is detected number of electrons, N_γ is detected number of γ -rays, ε_e is the efficiency of electron detection and ε_γ is the efficiency of γ -rays detection.

3. Experimental Methods and Results.

The experiment with bunched proton beams was carried out with FN Tandem accelerator at the University of Notre Dame Nuclear Science Laboratory. The ^{195}Pt and ^{196}Pt targets had thicknesses of 1.07 mg/cm^2 and 1.34 mg/cm^2 respectively, and they were used to populate levels in ^{195}Au . A beam of 7.75 MeV bunched protons was used for the ^{195}Pt experiment and 12 MeV bunched protons for the ^{196}Pt study. The Internal Conversion Electron Ball (ICEBall) array of 6 Si(Li) detectors with an energy resolution of 3-5 keV and 2 High Purity Germanium (HPGe) detectors with 109% relative efficiency was used. Si(Li) detectors detect conversion electrons and HPGe γ -rays simultaneously, therefore the conversion coefficients can be measured.

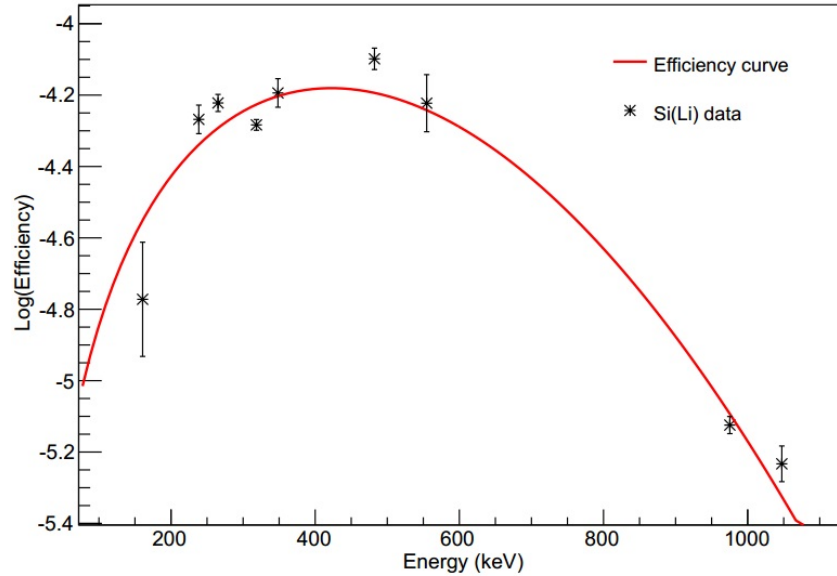


Fig. 1. The Si(Li) detector efficiency curve determined with ^{207}Bi and ^{133}Ba calibration sources. The curve was fit using $\ln(\epsilon) = p_0 + p_1 \ln(E) + p_2 E^2$, where p_0 , p_1 and p_2 are fitting parameters, ϵ is efficiency and E is energy.

Detectors efficiencies were determined for both Si(Li) and HPGe detectors with the use of different radioactive sources. ^{152}Eu was used for HPGe and ^{133}Ba , ^{207}Bi for Si(Li) detectors efficiencies measurements. Fig. 1 shows the efficiency curve for one of the Si(Li) detectors.

With the use of the efficiency and ^{195}Au related transitions counts, conversion coefficients were measured. Table 1 shows the results for both reactions for different transitions from different levels. Some of the conversion coefficients were measured at first time.

Mostly only K-shell conversion coefficients are measured as the most possible electron that can break out from the atom is K-shell electrons.

Table 1. Internal Conversion Coefficients from reactions $^{195}\text{Pt}(p,n)$ and $^{196}\text{Pt}(p,2n)$ with beam energy 7.75 MeV and 12 MeV respectively.

E_{level} [keV]	E_{γ} [keV]	E_e [keV]	$^{195}\text{Pt}(p,n)$ ICC	$^{196}\text{Pt}(p,2n)$ ICC	Multipolarity
261.39	261.39(1)	180.69[K]	0.37(4)	0.42(4)	M1+E2
		247.06[L]	0.062(6)	0.059(6)	
439.58	439.58(19)	358.88[K]	0.091(10)	0.14(3)	M1+E2
		425.28[L]	0.011(1)	0.013(7)	
702.95 ¹	440.86(13) ¹	360.16[K]	0.13(2)	0.11(1)	M1
831.49 ¹	391.54(4) ¹	310.80[K]	0.27(6)	0.54(14)	M2+E3
879.36	560.75(8)	480.08[K]	0.050(6)	0.050(5)	M1

¹Transitions and levels for which internal conversion coefficients were measured at first time.

The measured conversion coefficients can be compared with theoretical values [9] for multipolarity assignment. For example, the transition 261.39 keV conversion coefficient is 0.37(4) for (p,n) and 0.42(4) for (p,2n) reactions and the theoretical values are 0.484 for M1 transition and 0.156 for E2 transition. The measured conversion coefficient is in between two values. Therefore, the multipolarity will be M1+E2 for that transition. With the following way, all transition multipolarities were assigned. It can be seen that the conversion coefficients measurements match together for all transitions.

4. Conclusion

The Si(Li) detector was used to detect conversion electrons and the HPGe was used for γ -rays detection. Using the detectors simultaneously during the experiments allows to measure conversion coefficients. The work presents the results of measuring the conversion coefficients with Si(Li) and HPGe detectors. Some of the conversion coefficients were measured first time during this experiment.

References

- [1] P. Van Isacker, J. Jolie, K. Heyde and A. Frank, Phys. Rev. Lett. 54 653(1985).
- [2] J. Gröger, J. Jolie, R. Krücken, C. W. Beausang, M. Caprio, R. F. Casten, J. Cederkall, J. R. Cooper, F. Corminboeuf, L. Genilloud, G. Graw, C. Günther, M. de Huu, A. I. Levon, A. Metz, J. R. Novak, N. Warr and T. Wendel, Phys. Rev. C 62 064304 (2000).
- [3] J. Jolie, U. Mayerhofer, T. von Egidy, H. Hiller, J. Klor, H. Linder and H. Trieb, Phys. Rev. C 43 (1991) R16.
- [4] A. Metz, J. Jolie, G. Graw, R. Hertenberger, J. Gröger, C. Günther, N. Warr and Y. Eisermann, Phys. Rev. Lett. 83 1542(1999).
- [5] F. Iachello and A. Arima, The Interacting Boson Model, (Cambridge University Press, Cambridge, 1987)
- [6] F. Iachello and P. Van Isacker, The Interacting Boson-Fermion Model, (Cambridge University Press, Cambridge, 1991)
- [7] A. B. Balantekin and V. Paar, Phys. Rev. B 169 1(1986).
- [8] bricc.anu.edu.au