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PRECISION MEASUREMENT OF THE ^{203}Hg BETA - GAMMA DIRECTIONAL CORRELATIONS. J. CIPOLLA[†] and R. M. STEFFENDepartment of Physics, Purdue University, Lafayette, Indiana^{††}**MASTER**

Abstract: A precise measurement of the β - γ directional correlation of ^{203}Hg as a function of the average β - energy $\bar{W}$ (in units mc^2) is reported. The values of the anisotropy coefficient $A_{22}(\bar{W})$ in the β - γ directional correlation function $W(\theta) = 1 + A_{22}(\bar{W}) P_2(\cos \theta)$ are: $A_{22}(\bar{W} = 1.15) = -0.0007 \pm 0.0009$, $A_{22}(\bar{W} = 1.23) = -0.0016 \pm 0.0006$, $A_{22}(\bar{W} = 1.31) = -0.0020 \pm 0.0010$, $A_{22}(\bar{W} = 1.345) = -0.0018 \pm 0.0005$ and $A_{22}(\bar{W} = 1.38) = -0.0018 \pm 0.0011$.

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RADIOACTIVITY ^{203}Hg [from $^{202}\text{Hg}(n, \gamma)$];
measured $\beta\gamma(\theta)$.

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Precise measurements of the $\beta - \gamma$ directional correlation of ^{203}Hg are desirable in view of the use of this $\beta - \gamma$ cascade for parity - impurity measurements¹⁻³⁾.

The presence of a parity violating component in a γ - transition (e.g., a $M1 + E1$ mixture) will lead to a $\cos \theta$ term in a $\beta - \gamma$ directional correlation⁴⁾

$$W_{p.i.}(\theta) = 1 + A \cdot \cos \theta . \quad (1)$$

The (very small) amount of an "unnatural" parity admixture in a nuclear state can be predicted by the current - current coupling theory of weak interactions and hence an experimental determination of the coefficient A provides a test of this theory^{1,5)}. In favorable cases A is of the order of 10^{-4} . Because of the smallness of this coefficient these parity - impurity measurements are very difficult to perform and all corrections of the experimental data must be very carefully considered²⁾. In particular, if the β - transition is first - forbidden the correction for the "normal" $\beta - \gamma$ directional correlation

$$W_{\beta\gamma}(\theta) = 1 + A_{22} P_2(\cos \theta) \quad (2)$$

plays an important role. For allowed β - transitions $A_{22} \approx 0$ if higher order effects can be neglected.

The use of ^{203}Hg for parity - impurity measurements was suggested by Szymanski⁶⁾, who also estimated the expected value of $A \approx - 10^{-5}$. Although this parity - impurity anisotropy is very small, and hence difficult to observe, parity - impurity experiments on the decay of ^{203}Hg are facilitated by the simplicity of the ^{203}Hg decay scheme (see inset in Fig. 1).

The β - transition of 214 keV maximum energy is a first - forbidden β - transition and hence the ^{203}Hg β - γ directional correlation is expected to be anisotropic. The β - transition of ^{203}Hg shows all the characteristic features that are characteristic of the Coulomb - or ξ - approximation⁷⁾.

Several measurements of the ^{203}Hg β - γ directional correlation have been reported with conflicting results. In 1959 Steffen⁸⁾ obtained $A_{22} = - 0.0022 \pm 0.0009$ for β - particles of 100 - 207 keV energy. Bashandy and El - Nesr⁹⁾ reported values of A_{22} between 0.011 ± 0.005 and 0.039 ± 0.005 for the β - energy range 50 - 160 keV. Later Collin et al.¹⁰⁾ measured values of A_{22} between 0 and $- 0.015$ in the energy range 70 - 200 keV. A recent measurement was reported by Wyrick et al.¹¹⁾ who obtained $A_{22} = - 0.0008 \pm 0.0014$ in the β - energy range from 80 keV to 160 keV.

In this work the β - γ directional correlation of ^{203}Hg has been measured using the vacuum chamber and detectors described previously¹²⁾, in conjunction with a fast multichannel β - γ coincidence spectrometer. The ^{203}Hg sources were prepared by evaporating metallic ^{203}Hg on a thinly silvered Formvar foil. The source thickness was about $50 \mu\text{g}/\text{cm}^2$.

The β - γ coincidence rate was measured at seven angles from 90° to 270° and the β - γ directional correlation coefficient $A_{22}(W)$ was determined by a least - squares fit to the correlation function (2). The results were corrected for finite source and detector sizes.

The experimental values of $A_{22}(W)$ are listed in Table 1 and are shown in Fig. 1 as a function of the average β - particle energy W (in units of mc^2). The widths of the β - energy windows accepted by the

single - channel analyzers in the coincidence measurements is indicated in Fig. 1.

The results presented in this work clearly indicate that the "large" anisotropy values for the ^{203}Hg β - γ directional correlation reported by Bashandy and El - Nesr⁹⁾ are not correct. The agreement with the measurements of Wyrick et al.¹¹⁾, who find, within their larger limits of error, a vanishingly small anisotropy is satisfactory.

The determination of the nuclear beta matrix elements that contribute to the first - forbidden β - transition of ^{203}Hg is impossible at this state, since no sufficiently precise β - γ circular polarization correlation and β - spectrum shape measurements are available for ^{203}Hg .

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TABLE 1

 β - γ Directional correlation of ^{203}Hg

β energy range accepted by the β - detector	Average β energy W (in units mc^2)	$A_{22}(\bar{W})$
59 keV - 106 keV	1.15	- 0.0007 $\pm$ 0.0009
106 keV - 137 keV	1.23	- 0.0016 $\pm$ 0.0006
145 keV - 170 keV	1.31	- 0.0020 $\pm$ 0.0010
170 keV - 185 keV	1.345	- 0.0018 $\pm$ 0.0005
180 keV - 214 keV	1.38	- 0.0018 $\pm$ 0.0011

Figure Caption

Fig. 1. β - γ directional correlation coefficient of ^{203}Hg $A_{22}(\overline{W})$
as a function of β - energy W (in units mc^2)