Measurements of the Spectroscopic Quadrupole Moments of the $11/2^-$ Isomers ^{193m}Au, ^{195m}Au, and ^{197m}Au with MAPON ◇

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1. Summary

With measurements of modulated adiabatic passage on oriented nuclei (MAPON) of the $11/2^-$ isomers ^{193m}Au ($T_{1/2}$ = 3.9 s), ^{195m}Au ($T_{1/2}$ = 30.6 s), and ^{197m}Au ($T_{1/2}$ = 7.7 s) in hcp-Co, the electric quadrupole splitting frequencies eQV_{zz}/h were determined to be −46.82(11) MHz, −44.29(11) MHz, and −39.78(11) MHz for ^{193m}Au, ^{195m}Au, and ^{197m}Au, respectively. With the known electric field gradient of Au in hcp-Co, $eq = -0.977(29) \times 10^{17}$ V/cm^2, the spectroscopic quadrupole moments are deduced to be $Q(^{193m}\text{Au}) = +1.98(6)$ b, $Q(^{195m}\text{Au}) = +1.87(6)$ b, and $Q(^{197m}\text{Au}) = +1.68(5)$ b. Theoretical quadrupole moments calculated within the asymmetric rotor model are in moderate agreement with the experimental values.

2. Experimental Method and Results

The radioactive precursors of the Au isomers, ^{193m}Hg, ^{195m}Hg, and ^{197m}Hg were prepared at ISOLDE by bombarding a liquid Pb target with 1 GeV protons and implanted into hexagonal Co single crystals. The samples were cooled to temperatures of ∼ 5 - 10 mK with a ^{3}He-^{4}He-dilution refrigerator with a top-loading facility.

In hcp-Co, there exists an electric field gradient (EFG), causing a quadrupole splitting superimposed to the magnetic hyperfine splitting. The quadrupole subresonances are separated by $\Delta\nu_Q = 3\nu_Q/[2I(2I-1)]$, where $\nu_Q = e^2qQ/h$ is the quadrupole interaction frequency. Here I is the nuclear spin, eq is the EFG and Q is the spectroscopic quadrupole moment.

The magnetic resonance frequencies of ^{193m}Au, ^{195m}Au and ^{197m}Au were measured with NMR on oriented nuclei (NMR-ON) to be 743.7(1.9), 743.0(2) and 719.6(2) MHz. The quadrupole splittings were determined with MAPON [1]. Here *two* adiabatic fast passage (AFP) pulses which are separated in frequency by $\Delta\nu$, denoted as MAPON pulse, are applied. Then, if $\Delta\nu > \Delta\nu_Q$, the modulated passage results in a distinctive reorganization of sublevel populations in which a net population transfer of the first *two* accessed substate populations is cyclically permuted through to the final two substates, causing the γ-anisotropy to change. For $\Delta\nu < \Delta\nu_Q$, the successive double transits through each subresonance yield a null result, leaving the γ-anisotropy unchanged. As an example, Fig. 1 shows a typical MAPON spectrum for ^{197m}Au. The dependence of the quadrupole moments on the atomic number A is shown in Fig. 2.

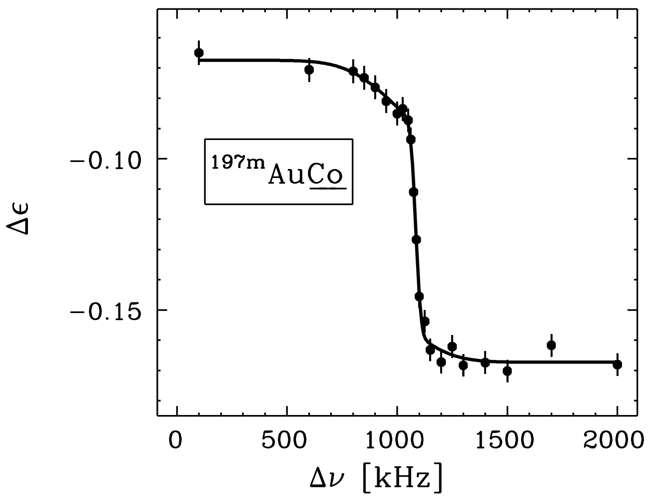

Fig. 1: MAPON spectrum of ^{197m}Au

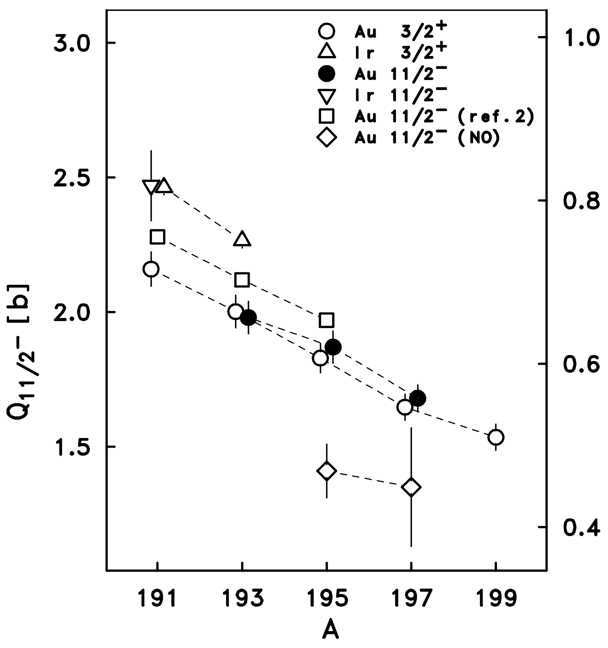

Fig. 2: Dependence of the quadrupole moments of the $3/2^+$ ground states and $11/2^-$ isomeric states in Au and Ir on the mass number A.

The dependence of the quadrupole moments on A is moderately well described by calculations in the framework of an odd quasi-particle coupled to an asymmetric rotor [2]. A full description of this work is given in Ref. [3].

References

[1] P.T. Callaghan et al. Phys.Rev. **B37** (1988) 4900
[2] H. Toki and A. Faessler, Nucl.Phys. **A253** (1975) 231
[3] G. Seewald, E. Hagn, E. Zech, D. Forkel-Wirth, and ISOLDE Collaboration, Nucl. Phys., in press

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