

THE REORIENTATION PRECESSION TECHNIQUE APPLIED TO
THE MEASUREMENT OF $Q(2_1^+)$ IN ^{110}Pd AND ^{108}Pd

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As distinguished from the reorientation technique, which has been applied in measurements of quadrupole moments for some years, the reorientation precession technique [1-3] is a first order effect. The reorientation technique is based on measurements of excitation cross-sections and the determination of second-order effects in these cross-sections. In reorientation precession measurements, however, one studies the precession of the gamma-ray distribution. This precession is due to the reorientation of the nuclear axis caused by the interaction between the electric field of the bombarding particle and the quadrupole moment of the excited state.

Our experiment consists of a comparison of the number of coincidences between a NaI-detector and two particle detectors, respectively. The particle detectors are both placed at $90^\circ \pm 0.1^\circ$ to the beam in the LAB-system. Two NaI-detectors are used. They are both placed in the reaction plane, symmetrically around the beam and making an angle of $22.5^\circ \pm 0.1^\circ$ to the beam. A simplified cross-section of the experimental setup is shown in fig. 1 together with the gamma-distribution $2^+ \rightarrow 0^+$ for ^{16}O -particles scattered on ^{110}Pd at 90° in the LAB-system. If the particle detectors were placed at 90° to the beam in the CM-system and if the bisect of the hyperbolic orbit was the symmetry axis, then there would be a perfect overlap between the two gamma-distributions for a quadrupole moment of zero. This is not the case and the 90° scattering angle in the

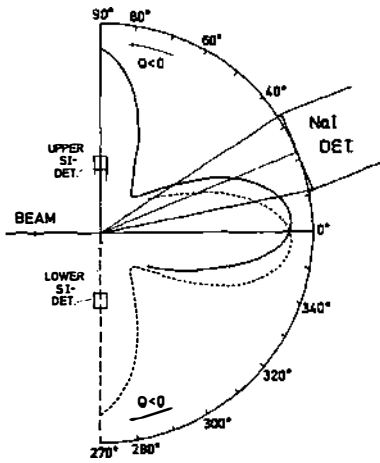


Fig.1. A schematic cross section of the experimental set-up showing the gamma-ray distribution $2_1^+ \rightarrow 0^+$ for particles scattered at 90° in the LAB-system. The precession of the gamma-ray distribution due to the interaction between a field gradient and a negative quadrupole moment of the nucleus is indicated in the figure.

LAB-system corresponds to 98.4° in the CM-system for ^{16}O on ^{110}Pd . Only one of the NaI-detectors is indicated in fig. 1 but with the angle notation given in the figure the second NaI-detector is placed at 337.5° . As is indicated in the figure, a negative quadrupole moment will cause a precession away from the beam (a positive quadrupole moment to the beam), and thus the ratio of the number of coincidences between the NaI-detectors and the two particle detectors will be changed.

The targets were prepared by rolling enriched (97%) ^{110}Pd and (95%) ^{108}Pd on a 10 mg/cm^2 Cu-backing. The use of a Cu backed target will prevent perturbations of the gamma-ray distributions as the recoiling nuclei are stopped in the backing material. The experiments were performed using ^{16}O ions accelerated in the EN tandem Van de Graaff at the Uppsala Tandem Laboratory. The effective energies were determined from kinematic relations for particles scattered in different angles both from the Pd-layer and from the Cu-backing.

Fig. 2 shows our experimental ratios $W(22.5^\circ)/W(157.5^\circ)$ for ^{110}Pd as a function of the energy of the incoming ion. Theoretical ratios calculated with the de

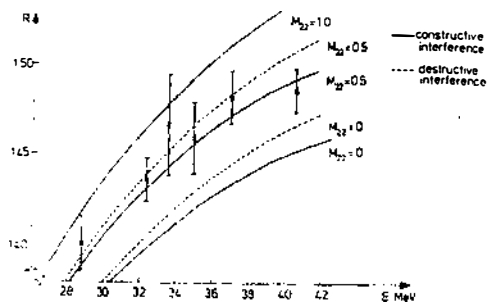


Fig.2. The experimental ratios $R=W(22.5^\circ)/W(157.5^\circ)$ for ^{110}Pd as a function of the energies of the ^{16}O -ions. The lines are theoretical values calculated with the de Boer-Winther program and a six level system.

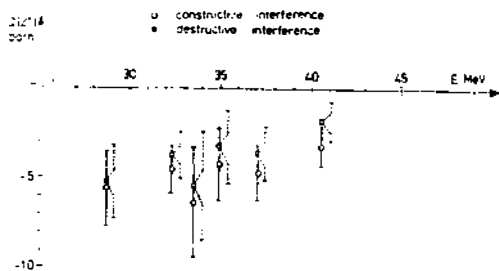


Fig.3. The extracted quadrupole moments for ^{110}Pd as a function of the energy of the ^{16}O -ions.

Boer-Winther program for some M_{22} -values are also shown in the figure. This calculation was performed using a six level system for ^{110}Pd ($0^+, 2^+, 2^+, 4^+, 0^+, 2^+$) with the matrix elements taken from $B(E2)$ -values measured by Robinson et al. [4]. As a result of the analysis with the de Boer-Winther program and the six level system for ^{110}Pd we obtained the quadrupole moments as given in fig. 3 as a function of the energy of the ^{16}O -ion.

TABLE 1

Experimentally determined values of the static electric quadrupole moment for the first excited 2^+ state in ^{110}Pd and ^{108}Pd .

	Ref. 9	Ref. 10	Mean Ref. 11	Present Semi.class. QM	Present
$Q(2_1^+)$ Constructive interference	-0.72 ± 0.08	-0.483 ± 0.049	-0.60 ± 0.12	-0.48 ± 0.08	-0.23 ± 0.11
^{110}Pd Destructive eb interference	-0.45 ± 0.08	-0.266 ± 0.049	-0.36 ± 0.12	-0.39 ± 0.08	-0.14 ± 0.11
	Ref. 9	Ref. 12	Ref. 13	Mean Ref. 11	
$Q(2_1^+)$ Constructive interference	-0.58 ± 0.13	-0.40 ± 0.04	-0.57 ± 0.05	-0.54 ± 0.06	-0.64 ± 0.14
^{108}Pd Destructive eb interference	-0.37 ± 0.12	-0.25 ± 0.04	-0.35 ± 0.05	-0.32 ± 0.06	-0.50 ± 0.14
					-0.29 ± 0.17

It is known that quantal corrections have an influence on the gamma-ray distribution (see for example ref. |5|). A quantum mechanical calculation has been performed |6| using the Smilansky Coupled Channel Code |7|. In this calculation a two-level system for ^{110}Pd was used. Since the dominant part of the quantum mechanical correction originates from kinematics the calculated corrections should not differ substantially from a many-level system calculation.

In table 1 we have summarized published values of the quadrupole moment of the first excited state in ^{110}Pd together with the weighted meanvalue of the present measurement. When calculating the meanvalue we have omitted the experimental value at 40.5 MeV since this energy probably is a too high bombarding energy |8|. Due to the rather large quantum mechanical corrections we have somewhat arbitrarily increased the errors 0.03 barns as compared with the de Boer analysis.

In table 1 we have also included preliminary results on ^{108}Pd . The experimental data in this case were analyzed using a five level system ($0^+, 2^+, 2^+, 4^+, 0^+$) and B(E2)-values taken from ref. |4|.

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