EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN – EP/89 – 08
19.1.1989

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Paper presented at the Workshop on On – Line Nuclear Orientation – 1,
St. Edmund Hall, Oxford, August 31 – September 4, 1988
submitted to Hyperfine Interactions

SHAPE TRANSITION IN LIGHT Pt ISOTOPES: MAGNETIC MOMENTS AND ELECTRIC QUADRUPOLE MOMENT RATIOS FOR ^{185,187,189}Pt.

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Abstract. Nuclear orientation and nuclear magnetic resonance experiments were performed on ^{185,187,189}Pt isotopes oriented in Fe and single crystal Zn at temperatures down to about 6 mK. The hyperfine splitting frequencies of ^{185}Pt and ^{187}Pt in iron were determined to be 164.9(2) and 261.1(2) MHz, respectively. With the hyperfine field of -126.1(2.5)T, the g-factors are deduced to be $|g(^{185}\mathrm{Pt})| = 0.172(3)$ and $|g(^{187}\mathrm{Pt})| = 0.272(5)$. The spectroscopic quadrupole moment of ^{187}Pt was found to be negative with magnitude similar to that of ^{189}Pt, indicating a predominantly oblate ground state deformation for both isotopes. The spectroscopic quadrupole moment of ^{185}Pt was found to be positive, with the ratio $Q(^{185}\mathrm{Pt})/Q(^{189}\mathrm{Pt}) = -3.6(9)$, clearly indicating a change to prolate ground state deformation.

1. INTRODUCTION

Many theoretical and experimental investigations of the structure of neutron deficient Pt isotopes suggest a change in the equilibrium deformation of the even-even core from axial oblate for the heavier isotopes becoming axial prolate close to A = 186, possibly passing through an intervening region of triaxiality. This brief report gives preliminary results of a nuclear orientation study aimed to investigate this shape development by direct quadrupole interaction measurements on the odd-A isotopes ^{185,187,189}Pt aligned in single crystal Zn. We also report measurements of the magnetic dipole moments of ^{185,187}Pt using nuclear magnetic resonance on oriented nuclei (NMR/ON).

2. EXPERIMENTAL

Low temperature nuclear orientation measurements on nuclei aligned through the interaction of the nuclear spectroscopic electric quadrupole moment Q with an axially symmetric electric field gradient (efg) V_{zz}, such as exists at substitutional lattice sites in hcp metals, yield both magnitude and sign of the interaction strength eQV_{zz}. If V_{zz} is unknown, measurements on pairs of isotopes in the same host give the ratio of their quadrupole moments. The expression for the angular distribution of gamma radiation from the aligned nuclear system is

$$W(\theta) = 1 + f\Sigma_\lambda B_\lambda(I_o, eQV_{zz}, T) U_\lambda A_\lambda P_\lambda(\cos\theta)$$

where θ is the angle of emission relative to the field gradient axis, B_λ describe the alignment of the parent nucleus (spin I_o) as a function of temperature T, $P_\lambda(\cos\theta)$ are Legendre polynomials of order λ and $U_\lambda A_\lambda$ are angular momentum coupling constants involving the spins of levels and multipolarities of observed and unobserved transitions in the decay. f is a multiplicative factor (≤ 1) which allows for the possibility that not all nuclei may experience the efg. In this work we assume that similar implantation conditions for different isotopes in the same sample lead to the same value of f for all isotopes.

To determine the sign and magnitude of the quadrupole interaction (from B_λ) the products $U_\lambda A_\lambda$ are needed. In this work these coefficients were determined from nuclear orientation in Fe, for which the magnetic hyperfine splitting was measured independently by NMR/ON.

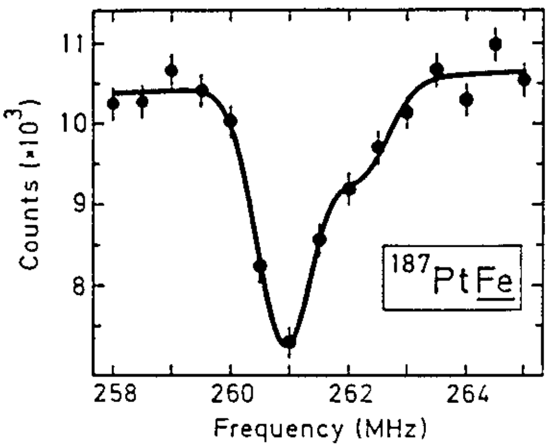
The experiments were carried out at the NICOLE dilution refrigerator installed recently at the mass separator ISOLDE-3, CERN /1/. Samples of Pt isotopes in Fe foils and Zn single crystals were prepared by implanting Hg isotopes which decay to Pt via Au. The implantation voltage was 60 kV. Fe foils prepared from commercially available pure iron were used. The surface of the Zn single crystals were prepared by cleavage with the c-axis perpendicular to the surface.

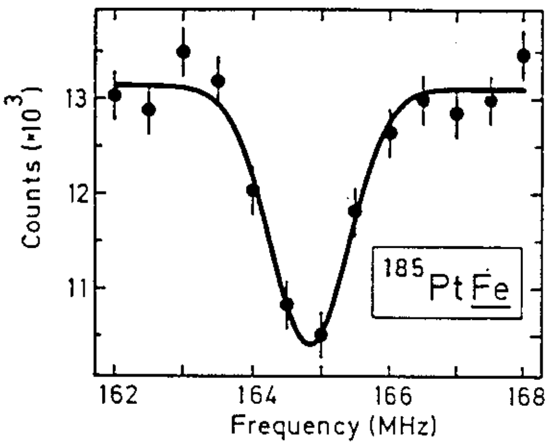
Following the implantation, after decay of the Hg and Au activities, the Fe foils were annealed at 850 C for 1000 s. Such annealing has been shown to improve the substitutional fraction of Pt isotopes in the Fe lattice /2/. The Zn samples were not annealed after implantation. The samples were then soldered with Wood's metal to the demountable copper sample holder of the dilution refrigerator, loaded and cooled to temperatures down to a minimum of 6 mK. Angular distributions of the gamma transitions were measured with four Ge(Li) detectors placed parallel and perpendicular to the orientation axis. In all experiments temperatures were measured using a single crystal ^{60}Co<u>Co</u> (hcp) nuclear orientation thermometer.

3. RESULTS

Figs. 1 and 2 show NMR/ON spectra of ^{187}Pt<u>Fe</u> and ^{185}Pt<u>Fe</u> measured in an external magnetic field of 0.1 T. For ^{187}Pt a satellite resonance at higher frequency is observed. The occurrence of such satellite resonances is believed to depend on the annealing procedure /2/; it is possible due to a different lattice site.

The zero-field resonance frequencies and the g-factors and magnetic moments, deduced with the hyperfine field $B_{hf} = -126.1(2.5)$ T /3/, are listed in Table 1. The combination of nuclear orientation and NMR/ON yields I = 3/2 for the ground state spin of ^{187}Pt, and most probably I = 9/2 for ^{185}Pt. A full description of the nuclear





Figs. 1 and 2. NMR/ON spectra of ^{187}Pt<u>Fe</u> (712 keV) and ^{185}Pt<u>Fe</u> (460 keV) with external magnetic field of 0.1 T.

Table 1. NMR/ON results for ^{187,185}Pt in iron. The g-factors and magnetic moments were calculated with B_{hf} = −126.1(2.5) T.

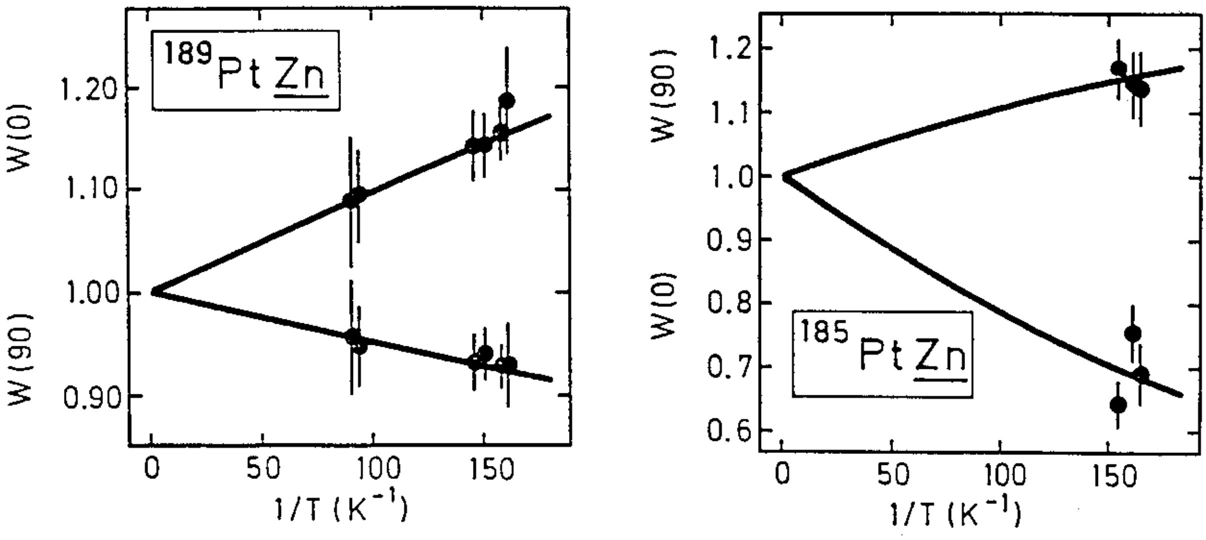
Isotope	I^{π}	Zero-field splitting (Mhz)	$\lvert g \rvert$	$\lvert \mu \rvert$ [μ_N]
^{187}Pt	$3/2^{(-)}$	261.1(2)	0.272(5)	0.408(8)
^{185}Pt	$(9/2^{+})$	164.9(2)	0.172(3)	[0.772(15)]

orientation experiments, which also yield imformation on the decay properties via the $U_{\lambda}A_{\lambda}$ coefficients, will be given elsewhere.

γ-anisotropies for ^{185}Pt<u>Zn</u> and ^{189}Pt<u>Zn</u> are shown in Figs.3 and 4. Preliminary results, assuming f = 1.0 for all samples, for the quadrupole splitting, are given in Table 2. The ratios $Q/Q(^{189}Pt)$ are obtained from samples in which both isotopes were implanted under the same conditions and, as remarked in section 2, are not dependent upon the value of f. The relatively large error in the case of ^{187}Pt is caused by a normalisation problem in this particular experiment. The negative sign is not in doubt.

Table 2. Preliminary results for quadrupole splitting frequencies of Pt isotopes in Zn.

Isotope	eQV_{zz}/h [MHz]	$Q/Q(^{189}Pt)$
^{189}Pt	− 150 (35)	
^{187}Pt	− 200 (100)	+1.3(7)
^{185}Pt	+ 540 (60)	−3.6(9)



Figs. 3 and 4. Nuclear alignment of ^{189}Pt<u>Zn</u> (721 keV transition) and ^{185}Pt<u>Zn</u> (460 keV transition).

4. CONCLUSIONS

The spectroscopic quadrupole moment of ^{189}Pt is known to be negative from previous nuclear orientation work, indicating an oblate ground state deformation /4/. From the present results we have shown that the ground state of ^{187}Pt has a quadrupole moment of the same sign and closely similar magnitude, giving no indication of a sharp change in equilibrium deformation. However the spectroscopic quadrupole moment of ^{185}Pt is definitely positive, giving clear evidence that the shape transition has been passed and that the shape is prolate at this mass number. A more complete analysis of these results, and of the magnetic moment and spectroscopic information derived from these experiments will be published later.

5. ACKNOWLEDGEMENTS

The authors thank all members of the ISOLDE and SC staff for assistance in running these experiments. The NICOLE collaboration acknowledges financial support from the Bundesministerium fur Forschung und Technologie (BMFT)(D), IN2P3 (F), The SERC Nuclear Structure Committee (UK) and the Interuniversitair Instituut voor Kernwetenschappen (B).

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