EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN-PPE/92-11
27.01.1992

TIME-RESOLVED AND TIME-INTEGRAL ON-LINE NUCLEAR ORIENTATION MEASUREMENTS OF NEUTRON DEFICIENT HG-AU-PT-IR NUCLEI

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ABSTRACT

The methods of time-resolved and time-integral on-line nuclear orientation have been applied to study short lived nuclei with the NICOLE facility (Nuclear Implantation into Cold On-Line Equipment) at ISOLDE-3 in CERN using beams of $^{182-186}$Hg. The half-lives in these decay chains are of the order of seconds and therefore comparable to the spin-lattice relaxation times of the nuclei in iron. As the relaxation rate depends strongly on the g-factor, g-factors of nuclei in the decay chains can be deduced from the observation of the time evolution of γ-ray anisotropy. Using this technique the existence of an isomer in ^{184}Au has been found and the g-factors of ^{184}Au, ^{184m}Au and ^{182}Au have been determined. Accurate half-lives have been extracted from the data. Time-integral nuclear orientation has been observed for short-lived as well as longer lived isotopes of the Hg decay chains. From these measurements, after proper correction for incomplete relaxation, the magnetic moments of ^{183m}Pt, ^{183}Ir and ^{182}Ir have been derived.The applicability of the time-resolved nuclear orientation technique for nuclei far from stability and its possible limitations is discussed.

(IS120)

accepted for publication in Hyperfine Interactions

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The methods of time-resolved and time-integral on-line nuclear orientation have been applied to study short lived nuclei with the NICOLE facility (**N**uclear **I**mplantation into **C**old **O**n-**L**ine **E**quipment) at ISOLDE-3 in CERN using beams of $^{182-186}$Hg. The half-lives in these decay chains are of the order of seconds and therefore comparable to the spin-lattice relaxation times of the nuclei in iron. As the relaxation rate depends strongly on the g-factor, g-factors of nuclei in the decay chains can be deduced from the observation of the time evolution of γ-ray anisotropy. Using this technique the existence of an isomer in ^{184}Au has been found and the g-factors of ^{184}Au, ^{184m}Au and ^{182}Au have been determined. Accurate half-lives have been extracted from the data.

Time-integral nuclear orientation has been observed for short lived as well as longer lived isotopes of the Hg decay chains. From these measurements, after proper correction for incomplete relaxation, the magnetic moments of ^{183m}Pt, ^{183}Ir and ^{182}Ir have been derived.

The applicability of the time-resolved nuclear orientation technique for nuclei far from stability and its possible limitations is discussed.

1. INTRODUCTION

The structure of nuclei as function of neutron and proton number below the doubly magic ^{208}Pb has been studied in detail in recent years by a variety of sophisticated techniques. In particular the neutron deficient Hg(Z=80), Au(Z=79) and Pt(Z=78) isotopes have provided an instructive illustration of the change in equilibrium deformation as the neutron number decreases towards midshell. In the odd A gold isotopes ^{183,185}Au the $1h_{9/2}$ proton intruder orbital becomes the ground state configuration and seems to determine the prolate deformation /1,2/. For the odd-odd Au nuclei rather important changes are expected, as the odd-neutron configuration in the odd Pt isotopes changes rapidly between N = 107...103. Experimental determination of moments and spins of nuclei below Z = 80 and N = 107 is therefore of strong interest.

The measurements described here have been performed with the NICOLE facility on-line

to ISOLDE-3 using its high production yields of neutron deficient Hg beams. The long decay chains of the Hg isotopes in this mass region are exellently suitable for systematic measurements at the short lived decay products Au, Pt and Ir. This work involved further development and the first application to nuclear g-factor measurement of a new technique of pulsed source on-line nuclear orientation (TR-OLNO)/3/.

2. EXPERIMENTAL DETAILS AND RESULTS

2.1. EXPERIMENTAL METHODS

2.1.1 Static nuclear orientation measurements

The angular distribution of γ-radiation emitted in radioactive decay of oriented nuclei can be written as:

$$W(\Theta,T) = 1 + f \sum B_k(\nu_m ,T) A_k U_k Q_k P_k (\cos\Theta) \quad , \qquad (1)$$

assuming axially symmetric magnetic hyperfine interaction with strength ν_m. This equation is described in detail in /4/. The orientation parameters B_k of the parent nuclear state with spin I are linear functions of the normalized population probabilities a(m,T) of the nuclear substate $|Im\rangle$ at temperature T which for full thermal relaxation obey a Boltzman distribution. For conventional NO experiments analysis of the temperature dependence of the γ-ray anisotropy R = W - 1 yields the strength of the hyperfine interaction, i.e. the product of the nuclear magnetic moment μ with the effective magnetic field at the nuclear site B_{eff} .

In the time-integral OLNO (TI-OLNO) experiments described here unpolarised radioactive nuclei with half-lives of the order of seconds are implanted continuously and the temperature dependence of the anisotropy is measured on-line. For short half-lives the assumption of full thermal relaxation before decay is not justified if the spin-lattice relaxation time and the half-life of the nuclei are of the same order of magnitude. In this case the population probabilities a(m,T) have to be calculated using relaxation theory to describe the data correctly /5, 6/. For the determination of ν_m from TI-OLNO data, the reduced relaxation rate :

$$r = 1 /(c_k g^2) \quad , \qquad (2)$$

where c_k denotes the Korringa constant, has to be known for the impurity-host system under investigation.

2.1.2 Time resolved on-line nuclear orientation (TR- OLNO) measurments

Different from time integral OLNO measurements, in TR-OLNO experiments a sequence of γ-spectra is recorded at a fixed temperature in time intervals which are comparable to the relaxation time of the nuclei and radioactive parent nuclei are implanted only for a small number of intervals at the beginning of the sequence. During the full sequence the time evolution of relaxation superimposed to the time evolution of the radioactive decay of all short-lived members in the decay chain is observed. As the relaxation process depends strongly on the nuclear g-factor, the g-factors of the involved isotopes and isomers can be derived, if the decay properties and the reduced relaxation rate r are known. On the other hand, if the g-factor is known the relaxation rate r can be deduced from a TR-OLNO experiment. In order to decouple 'spectroscopic' parameters

(e.g. half-lives, branching ratios, background from other isotopes) from orientation parameters (e.g. g-factors, U_k coefficients) TR–OLNO experminents have to be performed at least at constant low temperature and at warm sample temperature, where orientation and relaxation phenomena are absent.
To demonstrate the interrelation of decay and relaxation in a realistic case, a part of the decay scheme of ^{184}Hg is shown in fig.1.

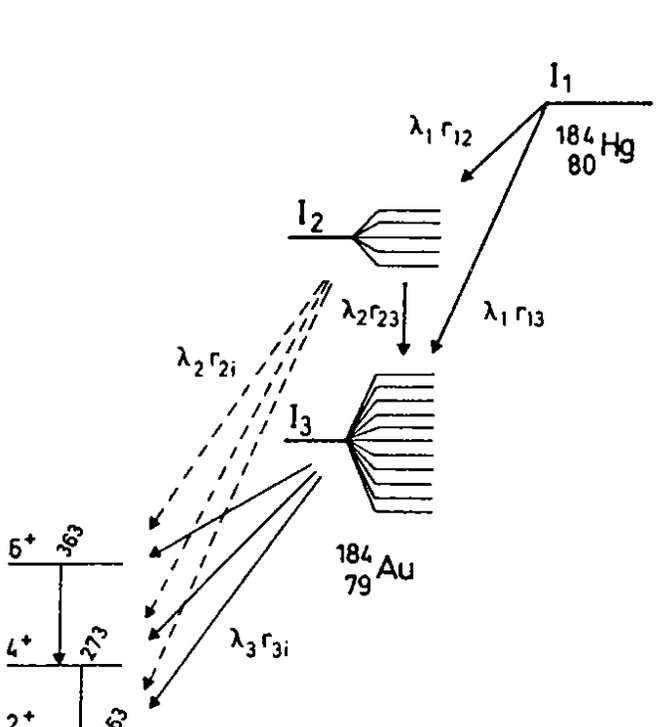

Fig. 1. Simplified decay scheme of ^{184}Hg

Here the implanted activity is ^{184}Hg with spin I = 0. In ^{184}Au an isomeric state exists which decays directly as well as via the ground state to members of the rotational band in ^{184}Pt. For both Au states half-lives and relaxation times are comparable. Therefore both the ground state and the isomeric state of ^{184}Au influence the time evolution of the observed γ-transitions in Pt. For the description of this system it is convenient to use a master equation system for all sublevels of all states which are involved:

$$\frac{d}{dt}\, a(I_i, m_i) = \sum_{n_i} \left(W_{n_i m_i}\, a(I_i, n_i) - W_{m_i n_i}\, a(I_i, m_i) \right)$$

$$+ \sum_{k<i} \lambda_k r_{ki} (2I_k+1) \sum_{m_k} \left[\begin{pmatrix} I_i & L & I_k \\ m_i & m_k - m_i & -m_k \end{pmatrix}^2 a(I_k, m_k) \right] - \lambda_i\, a(I_i, m_i) + P(t)\, \delta_{i,1} \qquad (3)$$

where the indices i and k numbers the different isotopes and isomers starting with the

implanted nucleus. The λ_k are decay rates and r_{ki} is the relative branching ratio for decay of level k to level i. The first term describes transitions between sublevels of level i due to spin-lattice relaxation.The transition probabilities W are given by /6/:

$$W_{m+1,m} = (\mu_n / 2k)\, r\ \ g^3\ B_{eff}\ [\ I(I+1) - m(m+1)\ ]\ /\ (\ 1 - e^{-x_L}\ ) \qquad (4)$$

$$W_{m,m+1} = (\mu_n / 2k)\, r\ \ g^3\ B_{eff}\ [\ I(I+1) - m(m+1)\ ]\ /\ (\ e^{x_L} - 1\ )$$

$$x_L = g\ \mu_n\ B_{eff}\ /(k\ T)$$

r is the relaxation rate defined in eq. (2) which is constant for a special impurity host combination, if hyperfine anomalies are neglected.
The transition probabilities W_{mn} are quite sensitive to the g-factor as they depend on g^3. Therefore it is, in principle, possible to determine the g-factor to high precision with a relaxation measurement.
The second term in eq. (3) describes the population of state i by radioactive decay from all levels k higher in energy than level i. This term, given here for a pure multipole transition, depends mainly on the decay parameters λ_k and the relative branching ratios r_{ki} . Depopulations of level i by decay to other nuclear states are given by the third term of eq. (3). Finally P(t), the only time dependent parameter, describes the feeding of the first level by the beam pulse. $P(t) = P_0$ for intervals when the ion beam is on, otherwise zero. Eq. (3) describes a system of ordinary differential equations which can be solved by application of standard numerical methods or the matrix method /6/.

2.1.3. Experimental set-up:
The on-line nuclear orientation (NO) experiments were performed with the NO facility NICOLE which is in operation at the isotope separator ISOLDE-3 at CERN. A short description is given in /7/. Details of the special data acquisition system will be described in a forthcoming paper.

2.2. EXPERIMENTS AND RESULTS

Mercury isotopes of mass number A = 182, 183, 184, 186 were produced with a 600 MeV proton or 910 MeV ^{3}He beam focussed on a molten Pb target via spallation reactions. The isotopes were mass separated with the ISOLDE 3 facility and implanted unpolarised with 60 keV energy into iron foils soldered onto the cold finger of the NICOLE dilution refrigerator. The implantation times were controlled by an electrostatic beam-gate. Temperature has been measured with a ^{60}CoCo (hcp) thermometer. Particulary Au, Pt and Ir isotopes in the decay chains have been studied.
For the analysis of TR-OLNO experiments a precise value for the relaxation rate of the system AuFe is necessary. Experimental values are listed in table 1. The values in the first three lines are precise and in excellent agreement. Furthermore the experimental conditions of these measurements (e.g. cold implantation) are most similar to our experiment. Therefore we adopt r = 23.4 (6) (Ks)$^{-1}$ for our data evaluations.

Table 1: Reduced relaxation constants for AuFe:

r (Ks)$^{-1}$	Isotope	Sample preparation	B_{ext}[T]	Method	Ref.
23.3 (7)	^{198}Au	cold implantation with 80 keV	0.6	R-SFM [a]	/8/
23.7 (13)	^{198}Au	cold implantation with 60 keV	0.6	R-SFM [a]	/9/
23 (5)	^{191m}Au	cold implantation of ^{191m}Hg with 50 keV	0.5	OLNO	/10/
9.4 (8)	^{198}Au	0.1 at.% AuFe molten sample	0.2	R-AFP [b]	/11/
8.7 (9)	^{195m}Au	recoil implantation of ^{195m}Hg	d)	R-SFM [c]	/12/

a) R–SFM: resonant perturbation by switched frequency modulation
b) R-AFP : resonant perturbation by adiabatic fast passage
c) same method as R-SFM, but evaluated with a single exponential function
d) extrapolated to B = ∞

2.2.1 A = 182

The decay of ^{182}Hg is drawn schematically in fig. 2. γ-spectra measured during implantation of ^{182}Hg show γ-lines of all isobaric Au, Pt, Ir, Os and Re isotopes from EC-or β$^+$-decay as well as lines of the A=178 chain after α-decay of ^{182}Hg.

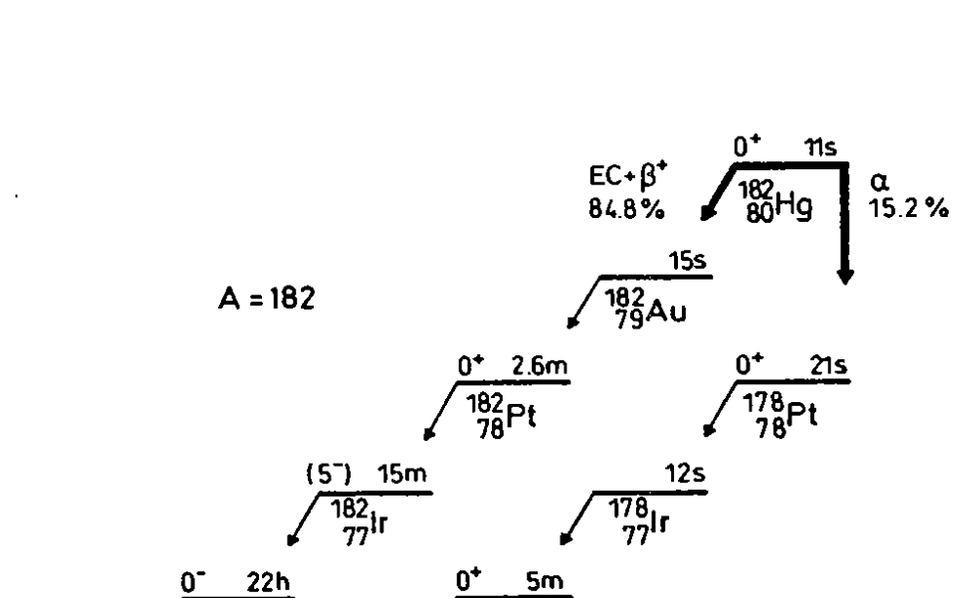

Fig. 2. Simplified decay scheme of ^{182}Hg /13/.

Both TI-OLNO and TR–OLNO measurements have been performed on these isotopes in host iron. In continuous implantation OLNO experiments the anisotropy of the γ-radiation

was measured as function of the sample temperature in an external magnetic field of 0.5 T. Anisotropy versus inverse temperature for the dominant 273 keV γ-transition in the decay of ^{182}Ir is plotted in fig. 3. The solid line represents the result of a least-squares fit of the theoretical function assuming full relaxation for the iridium nuclei. This assumption is justified by the half-life of $T_{1/2}$ = 15 min /13/ of ^{182} Ir<u>Fe</u>. Using the value 137.3 (7)T /14/ for the hyperfine magnetic field we obtain for the magnetic moment of the ground state of ^{182}Ir with I = (5) /13/:

$$| \mu | = 2.08\ (15)\ \mu_N$$

For the extraction of this result the measured anisotropies of the 127 keV and the 273 keV γ-transition were fitted simultaneously.

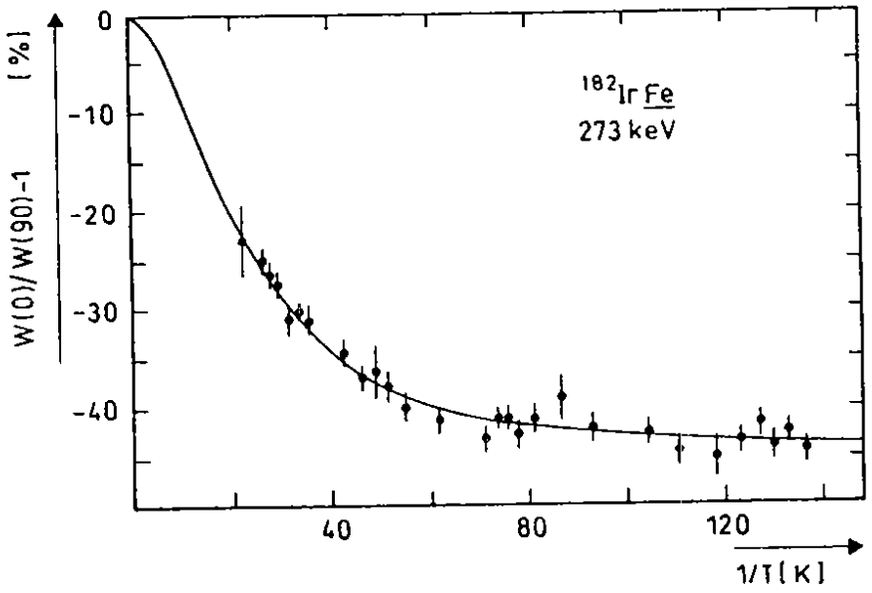

Fig. 3. Temperature dependence of the anisotropy of ^{182}Ir<u>Fe</u>.

The data for ^{182}Au ($T_{1/2}$ = 15.6 (5) s, see TR-OLNO evaluation) from the same TI-OLNO measurement were analysed taking into account the reduction of anisotropy caused by incomplete relaxation of the gold nuclei. Fig. 4 shows as example the anisotropy of the 155 keV γ-transition versus inverse temperature. The solid lines are the results of a least-squares fit to the data where the relaxation-rate from sect. 2.2. and the magnetic hyperfine field of 114.5 (17)T /15/ were used. The values of g-factor for different ground state spin assumptions which result from the fit are listed in table 3.

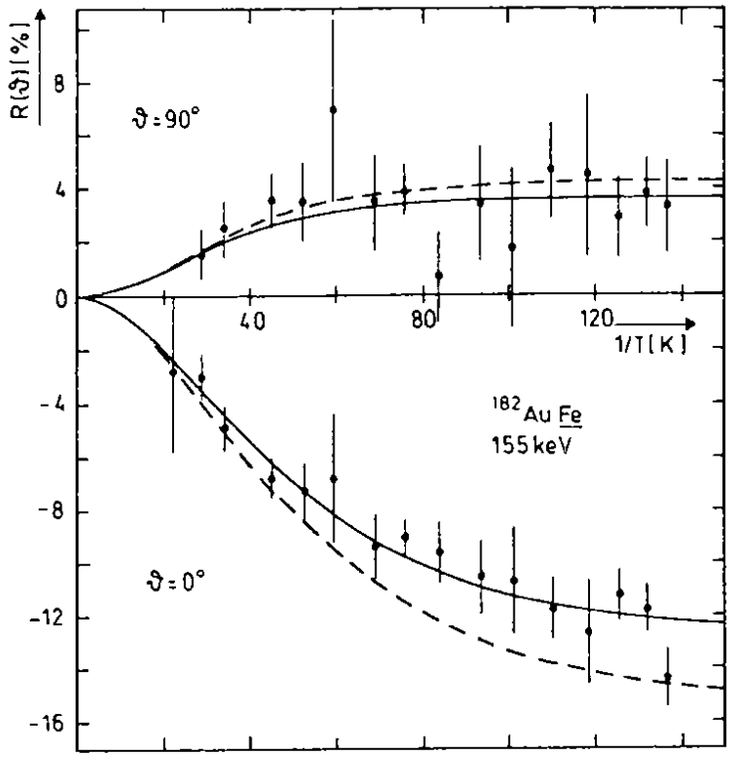

Fig. 4. Temperature dependence of the anisotropy of ^{182}AuFe. The solid line represents theory taking into acount attenuation due to incomplete relaxation. The broken line assumes full relaxation.

In the TR-OLNO experiments for A=182 the timing sequence was the following: One 'cycle' was divided into 64 intervals of 2 s duration. ^{182}Hg was implanted from the beginning of the second interval for a total of 9 intervals. For the rest of the sweep the growth and decay of the different isotopes in the decay chains of ^{182}Hg was observed without implantation. To get sufficient statistical precision many cycles were accumulated each for cold and warm samples. In fig. 5 the time evolution of the γ-activity for the different isotopes of the A = 182 chain is displayed for the experimental timing sequence. Taking the time dependent γ intensities from the TR-OLNO experiment performed at high temperatures, carefully corrected for contaminations from other isotopes, rather precise values for the half lives of Hg and Au have been derived. For ^{182}Hg the agreement between our value ($T_{1/2}$ (^{182}Hg) = 11.3 (2)s) and values from /13/ is good. In table 2 the half-life of Au as determined in this work and for comparison values from literature are listed.

Table 2: Half-life of ^{182}Au:

Half-life [s]	Method	Ref.
15.6 (4)	TR-OLNO	this work
20 (2)	α-spectroscopy	/16/
22.1 (13)	γ-spectroscopy	/17/
19 (2)	α-spectroscopy	/18/

The value of half-life from this work is considerably shorter than the three other values cited which, however, are much less precise.

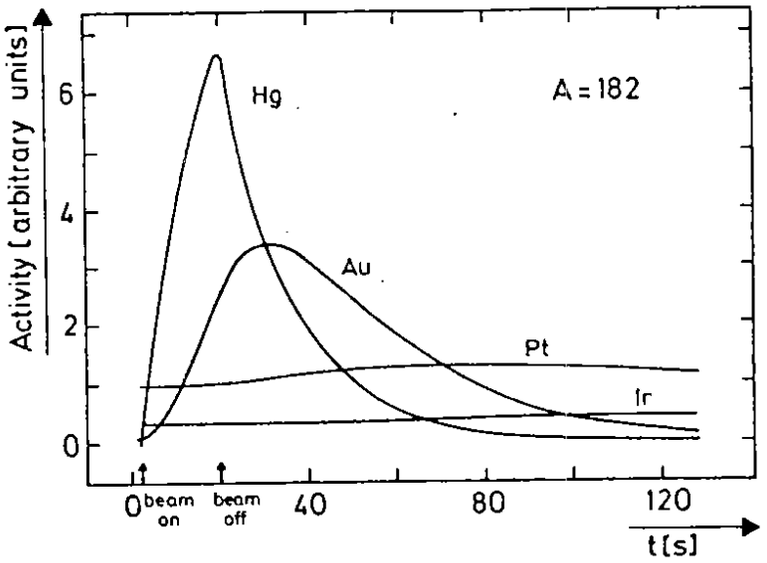

Fig. 5. Time evolution of activity in the decay of different isotopes of the A=182 chain for experimental conditions.

The TR-OLNO measurements at cold temperature were performed at constant temperature of 10.5 mK in an external magnetic field of 0.6 T. Experimental values of the ratio $W(0^o)/W(90^o) - 1$ for the 155 keV γ-line versus time are shown in fig. 6. The reduction of anisotropy on start of implantation at the second experimental point can clearly be seen as well as the smooth recovery back to equilibrium anisotropy. The solid line represents the result of a least-squares fit to the data. For this the full theoretical description, eq. (3), was used and the experimental timing sequence was taken into account. The data were corrected for experimentally determined admixture of γ-lines from the decay of ^{182}Hg. It is absolutely necessary to correct carefully for short lived Hg contaminations, because the time evolution of this Hg admixture is similar to that caused by relaxation effects.

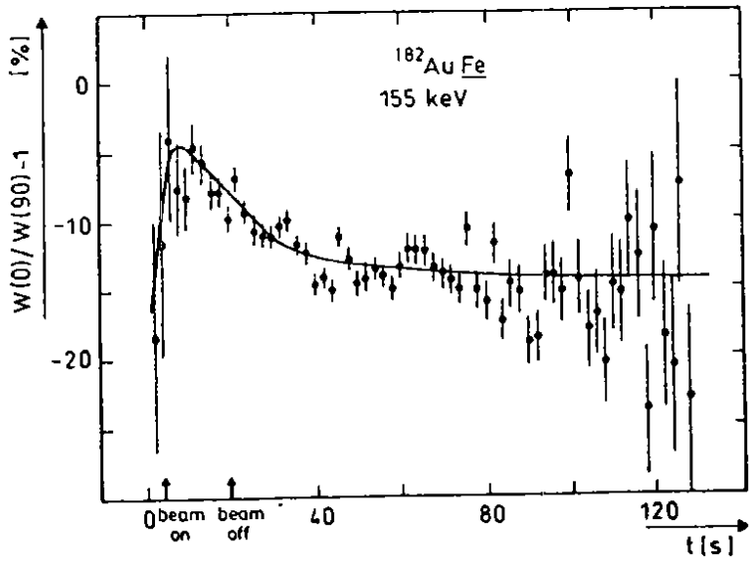

Fig. 6. Time dependence of the anisotropy of ^{182}Au<u>Fe</u>

In column 3 of table 3 g-factors of Au for different spin assumptions resulting from this data evaluation are given.

Table 3: g-factors of the ground state of ^{182}Au for different spin assumptions:

I	| g | (OLNO)	| g | (TR-OLNO)
1	0.85 (6)	0.73 (5)
2	0.68 (5)	0.62 (5)
3	0.53 (5)	0.55 (5)
4	0.43 (5)	0.51 (6)
5	0.35 (5)	0.46 (3)

Comparing the g-factors from OLNO and TR-OLNO measurements, given in table 3 for different spin of ^{182}Au, a choice of spin I = 2...4 is suggested by the best accord between the results of the two techniques.

2.2.2 A = 183

For the investigation of the A = 183 decay chain TI–OLNO experiments with continuous implantation of ^{183}Hg were performed. The anisotropy of different γ-lines was measured as function of sample temperature in an external magnetic field of 0.5 T.
A theoretical anisotropy function for fully relaxed nuclei was fitted to the data of the 228 keV γ-transition in the decay of ^{183}Ir ($T_{1/2}$= 57min). The assumption of A_4U_4= 0 is necessary for reasonable convergency of the fitting procedure. This should not lead to unreasonably large systematic errors because the k=4 term is considerably smaller than the k=2 term. As the spin of ^{183}Ir is not known we give the derived magnetic moments for the two in the literature proposed ground state configurations :

$|\mu(^{183}\text{Ir}, I=7/2\ /19/)| = 2.22\ (55)\ \mu_N$; $|\mu(^{183}\text{Ir}, I=5/2\ /20/)| = 2.05\ (34)\ \mu_N$

For ^{183m}Pt (I = (7/2) /19/, $T_{1/2}$= 42 s) which is produced in the decay sequence:

$$^{183}\text{Hg}\ (I = 1/2, T_{1/2}=8.8\ s) \rightarrow {}^{183}\text{Au}\ (I = 5/2,\ T_{1/2} = 42\ s) \rightarrow {}^{183m}\text{Pt}$$

relaxation can not be neglected. Therefore attenuation factors due to Hg and Au parent preorientation and decay of ^{183m}Pt have been calculated for secular equilibrium. For this calculation the following values have been used: $g(^{183}Hg)$=1.048 /21/, r(HgFe) = 10 $(Ks)^{-1}$ /22/, $g(^{183}Au)$=0.789 /23/, r(AuFe) = 23.3 $(Ks)^{-1}$ /8/ and r(PtFe) = 10 $(Ks)^{-1}$ /6/. Using the attenuation factors we deduced:

$$|\mu(^{183m}\text{Pt})| = 0.96(8)\ \mu_N$$

The result which is derived with the assumption of full relaxation is μ = 1.00(8) μ_N. This shows that the correction for relaxation is very small.
For A = 183 TR-OLNO measurements have been performed. The TR-OLNO experiment at cold sample did neither contradict nor confirm the result of the conventional OLNO experiment for ^{183m}Pt as the statistical errors in the TR-OLNO experiment are very high. A fit to the time dependence of the intensity of different γ-lines for warm sample clearly shows that there exist at least four γ-lines (172 keV, 221 keV, 342 keV, 393 keV) from the second generation of the decay chain with half-life of $T_{1/2}$ = 22 (2) s. The

absolute intensity of the 221 keV γ-transition in the decay of ^{183}Hg is of the order of 20%. The 172 keV and the 221 keV γ-lines show no anisotropy for cold sample. As suggested by Macias-Marques et al. /1/ these γ-lines could be interpreted as γ-transitions following the decay of ^{179}Pt (I = 1/2 /24/) which is produced via α-decay from ^{183}Hg. If this interpretation is correct values for the half-life of ^{179}Pt ($T_{1/2}$= 33 (4)s /25/ and $T_{1/2}$= 54 (4)s /26/) from literature are in striking disagreement with our value.

2.2.3 A=184

For the TR–OLNO experiment a cycle time of 310s which is about 6 times the half-life of ^{184}Au and a beam pulse length of 10s was chosen . The measurements were performed at low temperature (T=13 mK) as well as at high temperature. At warm temperature the 363 keV 6^+- 4^+ γ-transition in ^{184}Pt (see Fig.1) is clearly delayed with respect to the lower two transitions of the stretched E2 cascade in Pt. This effect could be explained only with the existence of an isomer in ^{184}Au with spin lower than the ground state spin. The internal transition between the two states has been identified by a conversion electron measurement to be of M3 multipolarity /27/. This implies, that the spin of the isomer and the ground state are either I(^{184m}Au)= 2 and I(^{184g}Au) = 5 or I(^{184m}Au) = 3 and I(^{184g}Au) = 6. From the TR-OLNO experiments at warm temperature the following half-lives of the gold isomers have been obtained: $T_{1/2}$(^{184m}Au)= 45 (1)s and $T_{1/2}$(^{184g}Au) = 19 (2) s. The analysis of data for cold temperature is complicated, as two states with unkown g-factors contribute to the relaxation structure (see eq. 3). Even the relative contributions of the two levels to any of the γ-lines are uncertain as the branching ratios are unknown. The large intercorrelation of the parameters in the fit function for the determination of both g-factors could only be reduced if the three γ-lines following the decay of Au (163 keV, 273 keV and 363 keV) are fitted simultaneously. A compilation of the results is given in table 4.

Table 4: g-factors of ^{184m}Au and ^{184g}Au for different spin assumptions

I (^{184m}Au)	I (^{184g}Au)	| g (^{184m}Au) |	| g (^{184g}Au) |
2	5	0.65 (14)	0.4 - 0.8
3	6	0.55 (14)	0.62 (15)

In the fit with spin sequence 2-5 unreasonably large values for two of the six U_2 coefficients occured. Therefore the value of the ground state g-factor is uncertain as it is very sensitive to restrictions of these U_2 coefficients. For every spin sequence the two solutions, for which the g-factors have either the same or opposite sign, gave within the errors the same result. The large errors quoted for the g-factors are the consequence of the short relaxation time (< 5 s) as compared to the life-times and the time windows. In fig. 7 the time dependence of the anisotropy of the 363 keV transition is shown. The solid line represents the result of the evaluation.

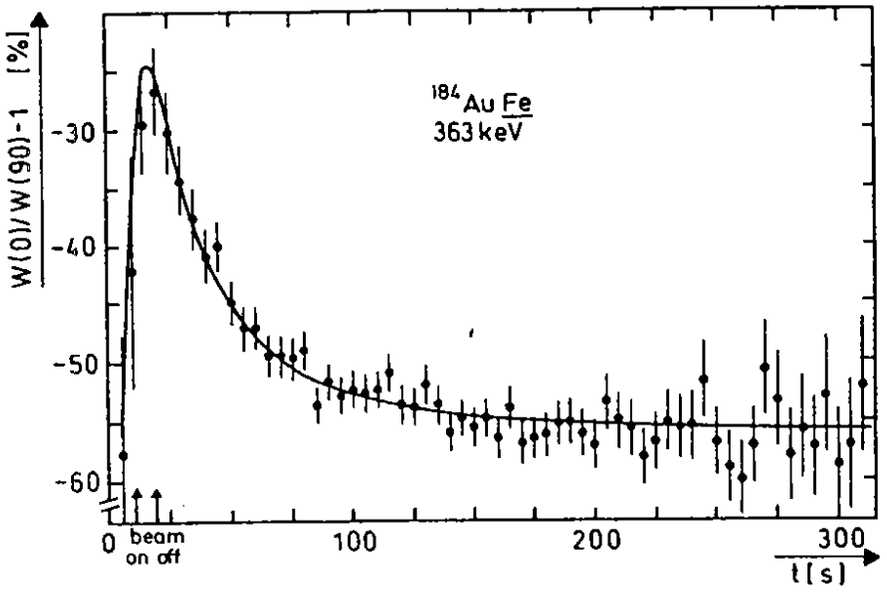

Fig. 7. Time dependence of anisotropy of the 363 keV γ-transition in the ^{184}Au decay.

2.2.4 A = 186

TR-OLNO experiments have been performed on the decay products with mass number A=186 in order to obtain a relaxation constant which represents the integral relaxation rate for all Au lattice sites produced by the cold implantation of Hg and the subsequent Hg β^+-decay. For ^{186}Au the g-factor is known /2/, therefore the relaxation rate could be determined by a TR-OLNO measurement as:

$$r\ (\ \underline{\mathrm{AuFe}}\ ) = 29\ (9)\ (\mathrm{Ks})^{-1}$$

The main problems of this experiment are the long half-lives of ^{186}Hg ($T_{1/2}$ = 83 s /28/) and ^{186}Au ($T_{1/2}$ = 11 min /28/) compared to the short relaxation time of some seconds. Because of the long half-life of ^{186}Au, the time between two beam pulses of 10 s length had to be chosen as 27 min. This means that only 4% of the time could be used for the relaxation measurement. This is explains the low precision of the result.

3. DISCUSSION

3.1 THE TR-OLNO METHOD

The measurements on short lived isotopes presented in this work have shown that it is possible to derive g-factors from TR-OLNO experiments with moderate precision. Far from stability also standard OLNO experiments corrected for relaxation yield the magnetic moment if the hyperfine field is known. In favourable cases the spin can also be determined if both standard OLNO and TR-OLNO methods are applied. In practice some problems, both technical and fundamental, occur which limit the general applicability and precision of the TR-OLNO method. In the following a few of these problems are discussed in detail.

i) The time evolution of the background contributions of other isotopes and drastic change of the dead time within a measurement cycle are similar in effect to the time evolution of the anisotropy of the isotope under investigation. Therefore the extracted γ-line intensities resp. the fitted function definitely has to take this into account to a

precision of about 0.1-1 %. In cases with very complex γ-spectra and drastic variation of the relative line intensities such as the experiments described here even with careful analysis background contributions of the order of 0.1% could not be avoided and were sometimes difficult to obtain with high precision. Furthermore, in order to get reasonable count rates all over the cycle, rather high dead times (~ 20%) had to be accepted. This dead time has to be measured precisely and reliably. The above mentioned problems do not occur in such extent in conventional OLNO experiments, because the dead time could be kept lower due to the constant beam. Even small background contributions from the unoriented Hg isotopes have not such influence on the result as they do not affect the fitted magnetic moment μ but only the fraction in good sites f.

ii)The high sensitivity in TR-OLNO experiments due to the g^3 dependence of the relaxation transition probabilities is only achieved if the life-times of the involved levels are of the order of the effective relaxation time. In the measurements described here this assumption was not fulfilled because the relaxation time is much shorter than the life-times of the Au isotopes under investigation. The shape of the time-dependent anisotropy is dominated by the life-time of the preceeding Hg isotope. Experimentally the time structure and the cycle time is fixed by the involved isotopes and cannot be changed. This limitation strongly reduces the sensitivity of this method to the g-factor. The above mentioned difficulties could be avoided if relaxation would be observed with the thermal cycling method /6/ using external perturbation of the system, namely switching the temperature of the sample holder in combination with continuous implantation.

iii) TR-OLNO measurements are certainly time differential measurements with regard to the time dependent phenomena e.g. the relaxation, but with regard to the hyperfine interaction TR-OLNO is still an integral measurement like a conventional OLNO experiment. This implies that, if the fraction on substitutional lattice sites is different from 1, not only the relaxation rate but also the distribution of the relaxation rate has to be known because the relaxation rates could be different at different lattice sites. Unfortunately there is almost no experimental information on this problem. For the cold implanted Au<u>Fe</u> system r values measured with resonance technique : r= 23.3 (7) $(Ks)^{-1}$, r = 23.7 (13) $(Ks)^{-1}$ (see table 1) have to be compared with the values measured with an integral technique : r = 23 (5) $(Ks)^{-1}$ (see table 1) and r = 29 (9) $(Ks)^{-1}$ using the TR-OLNO technique. The values do not differ significantly but the errors are too high to draw any conclusions concerning the distribution of relaxation rates in the system Au<u>Fe</u>.

Finally it should be pointed out, that the pulsed beam technique is a very powerful method for the determination of half-lives of all short lived members in the decay chain and seems to be superior to the tape transport technique. With the observation of the growth and decay of activities in combination with good time and energy resolution very clean time spectra are obtained which represent the whole history of the isotopes. In this way systematic errors are strongly reduced and in addition the occurence of isomers is immediately shown up in the measured spectra.

3.2 NUCLEAR PHYSICS RESULTS

The nuclei $^{182,183}Ir$, ^{183m}Pt and $^{182,184m,184g}Au$ that have been studied are all situated in a region where rather strong prolate deformed shapes show up with quadrupole deformation equilibrium values of $0.2 < \varepsilon_2 < 0.25$.

The Nilsson orbital for the odd proton levels near to Z=79 are determined by the 1 $h_{9/2}$ proton intruder orbital. In ^{185}Au, the ground state with $I^{\pi} = 5/2^-$ is believed to be a anti-aligned (J-2) member of the decoupled proton 1 $h_{9/2}$ orbital. Coriolis band mixing cal-

culations for the proton 1/2⁻[541] and 3/2⁻[532] Nilsson configurations performed by E. Van Walle /2/ result in a magnetic moment for the 5/2⁻ state varying between 2.2 μ_n and 2.5 μ_N for ε_2 = 0.20 - 0.25. The angular momentum values for the lowest levels in ^{181,183,185}Ir all indicate a rather stable 5/2⁻ and 9/2⁻ doublet structure originating mainly from the decoupled 1/2⁻[541] Nilsson orbital /29/. If one assume 5/2 for the spin of ^{183}Ir /20/ which is supported by the very close-lying values of the magnetic moment observed in this mass region for odd proton states of the same spin $I^\pi = 5/2^-$: $\mu(^{185}Au) = 2.22\ (14)\ \mu_N$ /2/, $\mu(^{183}Au) = 1.972\ (23)\ \mu_N$ /23/ and $\mu(^{185}Ir) = 2.49\ (29)\ \mu_N$ /2/, the present value : $\mu(^{183}Ir) = 2.05\ (34)\ \mu_N$ fits rather well in the systematics.

In the Nilsson neutron level scheme near N = 107, rapid variations occur which make predictions of nuclear moments quite difficult. Concerning the neutron 7/2⁻[514] Nilsson orbital which has been assigned to describe the ^{183m}Pt configuration, a magnetic dipole moment of -0.83 μ_N /30/ results from Nilsson model calculations (using a choice of g_s=0.6 $g_{s\,free}$ and the estimate g_R=Z/A). This result is quite close to predictions for analogous configurations in odd-A W and Os nuclei by Ekström et al. /31/ and to the experimental value for the 7/2⁻[514] configuration in ^{177}Hf of μ = 0.7936 (6) μ_N /32/. The experimental value determined in this paper of $\mu(^{183m}Pt) = 0.96\ (8)\ \mu_N$ is in rather good agreement with the suggested configuration.

For the doubly odd Au and Ir isotopes the situation is much more complex. The low projection of the proton 1 $h_{9/2}$ orbital : 1/2⁻[541] and 3/2⁻[532] yields a decoupling situation and therefore Coriolis band mixing calculations are needed. Furthermore, the rapidly varying set of Nilsson orbitals for the neutron configuration at N = 109, 107, 105 complicates the simple picture and rather subtle proton-neutron and Coriolis band-mixing effects may occur. Even for ^{186}Au, where the odd proton particle occupies a unique parity orbital, some difficulties arise in explaining both the $K^\pi = 3^-$ ground state band structure and its magnetic moment. Therefore, in this conference contribution, we briefly discuss the experimental aspects and systematics of the data. Some discussion of ^{182}Ir is given in /33/.

For ^{182}Au we derived $\mu(^{182}Au) = 1.65\ (15)\mu_N$, assuming I = 3 which gives the best agreement between the two different experimental techniques (see table 3) although the other spin values cannot be excluded. This magnetic moment is, within the errors, the same as the result for ^{184m}Au (assuming I=3) $\mu(^{184m}Au) = 1.65\ (42)\ \mu_N$. In ^{184}Au both spin combinations (2, 5) and (3, 6) for the isomer and the ground state are possible, but the spin combination 3, 6 clearly gives the better fit in our evaluations. Furthermore, only the result for I = 3 is in good agreement with results from laser-spectroscopy experiments which gave μ (^{184}Au) = 1.813 (19) I / (I+1/2) μ_N , and the condition I ≥ 3 /23/. The agreement with the present result suggests that in the laser spectroscopy experiments the longer lived isomeric state with I = 3 had been resonated.

Acknowledgements

The authors are indepted to all members of the ISOLDE collaboration and to the technical staff of the SC of CERN for their help and support to these experiments and to Prof. K. Heyde for discussion. They acknowledge financial support from Interuniversitair Instituut voor Kernwetenschappen (B), Bundesministerium für Forschung und Technologie contract 06BN4S1 and 181 (D), IN2P3 (F) and SERC Nuclear Research Comitee (U.K.)

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