ELECTRIC QUADRUPOLE INTERACTION OF
178Hf IN NONCUBIC METALS

B. Perscheid, G. Kaindl

To cite this version:
B. Perscheid, G. Kaindl. ELECTRIC QUADRUPOLE INTERACTION OF 178Hf IN NONCUBIC METALS. Journal de Physique Colloques, 1980, 41 (C1), pp.C1-139-C1-140. <10.1051/jphyscol:1980135>. <jpa-00219704>

HAL Id: jpa-00219704
https://hal.archives-ouvertes.fr/jpa-00219704
Submitted on 1 Jan 1980

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L’archive ouverte pluridisciplinaire HAL, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d’enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.
ELECTRIC QUADRUPOLE INTERACTION OF $^{178}_{\text{He}}$ IN NONCUBIC METALS

B. Perscheid and G. Kaindl

Institut für Atom- und Festkörperphysik, Freie Universität, Berlin, Germany.

The extensive experimental work of the last few years on electric-field gradients (EFG) at nuclear sites in noncubic metals has resulted in an empirical correlation proposed by Raghavan et al. /1/, according to which the total EFG is proportional to the ionic contribution. The validity of this correlation, however, is doubtful since a considerable number of exceptions has been found and since the sign of the EFGs is known only in relatively few cases. This situation motivates further studies of EFGs in metals especially by such methods where the sign of the EFG can also be determined. For an up-to-date review on experimental and theoretical results of EFGs in metals see /2/.

We report here on a study of EFGs at $^{178}_{\text{He}}$ probe atoms in the transition metals Ti, Zr, Ru, and Os, as well as in Be metal, using the 93-keV Mössbauer transition of $^{178}_{\text{Hf}}$. This gamma resonance with the spin sequence $0-2$ allows to evaluate sign and magnitude of the EFG even from polycrystalline samples.

The dilute alloys were prepared by argon-arc melting of $^{178}_{\text{W}}$ activity in metallic form with the corresponding host metals keeping the resulting impurity concentration below 1 at. % in all cases. The source activity was produced by a $^{181}_{\text{Ta}}(d, 5n)^{178}_{\text{W}}$ reaction. HfN was used as a single-line absorber, and both source and absorber were kept at liquid helium temperature in all experiments.

Argon-arc melting of noncubic metals always produces more or less oriented samples caused by a temperature gradient in the sample during the cooling process. In the following the direction of this temperature gradient will be referred to as the sample axis. All spectra of the transition metal hosts were taken with the sample axis parallel to the direction of the observed Mössbauer quanta. In case of the Be metal host three spectra with different orientations of the sample axis were recorded with the same sample.

Fig. 1 shows, as an example, the transmission spectrum obtained for Ti as host metal. From the asymmetry of the spectrum a positive sign of the EFG is readily derived. The results of the least-squares-fit analysis of the spectra are summarized in tab. 1. In case of the Be alloy the analysis revealed a strong orientation of the sample. The spectra of Ti and Zr, on the other hand, could be fitted well only by assuming nearly random orientation. In case of the Ru and Os alloys the orientation of the samples could not be determined from least-squares fits of the spectra. This causes some ambiguity on...
Table 1: EFGs at the nuclear site of Hf probe atoms in several noncubic metals

<table>
<thead>
<tr>
<th>metal</th>
<th>$\nu_{zz}^{\text{exp}} \left[ 10^{-17} \text{ cm}^2/\text{V} \right]$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be</td>
<td>+ 4.8(6)</td>
</tr>
<tr>
<td>Ti</td>
<td>+ 8.5(2)</td>
</tr>
<tr>
<td>Zr</td>
<td>+ 8.8(3)</td>
</tr>
<tr>
<td>Lu$^a$</td>
<td>+ 4.7(10)</td>
</tr>
<tr>
<td>Hf$^b$</td>
<td>+ 9.5(4)</td>
</tr>
<tr>
<td>Ru</td>
<td>± 4.8(5)</td>
</tr>
<tr>
<td>Os</td>
<td>± 6.9(4)</td>
</tr>
</tbody>
</table>

$^a$ Ref. /3/, $^b$ Ref. /4/ 

the sign of the EFGs in these two cases. The magnitude of the EFGs, however, was found to be not affected within the quoted error limits by assuming different types of orientation of the two samples.

The EFG at nuclear sites in noncubic metals is usually assumed to be composed of an ionic contribution $\nu_{zz}^{\text{ion}} \cdot (1 - \lambda_{\infty})$ and an electronic contribution $\nu_{zz}^{\text{electron}}$

$$\nu_{zz}^{\text{exp}} = \nu_{zz}^{\text{lat}} - \nu_{zz}^{\text{ion}}$$

$\nu_{zz}^{\text{lat}}$ represents the point charge lattice sum over the positive ions and $\lambda_{\infty}$ is the Sternheimer antishielding factor. Raghavan et al. /1/ have proposed a proportionality between $\nu_{zz}^{\text{ion}}$ and $\nu_{zz}^{\text{lat}}$:

$$\nu_{zz}^{\text{ion}} = - \kappa \cdot \nu_{zz}^{\text{lat}} (1 - \lambda_{\infty})$$

with a "universal" constant $\kappa$ taking values between +2 and +4. The experimental results for the EFGs of Hf probe atoms in transition metals do not follow this correlation. Recently Ernst et al. /3/ showed that the EFGs of pure systems can be divided into two groups with proportionality constants $\kappa \approx -3$ for metals with the outermost d-shell less than half full and $\kappa \approx +2$ for all other hexagonal metals. The EFGs of Hf probe atoms in host metals with less than half full d-shell arrange themselves in the $\kappa \approx -3$ region. Thus the overall systematics found for pure systems by Ernst et al. seems to apply also for the impurity systems studied here. It should also be noted that the EFGs found for Ta probe atoms in the same host metals /2, 5/ fit in a similar way in the cor-

This work was supported by the Sonderforschungsbereich 161 of the Deutsche Forschungsgemeinschaft and by the Gesellschaft für Kernforschung GmbH, Karlsruhe. Valuable discussions with G. Wortmann are gratefully acknowledged.

/2/ E. N. Kaufmann, R. Vianden, Rev. Mod. Phys. 51, (1979), 161
H. Ernst, thesis T U Munich (1979)