# BRIEF COMMUNICATIONS

## Comments on "Résonance paramagnétique électronique de Gd$^{3+}$ dans PbTe, phenomènes d'échange"

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Analysis of experimental data shows that, for Gd concentrations up to 7 cation%, the concentration dependence of the ESR linewidth of cubic Gd$^{3+}$ centers in Gd : PbTe solid solutions can be explained in terms of dipolar broadening in the presence of exchange interactions. © 1991 Academic Press, Inc.

In a recent paper (*1*), Brun *et al.* reported ESR results on Gd : PbTe solid solutions. The concentration dependence of the ESR linewidth of cubic Gd$^{3+}$ centers is compared with theoretical calculations using the theory of Kittel and Abrahams (*2*). It should be recognized that this theory was formulated assuming that there are no exchange interactions between the paramagnetic ions. In the presence of exchange interactions, it can be shown (*3*) that the ESR linewidth is given by

$$\Delta H_{pp} = \pi \frac{\sqrt{7}}{15}$$
$$A(S)[S_1(r_c)]^{3/2}[S_2(r_c)]^{-1/2}f(1-f)^{z(r_c)}, \quad (1)$$

where

$$A(S) = \frac{\mu_0}{4\pi} \frac{g\beta}{a^3} \left[ \frac{S(S+1)}{1.4 + 0.3(S^2 + S)^{-1}} \right]^{1/2}, \quad (2)$$

$$S_1(r_c) = a^6 \sum_{r_{jk} < r_c} r_{jk}^{-6}, \quad (3)$$

$$S_2(r_c) = a^{12} \sum_{r_{jk} < r_c} r_{jk}^{-12}, \quad (4)$$

where $S$ is the spin of the paramagnetic ion, $r_c$ is the effective range of the exchange interaction, $f$ is the concentration of the paramagnetic ions, $z(r_c)$ is the number of cation sites included in a sphere of radius $r_c$, $g$ is the $g$-factor, $\beta$ is the Bohr magneton, $a$ is the lattice constant, and $r_{jk}$ is the distance between the $j$ and $k$ lattice sites.

Equation (1) was applied to the Gd$^{3+}$ : PbTe system using the following parameters, appropriate to the Gd$^{3+}$ ions occupying cubic symmetry sites in the PbTe lattice (*1*): $S = 7/2$, $g = 1.991$, $a = 0.6460$ nm. The results are shown in Fig. 1 for five different ranges of the exchange interaction. The experimental data of Brun *et al.* (*1*) and of Hedgcock *et al.* (*4*) are also shown. Equation (1) was derived assuming that the linewidth in the crystallites that make up a powder is the same as in a single crystal; since this is not true in the case of Gd : PbTe (*1*), the experimental linewidths were divided by a factor of 3.5, corresponding to
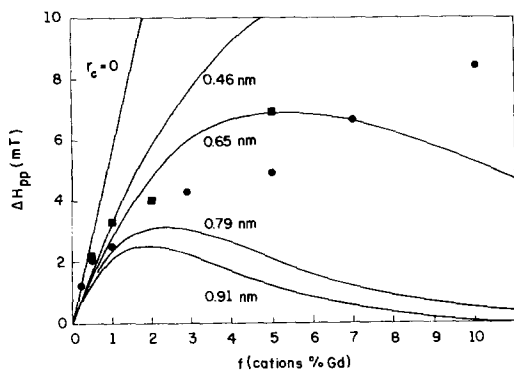
FIG. 1. Concentration dependence of the peak-to-peak linewidth $\Delta H_{pp}$ in $Gd^{3+}$ : PbTe. The curves are theoretical, for five different ranges of the exchange interaction. Experimental points: ●, Ref. (1); ■, Ref. (4).

the ratio between the linewidths in powder and single-crystal samples for the same Gd concentration (1). For samples doped with up to 7 cation% Gd, the experimental results are consistent with the theoretical predictions if the range of the exchange interaction is assumed to be 0.65 nm, of the same order as in the Cr : MgO (3) and Gd : CaF$_2$ (5) systems. For the sample doped with 10 cation% Gd, the linewidth is larger than predicted assuming the same range for the exchange interaction. This can be due to clustering effects. The agreement between the experimental results and the theoretical predictions seems to imply that, for Gd concentrations up to 7 cation%, the concentration dependence of the linewidth in Gd:PbTe solid solutions can be explained in terms of dipolar broadening in the presence of exchange interactions.

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