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RESOLVED FINE STRUCTURE OF Eu^{2+} IN $BaAl_4$

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We report on the observation of well resolved fine structure of Eu^{2+} in single crystals of the intermetallic compound $Eu_xBa_{1-x}Al_4$ ($x = 0.01$, 0.005). $BaAl_4$ as well as $EuAl_4$ is body centered tetragonal (fig. 1, space group I $4/_{mmm}$, $a = 4.566$ Å, $c = 11.25$ Å respectively $a = 4.398$ Å, $c = 11.17$ Å).

The susceptibility of $Eu_{0.005}Ba_{0.995}Al_4$ obeys the Curie-Weiss law with an effective moment of 7.2 Bohr magnetons.

The ESR measurements were performed in the Q- and X-band in the temperature range form 1.5 K to 4.2 K. Figure 2 shows a fine structure spectrum in Q-band at 1.5 K with $H_0 \parallel [100]$. Using the spin Hamiltonian for tetragonal symmetry

$$\mathscr{H} = \beta \, . \, H \, . \, \tilde{g} \, . \, S + \frac{1}{3} D \, . \, O_2^{\circ} + \frac{1}{120} B \, . \, O_4^{\circ} + \frac{1}{24} a \, . \, O_4^4$$

yields the following parameters:

$g_x = g_y = 1.985 \pm 0.01$; $g_z = 2.003 \pm 0.01$; $D = -2.722 \pm 0.01$ GHz
$a = +0.179 \pm 0.005$ GHz; $B = +0.086 \pm 0.01$ GHz.

The calculated and measured angular dependence of the fields for resonance for the seven fine structure lines in Q-band is plotted in figure 3. The Boltzmann population factors reduce the number of the observable resonance lines at the Q-band whereas at X-band all the transitions can be observed.

The linewidths of all transitions broaden linearly with temperature. The slopes b and the residual widths a are given in table 1.

A more elaborate work, including the discussion of our results with the theory of Plefka [1] or Barnes [2], will be published.

TABLE 1

Measured residual widths a and slopes b

$\Delta H = a + b.T\,;\ H_\circ \parallel [100]$

		$-7/2 \leftrightarrows -5/2$	$-5/2 \leftrightarrows -3/2$
$x = 0.005$	*a*	100 Gauss	160 Gauss
	b	14.0 ± 5 Gauss/deg	15.0 ± 5 Gauss/deg
$x = 0.01$	*a*	205 Gauss	240 Gauss
	b	13.5 ± 5 Gauss/deg	9 ± 5 Gauss/deg

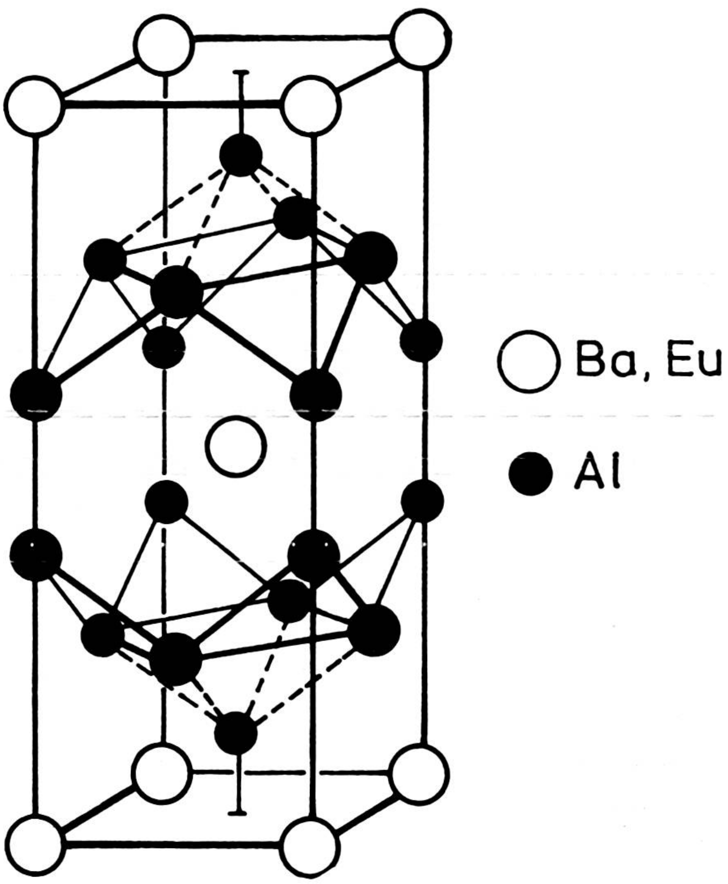

FIG. 1. — The unit cell of $BaAl_4$

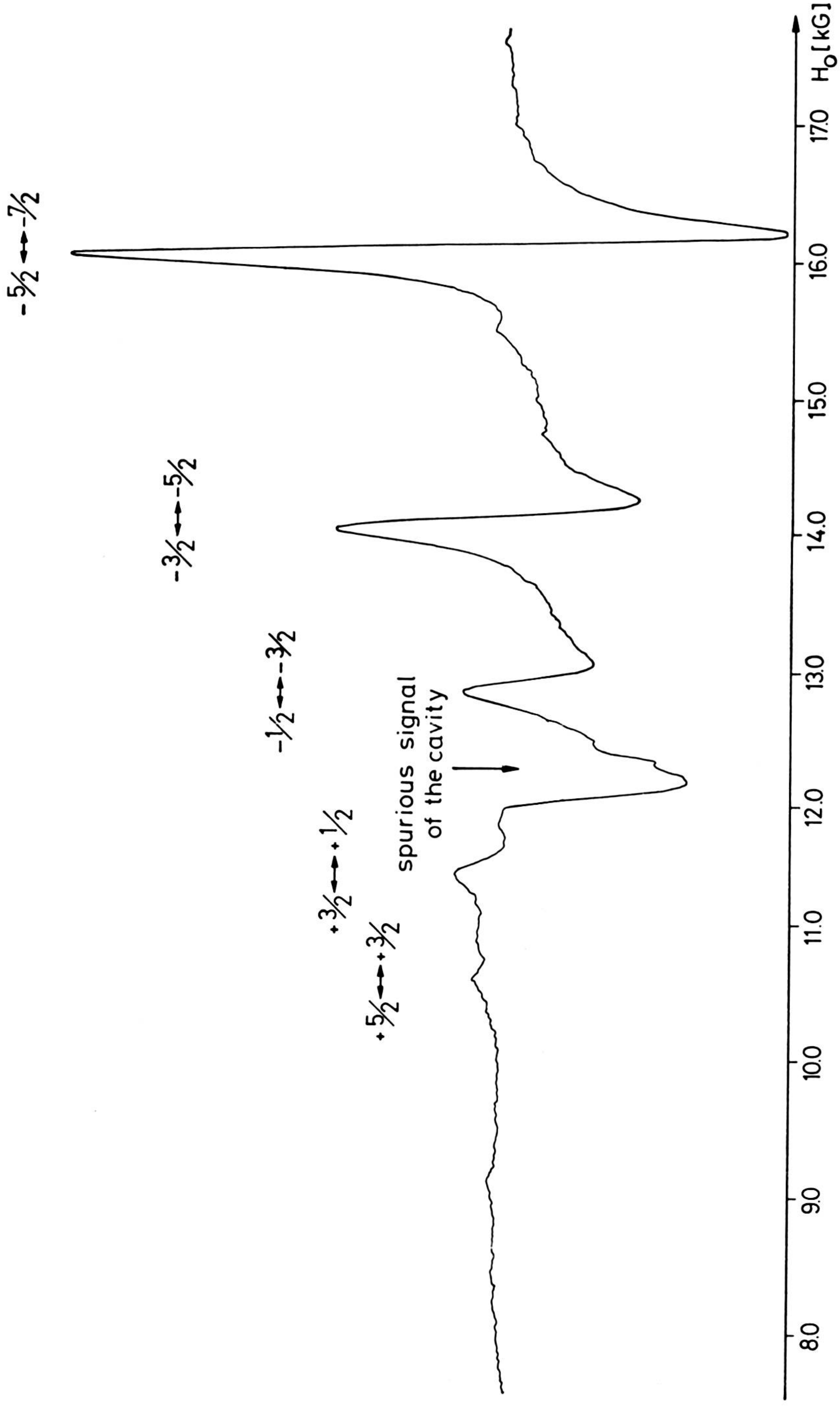

FIG. 2. — Fine structure spectrum of $Eu_{0.005}Ba_{0.995}Al_4$
$H_\circ$ || [100] ν = 34.78 GHz; T = 1.5 K

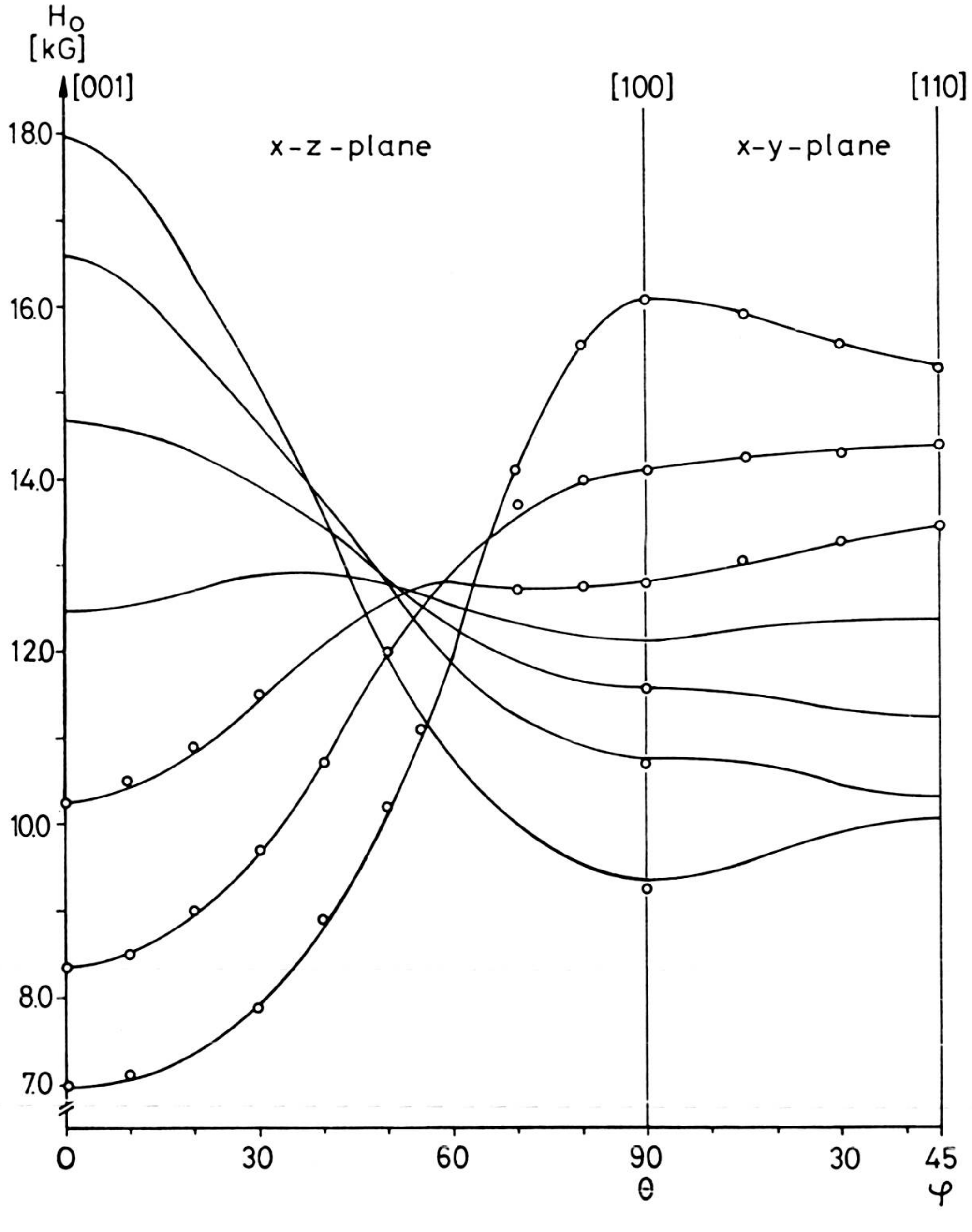

FIG. 3. — Angular dependence of the fields for resonance for the seven fine structure lines $\nu = 34.78\ GHz$; Θ = angle (H_o, z); φ = angle (H_o, x)

——— calcultated
○ ○ ○ measured

REFERENCES

[1] T. Plefka. Phys. stat. sol. (b) *55*, 129 (1973).
[2] S. E. Barnes, Phys. Rev., *B9*, 4789 (1974).

DISCUSSION

Shaltiel: Did you see any effects of hopping by turning the magnetic field so that the lines become closer together ? May be there you should see hopping effects where the line becomes much narrower than it should be if you take the convulution of each separate line. Did you see such effects ?

Elschner: No, but we cannot see any hyperfine structure. This is, I think, collapsed.

Orbach: I thought that the hyperfine splitting was less than the linewidth of the individual fine structure lines. There is another aspect of this and that is that this may be the first example of that intermediate regime where you are between the no bottleneck limit and the completely collasped fine structure limit, where you can still resolve the individual fine structure lines and be in the bottleneck régime. Then the temperature dependence of the linewidth is not the same as you would get if there were no bottleneck present. There is a slight alteration in the slope of the linewidth due to the presence of the bottleneck.

David's comment is that as you rotate the magnetic field the lines get together, when all of a sudden they go woomph, and that would be very interesting; but that did not happen ?

Elschner: No.