DE HAAS–VAN ALPHEN EFFECT AND METAMAGNETIC TRANSITION IN $GdIn_3$*

Z. Kletowski

W. Trzebiatowski Institute of Low Temperature and Structure Research
Polish Academy of Sciences
P.O. Box 1410, 50-950 Wrocław, Poland

and A. Tal

Van der Waals–Zeeman Institute, University of Amsterdam
Valckenierstraat 65, 1018 XE Amsterdam, The Netherlands

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The de Haas van Alphen effect was investigated in the antiferromagnatic compound $GdIn_3$. A number of Fermi surface branches were observed. The list of the all detected frequencies and related cyclotron masses is given. The anisotropy of the critical field connected with the observed metamagnetic transition was measured. The angular dependence of this anisotropy shows that magnetic moment alignment in $GdIn_3$ is probably tilted by 5 degree from the [111] direction.

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The intermetallic compound $GdIn_3$ is an antiferromagnetic system crystallising in the $AuCu_3$ type of crystal structure. Its Néel temperature of 45 K is the highest one among compounds of the $REIn_3$ series (RE=rare earth) for which the salient features such as Kondo effect, magnetic moment formation, crystal field effects or multiaxial magnetic structures are observed. Although, $GdIn_3$ is one of the simplest magnetic system among this series, due to a good localisation of the half-filed $4f$ shell and the $L = 0$ state of the Gd^{+3} ion, its magnetic properties have not been recognised well till now. Magnetisation and de Haas–van Alphen (dHvA) effect measurements performed in fields up to 14 T [1] proved that the magnetisation of

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$GdIn_3$ is linear in the magnetic field along the principal crystallographic axes and that its Fermi surface is similar to that observed in the nonmagnetic $LaIn_3$. No data on the magnetic structure of this compound have been available till now. Some light have been thrown on this subject by studies of the temperature dependence of the ^{119}Sn Mössbauer spectra across the series of pseudobinary $Gd(Sn_{1-x}In_x)_3$ alloys. For the alloy with $x = 0.98$ this studies [2] suggested a magnetic moment alignment close to the (111) plane. The last observation was recently confirmed in by the magnetisation and longitudinal megnetoresistance measurements of the $GdIn_3$ performed in strong magnetic fields up to 38 T [3]. In addition, they also showed $GdIn_3$ to undergo a metamagnetic transition at the field of about 30 T.

In this paper results of the dHvA effect measurements done in very strong magnetic magnetic fields up to 38 T are reported. The experiment was performed in a pulse magnet installed at the Van der Waals–Zeeman Laboratory, University of Amsterdam. For this purpose single crystals of $GdIn_3$ were grown by crystallisation from molten solution by slow cooling of the melt [4]. The Residual Resistivity Ratio (RRR) of the samples used in our experiment was equal 75.

A number of frequencies and Fermi surface branches were observed. Only about half of the detected frequencies coincide with those observed previously [1], however in our experiment, they have been found as slightly shifted along the frequency scale compared to the latter. The remaining frequencies were not observed up to now. This finding suggests that the Fermi surface in the $GdIn_3$ is more complicated than that described in [1].

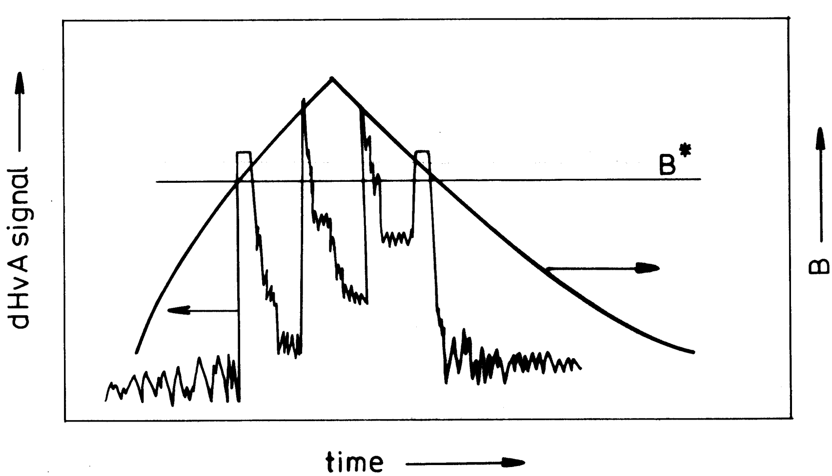

Fig. 1. Time dependence of the magnetic field strength and the dHvA signal. The B (star) is the critical magnetic field of the metamagnetic transition.

Both the amplitude and the frequency of the dHvA oscillations change rapidly when the magnetic field is increased above critical field of the metamagnetic transition, see Fig.1. Then, in the frequency range above 1000 T new strong frequencies appear located close (within 10 degree) to the [111] axis. The list of frequencies and related cyclotron masses detected in the three principal directions is given in Table I. The marked frequencies refer to those which have been observed earlier by Umehara at al. [1]. Since the sharp change in the shape of the dHvA spectra occurs on passing the metamagnetic transition, one could infer from the dHvA data the value of the magnetic field required to induce such a metamagnetic transition. It appears that this magnetic field is anisotropic and data taken in (100) and (110) crystallographic planes are showed in Fig. 2. As seen the metamagnetic transition field varies from 28,1 to 33.0 T. For the three principal crystallographic axes the [100], [110] and [111] values of the metamagnetic field found in this experiment are 32.0, 31.0 and 28.2, respectively. However the minimal value of the metamagnatic transition field of 28.1 T was determined for the field direction deviated by 5 degree with respect to the [111] axis. This means that the magnetic moment alignment is probably not exactly along the [111] direction but it is tilted by 5 degree from this direction.

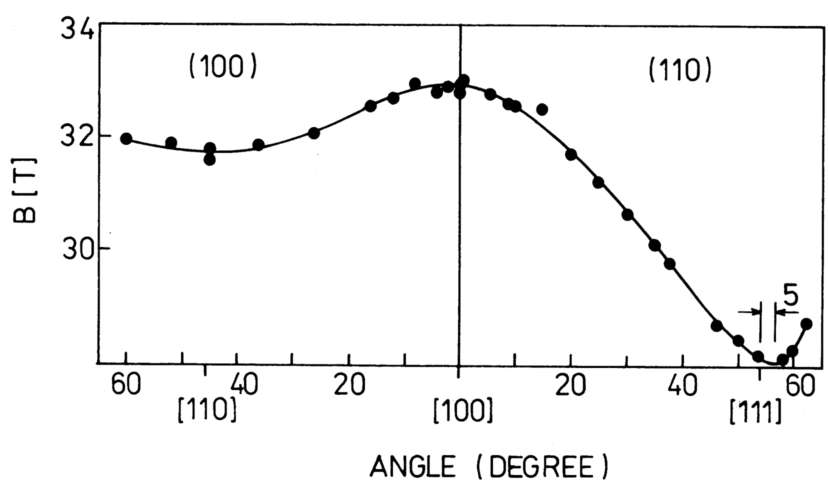

Fig. 2. Angular dependence of the critical field required to induce the metamagnetic transition in $GdIn_3$. The data have been taken in the (100) and (110) crystallographic planes.

TABLE I

List of frequencies and effective masses detected in the three principal directions for the $GdIn_3$.

[100]		[110]		[111]	
Frequency [T]	m_c/m_0	Frequency [T]	m_c/m_0	Frequency [T]	m_c/m_0
3150	0.68				
				2840	0.55
2440	0.80				
1680	–			1720	0.85
1640	–	**1360**	0.4		
1080	0.31	**1280**	0.4	1260	0.74
660	–				
610	–				
580	–	**500**	–	**560**	0.24
440	–	450	–		
410	–	430	–		
390	–				
360	–	**300**	0.42	350	–
280	–			270	–
223	0.35	228	–		
210	0.30				
195	–				
185	0.2	**107**	0.2	**143**	0.26

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