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## Laser induced ultrafast 3d and 4f spin dynamics in CoDy ferrimagnetic alloys as a function of temperature

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1 Title: **Laser induced ultrafast 3d and 4f spin dynamics in CoDy ferrimagnetic alloys as a**  
2 **function of temperature.**

3  
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20  
21 **0. Abstract**

22  
23 We report an element- and time-resolved investigation of femtosecond laser induced  
24 ultrafast dynamics of the Co 3d and Dy 4f spins in a ferrimagnetic Co<sub>80</sub>Dy<sub>20</sub> alloy as a function  
25 of the temperature. We observe that the Co characteristic demagnetization time ( $\tau_{\text{Co}}$ ) remains  
26 nearly constant ( $\sim 0.2$  ps) on increasing the temperature. Conversely, the Dy characteristic  
27 demagnetization time ( $\tau_{\text{Dy}}$ ) decreases from  $\sim 1$  ps to  $\sim 0.4$  ps with the rise of temperature.  
28 Comparing our experimental data with literature shows that  $\tau_{\text{Co}}$  and  $\tau_{\text{Dy}}$  are independent of the  
29 alloy composition or the demagnetization amplitude and that  $\tau_{\text{Dy}}$  scales with the relative  
30 temperature  $T^* = T_{\text{Curie}} - T$ .

31  
32 *Key words:*

33 **Ferrimagnetic alloys, ultrafast laser induced demagnetization, femtosecond laser, time-**  
34 **resolved X-ray Magnetic Circular Dichroism.**

35 Highlights:

- 36 • Element- and time-resolved investigation of laser induced ultrafast Co3d and Dy4f spin  
37 dynamics in a ferrimagnetic CoDy amorphous alloy as a function of temperature.  
38
- 39 • The Co characteristic demagnetization time remains nearly constant (~0.2 ps) on  
40 increasing the temperature while the Dy characteristic demagnetization time decreases  
41 from ~1 ps to ~0.4 ps with the rise of temperature.  
42

43 **1. Introduction**

44

45 Excitation of ferromagnetic layers with infra-red (IR) femtosecond (fs) laser pulses leads to  
46 a quenching of the magnetic order on a sub-picosecond time scale [1]. The microscopic  
47 mechanisms governing this ultrafast demagnetization are still subject to controversy in spite of  
48 intensive experimental and theoretical studies [2 - 8]. Although these investigations have  
49 revealed fundamental dissimilarities in the laser induced ultrafast magnetization dynamics in  
50 transition metals (TM) [1, 9 - 11] and in rare-earth (RE) films [12 - 16], a few general features  
51 were established. For instance, a rise in temperature results in an increase of the characteristic  
52 quenching times ( $\tau$ ) of the 3d magnetic order in pure transition metals (TM) and 5d magnetic  
53 order in pure rare-earth (RE) films [11, 13, 17]. In the specific case of pure RE layers, such  
54 behaviour is also expected for the localized 4f spins as theoretically predicted [13] and sustained  
55 by experiments that have evidenced concomitant laser induced dynamics of the 5d and 4f spins  
56 [12 - 14, 16, 18]. In these experiments, the IR fs laser pulses excite the RE 5d spins while the  
57 RE 4f spin dynamics is indirectly triggered via the 5d-4f intra-atomic exchange coupling [12,  
58 14].  
59

60 In RE-TM ferrimagnetic alloys, the RE 4f spin order originates from the Ruderman-Kittel-  
61 Kasuya-Yosida (RKKY) exchange coupling [19]. The RE 4f – RE 4f indirect exchange coupling  
62 is mediated by the RE 5d as well as the TM 3d electrons in the conduction band [20].  
63 Interestingly, the published element- and time-resolved experiments have reported distinct laser  
64 induced ultrafast dynamics for the TM 3d and RE 4f spins in spite of this RKKY exchange  
65 coupling [21 – 30]. Recently, the Landau-Lifshitz-Bloch (LLB) model [13, 17] was extended  
66 to treat the laser induced ultrafast dynamics in multi-sublattices ferrimagnetic alloys [31] such  
67 as FeCoGd [32], CoTb [33] and FeTb [34] alloys. The calculations based on this modified LLB

68 model have shown that the characteristic demagnetization times of both the FeCo ( $\tau_{\text{FeCo}}$ ) and  
69 the Gd ( $\tau_{\text{Gd}}$ ) sublattices in FeCoGd alloys strongly depend on the difference between the initial  
70 temperature (T) and the Curie temperature ( $T_{\text{Curie}}$ ) of the alloy [32]. This theoretical work  
71 highlights explicitly the differences between the ultrafast laser induced TM 3d and the RE 4f  
72 spin dynamics in these alloys with the variation of the temperature [32]. Hennecke et al. have  
73 invoked the effect of temperature to explain the short Gd demagnetization time they have  
74 evidenced in a FeCoGd alloy [30]. Ferté et al. have earlier investigated the laser induced  
75 demagnetization in  $\text{Co}_{80}\text{Dy}_{20}$  and  $\text{Co}_{78}\text{Dy}_{22}$  alloys at different initial temperatures but ensuring  
76 a constant relative temperature  $T_{\text{Curie}} - T$  [27]. They have shown that the response of the Dy  
77 (resp. Co) magnetization to laser excitation was the same for both alloys in line with the LLB  
78 calculations. The distinct dynamics of 3d and 4f spins is believed to be the key ingredient for  
79 ultrafast all optical switching [21, 35] as well as ultrafast spin-transfer torque assisted switching  
80 [36] in RE-TM alloys. Thus, it is of paramount importance to determine the correlation between  
81 the characteristic demagnetization times and physical parameters such as the temperature.  
82 However, systematic element- and time-resolved investigations of laser induced spin dynamics  
83 in a single RE-TM alloy as a function of temperature are still lacking.

84

85 In this work, we have studied the laser induced ultrafast dynamics of Co3d and Dy4f spins  
86 in a  $\text{Co}_{80}\text{Dy}_{20}$  ferrimagnetic alloy as a function of temperature by mean of time-resolved X-Ray  
87 Magnetic Circular Dichroism (tr-XMCD) [37]. Interestingly, we report experimental evidences  
88 that the dependence of the laser induced dynamics of Co 3d and Dy 4f spins on temperature are  
89 clearly different. We observe that  $\tau_{\text{Co}}$  remains nearly constant ( $\sim 0.2$  ps) while  $\tau_{\text{Dy}}$  decreases from  
90  $\sim 1$  ps to  $\sim 0.4$  ps when the temperature rises from 160K to 350K. Furthermore, a comparison of  
91 our experimental data with existing data from literature on laser induced ultrafast dynamics of  
92 Dy 4f spins in CoDy alloys [25, 27] suggests that  $\tau_{\text{Dy}}$  is determined by  $T^* = T_{\text{Curie}} - T$ .

93

## 94 **2. Material and methods**

95

96 The 18 nm thick  $\text{Co}_{80}\text{Dy}_{20}$  alloy layer was deposited by DC magnetron sputtering on a “heat  
97 sink” Ta(3)/Cu(20)/Ta(3) multilayer sustained by a  $\text{Si}_3\text{N}_4$  membrane. The alloy was capped with  
98 a Al(3)/Ta(3) bi-layer to prevent oxidation. The  $\text{Co}_{80}\text{Dy}_{20}$  alloy displays an out-of-plane  
99 magnetic anisotropy. We have recorded hysteresis loops at various temperatures using SQUID  
100 magnetometry to extract the dependence of the coercive field ( $H_C$ ) on temperature. For these

101 measurements, we have used a test  $\text{Co}_{80}\text{Dy}_{20}$  alloy layer deposited simultaneously with the one  
102 used for the time-resolved experiments but on a Si substrate (figure 1). This figure shows a  
103 divergence of  $H_C$  in the vicinity of  $T \sim 250\text{K}$  indicating the temperature of magnetic  
104 compensation [38, 39].

105

106 The tr-XMCD experiments were carried out at the femtoslicing beam line of the BESSY II  
107 synchrotron radiation source at the Helmholtz-Zentrum Berlin [37]. The magnetization  
108 dynamics have been measured by monitoring the transmission of circularly polarized X-ray  
109 pulses tuned to specific core level absorption edges as a function of a pump-probe delay for two  
110 opposite directions of the magnetic field. The photon energy was set to the  $\text{CoL}_3$  and the  $\text{DyM}_5$   
111 edges using a reflection zone plate monochromator on UE56/1-ZPM. The full width at half  
112 maximum (FWHM) of the 800nm pump laser was set to  $500 \mu\text{m}$  to ensure homogeneous  
113 pumping over the probed area of the sample (FWHM  $\sim 200 \mu\text{m}$ ). A magnetic field of  $\pm 0.55 \text{ T}$   
114 was applied along the propagation axis of both the IR laser and the X-ray beam during the  
115 experiment. The measurements were carried out at  $T^* = 350 \text{ K}$  (configuration 1),  $400 \text{ K}$   
116 (configuration 2) and  $540 \text{ K}$  (configuration 3) with  $T^* = T_{\text{Curie}} - (T_{\text{cryo}} + \Delta T)$  as illustrated in  
117 figure 2. Here,  $T_{\text{cryo}}$  is the temperature of the cryostat and  $\Delta T$  is the temperature elevation due  
118 to the continuous laser heating (table 1). The Curie temperature of the  $\text{Co}_{80}\text{Dy}_{20}$  alloy ( $T_{\text{Curie}} =$   
119  $700 \text{ K}$ ) is extrapolated from literature [40] and from mean field calculations [41, 42]. As only  
120 one single sample was used in this experiment, any small error on the estimated value of  $T_{\text{Curie}}$   
121 would shift  $T^*$  without affecting our conclusions. We have determined that the coercive field  
122 of the  $\text{Co}_{80}\text{Dy}_{20}$  alloy was below  $0.55 \text{ T}$  either below  $160 \text{ K}$  or above  $300 \text{ K}$  by monitoring the  
123 XMCD amplitude as a function of temperature. The divergence of  $H_C$  between  $160 \text{ K}$  and  $300$   
124  $\text{K}$  is related to  $T_{\text{comp}} \sim 250 \text{ K}$  as illustrated in figure 1. As a consequence, the experimental  
125 parameters, such as the pump laser powers ( $P$ ) and  $T_{\text{cryo}}$ , have been chosen so that  $T_{\text{cryo}} + \Delta T$   
126 stay in the temperature ranges that allow for magnetic saturation of our alloy. We have relied  
127 on the thermal variation of the coercive field to determine  $\Delta T$  for the two different pump laser  
128 powers ( $P = 17$  and  $50 \text{ mW}$ ) that we have used during the experiment. To do so, we initially set  
129  $T_{\text{cryo}} = 80 \text{ K}$  and turned on the laser.  $P = 17 \text{ mW}$  was the largest laser power for which  $T_{\text{cryo}} +$   
130  $\Delta T$  stays below  $T = 160\text{K}$ . Above this temperature, the CoDy alloy could not be saturated. As a  
131 consequence, we estimated that  $\Delta T \sim 80 \text{ K}$  for  $P = 17\text{mW}$ . In order to estimate  $\Delta T$  with  $P = 50$   
132  $\text{mW}$ , we compared the hysteresis loops at  $T_{\text{cryo}} = 300$  and  $320 \text{ K}$  with  $P = 0 \text{ mW}$  to the hysteresis  
133 loops recorded at negative delay for  $T_{\text{cryo}} = 80\text{K}$  with  $P = 50 \text{ mW}$  (figure 3). The same signs of  
134 the hysteresis loops indicate that these measurements were performed above  $T_{\text{comp}}$ . Moreover,

135 we notice that the coercive field is smaller for  $P = 50\text{mW}$  and  $T_{\text{cryo}} = 80\text{K}$  compared to  $P = 0$   
136  $\text{mW}$  and  $T_{\text{cryo}} = 300$  and  $320$  K. According to the thermal variation of the saturation field above  
137  $T_{\text{comp}}$  (figure 1), we estimated that  $T_{\text{cryo}} + \Delta T$  is above  $320\text{K}$  for  $P = 50\text{mW}$  and  $T_{\text{cryo}} = 80\text{K}$ .  
138 The shape of the hysteresis loop at  $P = 50\text{mW}$  and  $T_{\text{cryo}} = 80\text{K}$  also indicates that we are close  
139 to the temperature of spin reorientation transition [43]. As a consequence, we estimated  $\Delta T >$   
140  $250$  K for  $P = 50$  mW. Our procedure to estimate  $\Delta T$  results in significant error bars on  $T^*$   
141 (figure 5). Nevertheless, we estimated that we performed the time-resolved experiments at  $T^*$   
142  $= 350$  K,  $400$  K and  $540$  K (figure 2, table 1). The measurements were carried out above  $T_{\text{comp}}$   
143 for the configurations 1 and 2 (figure 2a and b) and below  $T_{\text{comp}}$  for the configurations 3 (figure  
144 2c) [27].

145

### 146 **3. Experimental results and discussion**

147

148 The normalized transient XMCD signals recorded at the Co  $L_3$  and Dy  $M_5$  edges for  $T^* =$   
149  $350$ ,  $400$  and  $540$  K are displayed in figure 4a, b and c respectively. At  $T^*=540\text{K}$  (figure 4c),  
150 the maximum demagnetization of the Co sublattice is reached while the demagnetization of the  
151 Dy sublattice has barely started as reported in a large number of element- and time-resolved  
152 experiments for different RE-TM alloys [21 - 27]. In contrast, at  $T^* = 350\text{K}$  (figure 4a), the  
153 magnetization of the Dy sublattice is close to its minimum value while the minimum  
154 magnetization of the Co sublattice is reached. The tr-XMCD curves at the Co  $L_3$  edges were  
155 fitted with two exponential functions (respectively the demagnetization and the magnetization  
156 recovery) convoluted with a Gaussian function which account for the experimental time  
157 resolution ( $130$  fs) [24, 44, 45]. It is worth noticing that we have imposed a lower limit at  $130$   
158 fs for the characteristic demagnetization times during the fitting procedure. It means that the  
159 actual  $\tau_{\text{Co}}$  is possibly below the experimental time resolution for  $T^* = 400$  K and  $540\text{K}$ . The tr-  
160 XMCD curves at the Dy  $M_5$  edge were adjusted by a single exponential decay convoluted by a  
161 Gaussian function since we did not observe any recovery on the recorded time range. We have  
162 extracted the characteristic demagnetization times ( $\tau$ ) from these fits as well as their error bars,  
163 which correspond to one standard deviation (table 1). The dependence of the characteristic  
164 demagnetization times on temperature for both sublattices are displayed in figure 5. We also  
165 report the characteristic demagnetization times for the Co and Dy sublattices in various CoDy  
166 alloys measured by Ferté et al (in  $\text{Co}_{80}\text{Dy}_{20}$  and  $\text{Co}_{78}\text{Dy}_{22}$ ) [27] and Radu et al (in  $\text{Co}_{83}\text{Dy}_{17}$ )  
167 [25] in figure 6. Ferté et al have explicitly given the numerical values for  $T_{\text{cryo}}$ ,  $T_{\text{Curie}}$  and  $\Delta T$

168 [27] and therefore we have derived  $T^* = 430$  and  $450\text{K}$  for the  $\text{Co}_{80}\text{Dy}_{20}$  and  $\text{Co}_{78}\text{Dy}_{22}$  alloys  
 169 respectively. Radu et al have performed their measurements at  $T = 100\text{K}$  without considering  
 170 any DC heating. Therefore, we assume  $\Delta T = 0\text{K}$  and we include an extended error bar for this  
 171 data. It is worth noticing that including a temperature elevation of  $\Delta T \sim 100\text{-}200\text{ K}$  (typical  
 172 values estimated for the pump-probe experiments on thin films) will not change our main  
 173 message. Thus, we derived  $T^*=930\text{K}$  since  $T_{\text{Curie}} = 1030\text{K}$  for their  $\text{Co}_{83}\text{Dy}_{17}$  alloys [43].

174

175 *Table 1: Characteristic demagnetization times extracted from the fit functions as a function of*  
 176 *temperature  $T^*$ . The cryostat temperature ( $T_{\text{cryo}}$ ), the laser continuous heating ( $\Delta T$ ), the laser*  
 177 *power and the X-ray absorption edges are also recalled.*

$T^*$ (K)	$T_{\text{Cryo}}$ (K)	$\Delta T$ (K)	Laser power (mW)	Edge	Demagnetization time $\tau$ (fs)
540	80	80	17	Co $L_3$	$130 \pm 100$
540	80	80	17	Dy $M_5$	$980 \pm 200$
400	220	80	17	Co $L_3$	$130 \pm 60$
400	220	80	17	Dy $M_5$	$570 \pm 90$
350	80	> 250	50	Co $L_3$	$212 \pm 25$
350	80	> 250	50	Dy $M_5$	$400 \pm 100$

178

179 In figure 5, we observe that  $\tau_{\text{Co}}$  is almost constant within the error bars between  $T^* =$   
 180  $350\text{ K}$  and  $T^* = 540\text{K}$  in spite of the various laser powers used, and thus the different  
 181 demagnetization amplitudes, in line with previous work by Jal et al [46]. We also observe a  
 182 clear decrease of  $\tau_{\text{Dy}}$  when  $T^*$  decreases from  $540\text{K}$  to  $350\text{K}$  (figure 5). In pure Gd layers, the  
 183 characteristic demagnetization time  $\tau_{\text{Gd}}$  related to the (5d, 6s) magnetic order increases when  
 184 the laser power is increased [13, 16]. The concomitant quenching of itinerant (5d, 6s) and  
 185 localized 4f magnetic order in pure RE layers [12 - 16, 18, 47] suggests that such an increase is  
 186 also expected for the 4f spins. However, such a behavior is not observed in our CoDy alloy  
 187 since the shorter demagnetization time ( $\tau_{\text{Dy}}$ ) is obtained for the larger laser power ( $P = 50\text{mW}$ )  
 188 and thus also for the larger demagnetization amplitude. Therefore, we can rule out the distinct  
 189 laser power as the origin of the measured variation of  $\tau_{\text{Dy}}$  with temperature. Gang et al. have  
 190 reported a decrease of the Ni 3d characteristic demagnetization time in NiPd ferromagnetic

191 alloys when the Curie temperature is reduced (and thus  $T^*$ ) by increasing the Pd concentration  
192 [48]. They have attributed such feature to an increase of the spin-flip scattering probability [2]  
193 with Pd content, caused by its larger spin-orbit coupling compared to pure Ni. In our case, this  
194 explanation does not hold since we have studied a single alloy composition. According to the  
195 LLB calculations in ferrimagnets [32], by increasing the temperature, we would expect to go  
196 from a situation in which  $\tau_{TM} < \tau_{RE}$  at low temperatures ( $T \ll T_{Curie}$ ) to a situation in which  $\tau_{TM}$   
197  $\sim \tau_{RE}$  at higher temperatures ( $T > 0.8 T_{Curie}$ ). The transition between these dynamical regimes  
198 requires that  $\tau_{Dy}$  decreases and/or  $\tau_{Co}$  increases in the intermediate temperature range. Our  
199 experimental findings are thus consistent with this LLB prediction but call for further  
200 experiments at even higher temperatures, especially in the vicinity of  $T_{Curie}$  to challenge further  
201 their predictions.

202

203 Two qualitative descriptions can be proposed to explain the different temperature  
204 dependent evolution of  $\tau_{Co}$  and  $\tau_{Dy}$ . The first one considers that different microscopic  
205 mechanisms are supposed to be responsible for the laser induced ultrafast quenching of Co 3d  
206 and Dy 4f magnetic orders. Indeed, the dynamics of TM 3d spins is presumably caused by spin-  
207 flip scattering [49 - 51] and superdiffusive spin transport [3, 52] while the dynamics of the RE  
208 4f spins is claimed to be related to spin-waves [53 - 55]. The second one considers that the Co  
209 3d spin dynamics is mainly governed by the direct ferromagnetic Co – Co exchange coupling  
210 while the Dy 4f spin dynamics is mainly governed by the indirect antiferromagnetic Co – Dy  
211 exchange coupling. Recent measurements have shown that antiferromagnetic and  
212 ferromagnetic materials exhibit distinct laser induced ultrafast dynamics [56].

213

214 Finally, in figure 6, we compare our experimental results with existing data from the  
215 literature [31, 33] by plotting  $\tau_{Co}$  and  $\tau_{Dy}$  as a function of  $T^*$  for different alloy compositions.  
216 We observe that  $\tau_{Co}$  and  $\tau_{Dy}$  are both constant (within error bars) from  $T^* = 930$  K to  $T^* = 540$   
217 K. From  $T^* = 540$  K to  $T^* = 350$  K, we observe that  $\tau_{Co}$  is constant while  $\tau_{Dy}$  decreases,  
218 confirming our experimental results from figure 5. It is also very interesting to note that the  $\tau_{Dy}$   
219 extracted from the work of Ferté et al. are consistent with our present results for similar  $T^*$   
220 although in their case the demagnetization amplitudes were larger than 80%. It suggests that  
221  $\tau_{Dy}$  does not depend on the demagnetization amplitude but mainly on  $T^* = T_{Curie} - T$ .

222

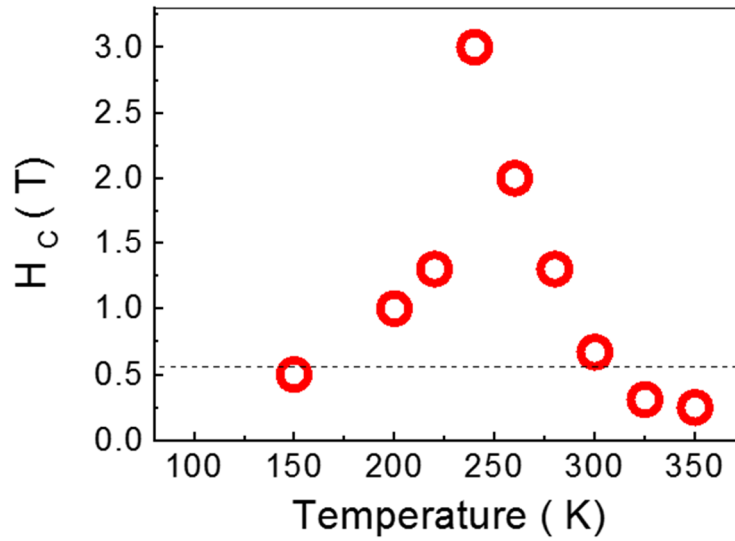
223 **4. Conclusions**



224

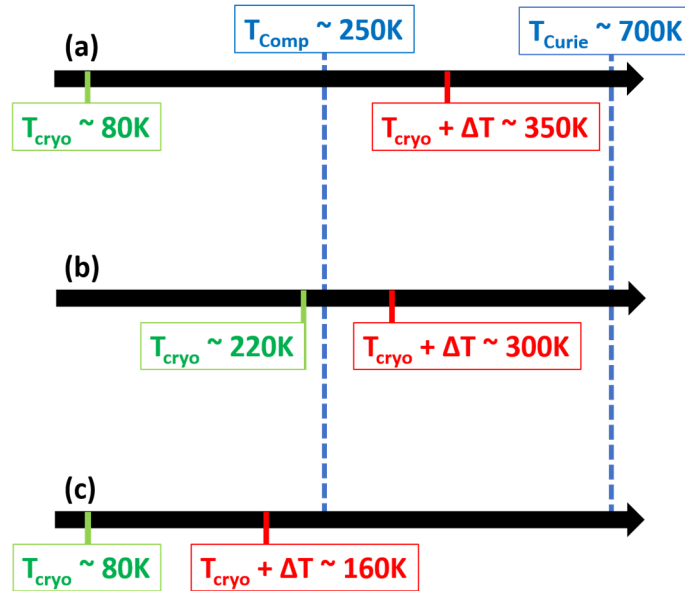
225        We have investigated the laser induced ultrafast dynamics of Co 3d and Dy 4f spins in a  
226 ferrimagnetic CoDy alloy as a function of temperature by element- and time-resolved XMCD.  
227 We have revealed striking differences between the Co 3d and Dy 4f spin dynamics when the  
228 temperature is varying from 160 K to 350K. The characteristic demagnetization time of the  
229 Dy4f sublattice decreases while it is almost constant for the Co3d sublattice. This experimental  
230 findings sustain some of the predictions of the LLB model, namely that the characteristic  
231 demagnetization time of the RE sublattice should be smaller than that of the TM sublattice at  
232 high temperature. Our experimental results also confirm that the characteristic demagnetization  
233 time of the Co sublattice does not depend on the composition, on the demagnetization amplitude  
234 nor on the temperature in CoDy alloys as reported by Jal et al [46]. Finally, our data set,  
235 amended with data extracted from literature, suggest that the characteristic demagnetization  
236 time of the Dy sublattice is determined by  $T^* = T_{\text{Curie}} - T$  and does not depend on the  
237 demagnetization amplitude or alloy composition. Our work calls for further experimental  
238 investigations at elevated temperatures to challenge the predictions of the LLB model for spin  
239 dynamics in RE-TM alloys, especially in the vicinity of  $T_{\text{Curie}}$ . Such experimental confirmation  
240 would link the characteristics of laser induced ultrafast dynamics and the static magnetic  
241 properties of ferrimagnetic alloys [32]. We hope this work will motivate further experimental  
242 investigation at elevated temperatures as well as development of the LLB model to  
243 ferrimagnetic alloys [57].

244  
245 **Figures:**

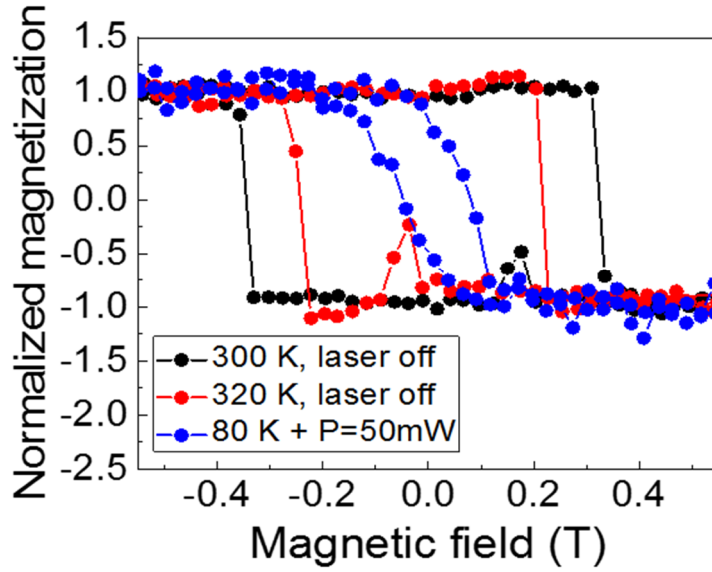


246  
247  
248 *Figure 1: Dependence of the coercive field ( $H_C$ ) on the temperature for a  $Co_{80}Dy_{20}$  alloy measured by means of*  
249 *SQUID magnetometry (red empty circles).  $H_C$  diverges in the vicinity of  $T \sim 250K$  defining the temperature of*  
250 *magnetic compensation ( $T_{comp} \sim 250K$ ). The horizontal dotted line corresponds to  $H = 0.55 T$  which is the maximum*  
251 *magnetic field available on the femtoslicing end-station [37]. The  $Co_{80}Dy_{20}$  alloy layer used for SQUID*  
252 *measurements was deposited simultaneously with the one used for the time-resolved experiments deposited on*  
253 *transparent SiN membrane.*

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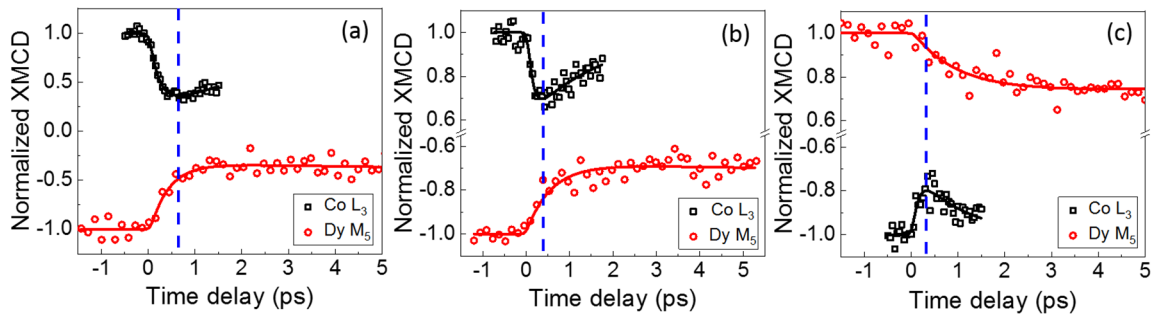


255  
256  
257 *Figure 2: Sketch of the experimental conditions to achieve our different relative temperatures  $T^* = T_{Curie} - (T_{cryo} -$*   
258  *$\Delta T) = 350K$  (a),  $400K$  (b) and  $540K$  (c).*



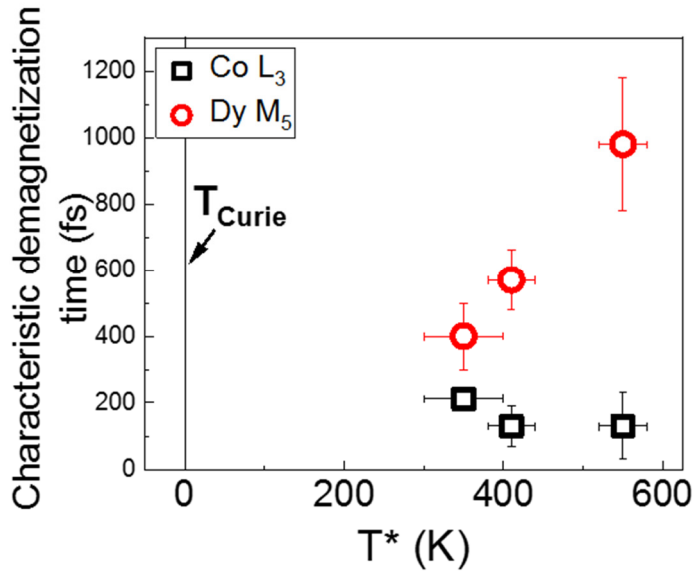
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Figure 3: Hysteresis loops recorded by monitoring the X-ray transmission at the Dy  $M_5$  absorption edge as a function of the magnetic field. The experimental configurations were  $P = 0mW$  and  $T_{cryo} = 300K$  (black circles),  $P = 0mW$  and  $T_{cryo} = 320K$  (red circles) and  $P = 50mW$  and  $T_{cryo} = 80K$  (black circles).



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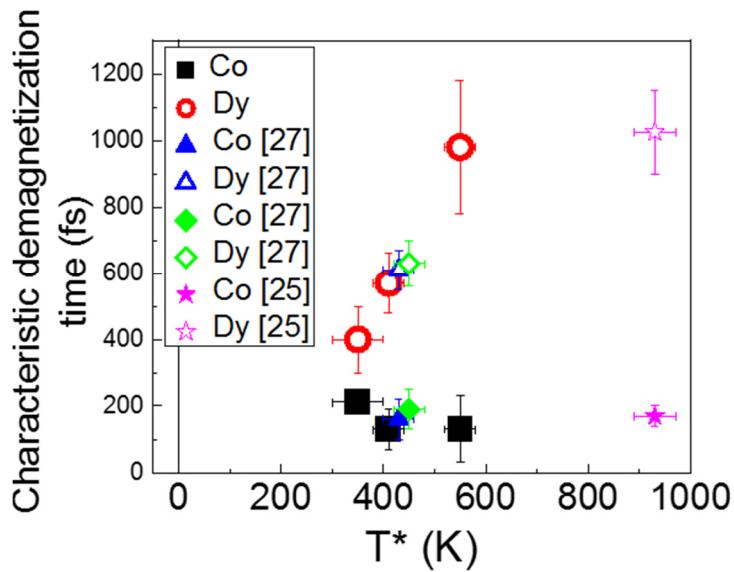
Figure 4: Transient XMCD at the Co  $L_3$  (black squares) and Dy  $M_5$  (red circles) edges as a function of the pump – probe delay measured at  $T^* = 350 K$  (a),  $400 K$  (b) and  $540 K$  (c). The solid lines are the fitting functions. The vertical blue dotted lines denote the delay at which the magnetization of the Co sublattices reaches the minimal value.



269

270 *Figure 5: Characteristic demagnetization times for Co (black squares) and Dy (red circles) sublattices as a*  
 271 *function of  $T^*$ . The error bars on the characteristic demagnetization times is given by the standard deviation from*  
 272 *the fitting function. The error bars on the temperature were experimentally estimated (details in the text).*

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274

275 *Figure 6: Characteristic demagnetization times for Co (filled symbols) and Dy (open symbols) sublattices as a*  
 276 *function of  $T^*$ . We report our experimental results (black squares and red circles) superposed to published data*  
 277 *extracted from element and time-resolved experiments performed on  $Co_{80}Dy_{20}$  (filled and empty blue triangles)*  
 278 *[27],  $Co_{78}Dy_{22}$  (filled and empty green lozenges) [27] and  $Co_{83}Dy_{17}$  (filled and empty magenta stars) [25].*

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280

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