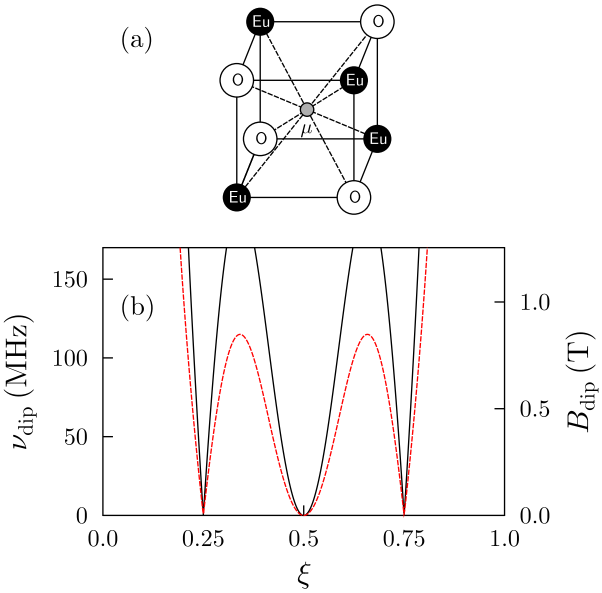

FIG. 2: (Color online.) (a) Muon site in EuO. The crystal structure for one-eighth of the unit cell is shown (the side of the cube is $a/2$). (b) Calculated dipole field along the $\langle 111\rangle$ axes in EuO. The muon is located at $\xi\xi\xi$ and the Eu moments are all aligned along [111] (solid black line) or one of $[\bar{1}11]$, $[1\bar{1}1]$ or $[11\bar{1}]$ (dashed red line).

$\frac{1}{4}\frac{1}{4}\frac{1}{4}$ position in which the dipolar field is zero, so that the observed local field ($B_\mu = 0.22\,\mathrm{T}$ at $T = 0$) is due to a sum of the Lorentz field ($B_\mathrm{L} = \mu_0 M/3 = 0.80\,\mathrm{T}$ at $T = 0$), B_demag and B_hf. Since the sample is polycrystalline and multidomain, we neglect B_demag and deduce that the hyperfine field $B_\mathrm{hf} < 0$ (antiparallel to the magnetization), as found for EuS [22], and takes the value $B_\mathrm{hf} = -B_\mathrm{L} \pm B_\mu$, and so either -0.58 or $-1.02\,\mathrm{T}$. For both samples, the amplitude of the oscillatory component is reduced from the full value at low temperature [see Fig. 1(a,b)], but recovers on warming towards T_C, so a fraction of muons may implant in some additional state which depolarizes the muon very rapidly.

We note that a recent experiment [23] on SmS has shown evidence for the formation of a bound magnetic polaron consisting of an electron around the implanted muon, in which the electron localization is stabilised by exchange energy. This occurs in the paramagnetic state in which a ferromagnetic droplet is localized in the paramagnetic host. A similar effect has been noted in EuS [24] although the larger magnetization ensures it occurs at temperatures $\gg T_\mathrm{C}$ [25] and the same will be true in EuO in which the magnetization is even larger. Therefore such a muon-related polaron is not relevant for EuO in the studied temperature regime.

The temperature dependence of the precession frequency for both EuO and $Eu_{0.994}Gd_{0.006}O$ was followed near T_C and the results are plotted in Fig. 3. The fitted

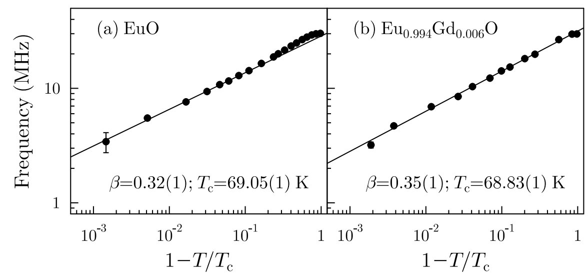

FIG. 3: Precession frequency extracted from μSR data as a function of temperature close to T_C for (a) EuO and (b) $Eu_{0.994}Gd_{0.006}O$.

values of T_C and the critical exponent β are similar in each case, though the value of β is quite sensitive to the precise value taken for T_c. Due to the difficulty in stabilising the temperature better than $\approx 10\,\mathrm{mK}$, we do not believe that the difference between the two values of β is significant. They are both close to 0.36–0.37 obtained using neutron scattering [26] and 0.38 obtained from a second order ϵ expansion for the Heisenberg ferromagnet with dipolar interactions [27].

Above T_C, we observe simple exponential relaxation [Fig. 1(a,b)] with a relaxation rate λ. For zero-field relaxation of muons initially polarized parallel to z, λ can be written in terms of field-field correlation functions using $\lambda = \frac{\gamma_\mu^2}{2}\int_{-\infty}^{\infty}\mathrm{d}t\,\left(\langle B_x(0)B_x(t)\rangle + \langle B_y(0)B_y(t)\rangle\right)$ [18]. When each Eu spin component fluctuates, it produces a field fluctuation via the resulting modulation of the dipolar and hyperfine couplings. Our measurements of the zero-field relaxation rate for the EuO sample are plotted in Fig. 4 (a less complete set of data for the Gd-doped sample is also shown). There is a small rise in λ as the temperature is lowered towards T_C but apart from this λ remains just below $\approx 2\,\mathrm{MHz}$ for both samples across the entire range studied.

These results can be compared with calculations on a localized Heisenberg ferromagnet which have been performed with EuO in mind [15, 16] (Fig. 4). The theory of Lovesey and Engdahl [15] includes only the dipolar coupling and has been evaluated for temperatures above $1.3T_\mathrm{C}$, assuming a muon site of $\frac{1}{4}\frac{1}{4}\frac{1}{4}$. Though underestimating the observed experimental values, this theory does remarkably well in providing a good estimate of the rough size of λ, the discrepancy perhaps being due to neglecting the hyperfine contribution. It is known that critical fluctuations enhance the role of the hyperfine coupling over the dipole coupling [14] because $B_\mathrm{dip} = 0$ at the muon site in the ordered state and the peak in the susceptibility is at $\mathbf{k} = 0$. Nevertheless, when the dipolar calculation is extended into the critical regime (just above, and very close to, T_C) it predicts a divergence in λ which is not observed. An earlier mode-coupling approach [16] also predicts a very sharp increase in λ on