

Direct and indirect estimates of magnetocaloric response in Fe-Mn-Ga alloy



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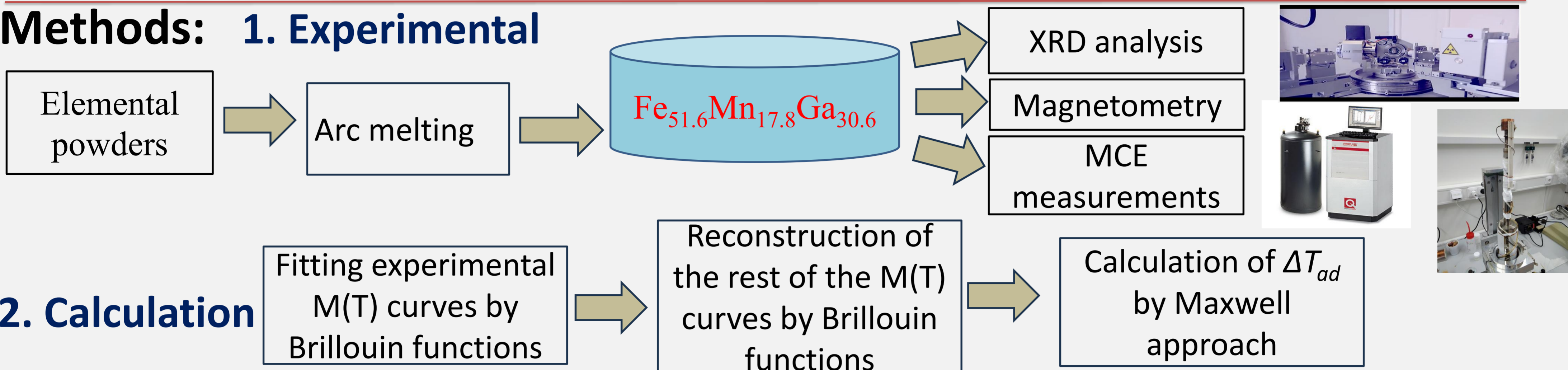
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Introduction: Fe–Mn–Ga shape-memory Heusler alloys have recently attracted attention as candidates for elastocaloric and magnetocaloric refrigeration. A giant negative magnetic entropy change of $\sim 60 \text{ J kg}^{-1} \text{ K}^{-1}$ at 5 T has been reported in Fe–Mn–Ga alloys with B2-type structure, driven by a field-induced antiferromagnetic-to-ferromagnetic transition [H. Yang et al., *Intermetallics* 127, 106975 (2020)]. The present study focuses on the ferromagnetically ordered L2₁ polymorph Fe_{51.6}Mn_{17.8}Ga_{30.6} and evaluates its magnetocaloric potential through combined structural, magnetic, and direct calorimetric measurements, complemented by a Brillouin-function-based indirect calculation scheme.

Methods: 1. Experimental



2. Calculation

Results:

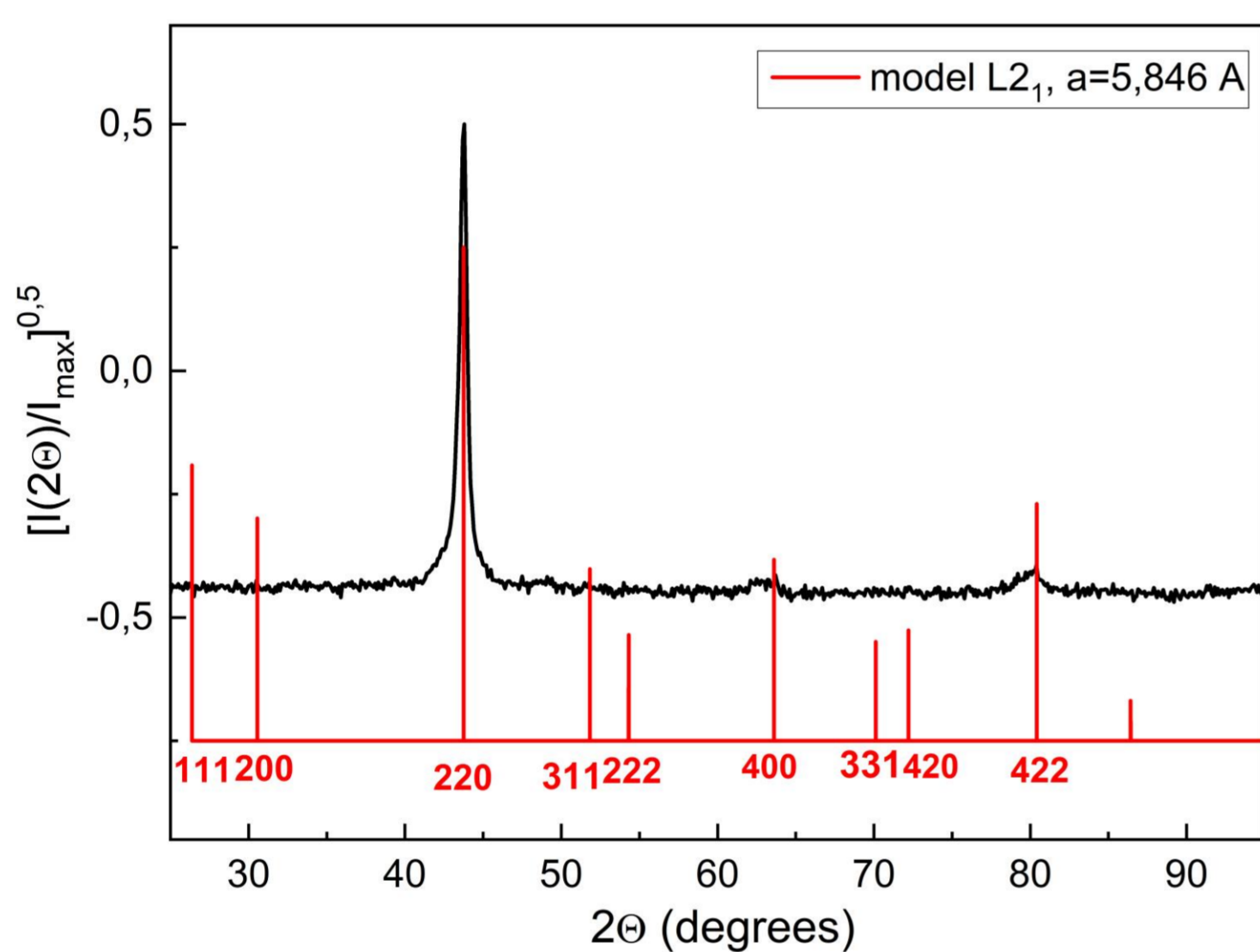


Figure 1. Experimental (black) and Rietveld-simulated (red) XRD patterns for Fe_{51.6}Mn_{17.8}Ga_{30.6} at room temperature, confirming the L2₁-ordered Heusler structure with lattice parameter $a = 5.846 \text{ \AA}$. Miller indices of the principal reflections are indicated.

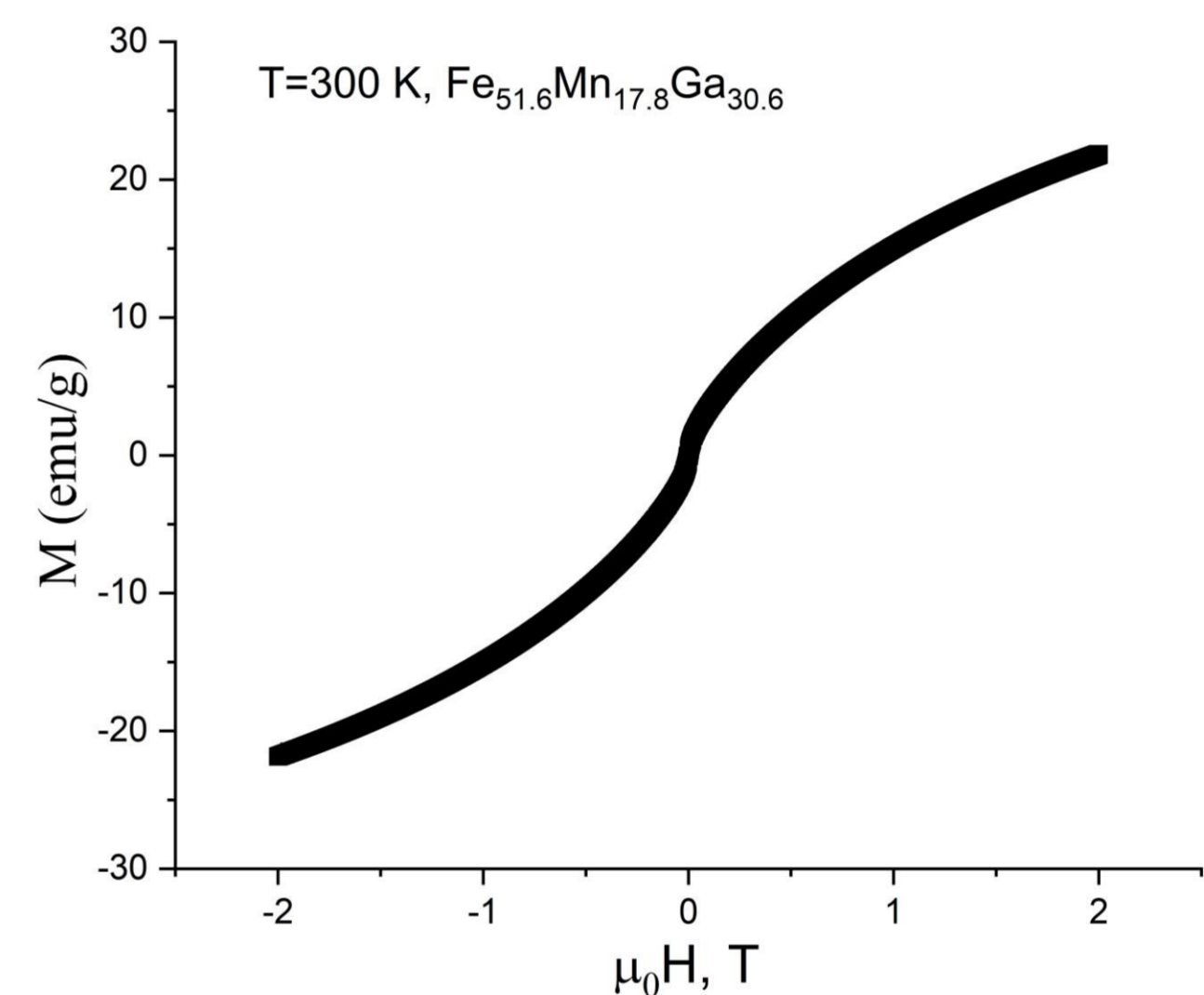


Figure 2. Magnetization hysteresis loop $M(H)$ measured at $T = 300 \text{ K} > T_c \approx 200 \text{ K}$ for Fe_{51.6}Mn_{17.8}Ga_{30.6}. The S-shaped, hysteresis-free response with no saturation up to 2 T indicates the presence of short-range ferromagnetic nanoclusters (Griffiths-like phase) persisting well above T_c

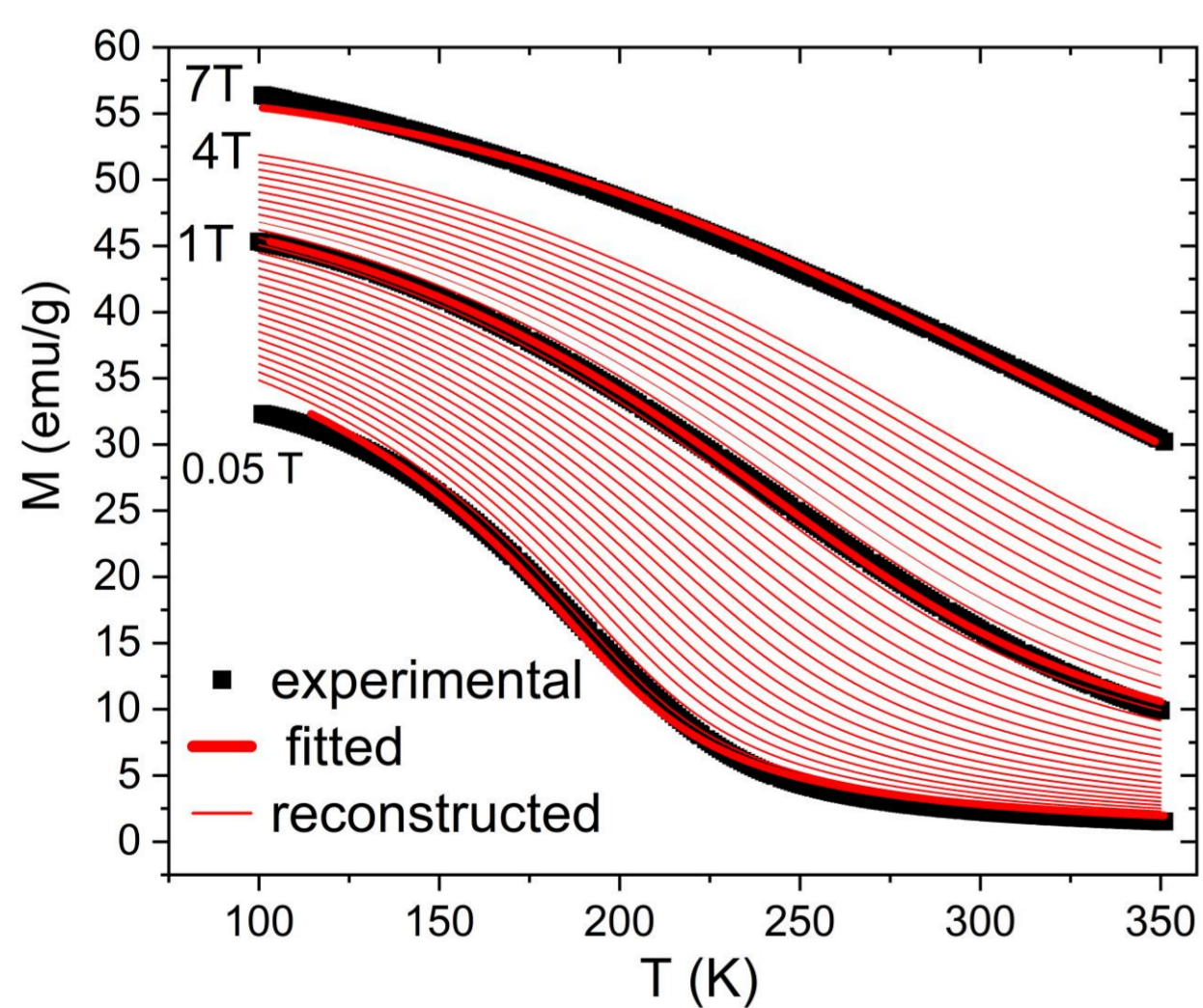


Figure 3. Magnetization $M(T)$ curves including experimental data, Brillouin function fits $M = M_0(H) \cdot B_J((a(H) + \lambda \cdot M)/T)$ with shared parameters $J = 1.7$, $\lambda = 4$, and the curves reconstructed at intermediate fields using the fitted parameters.

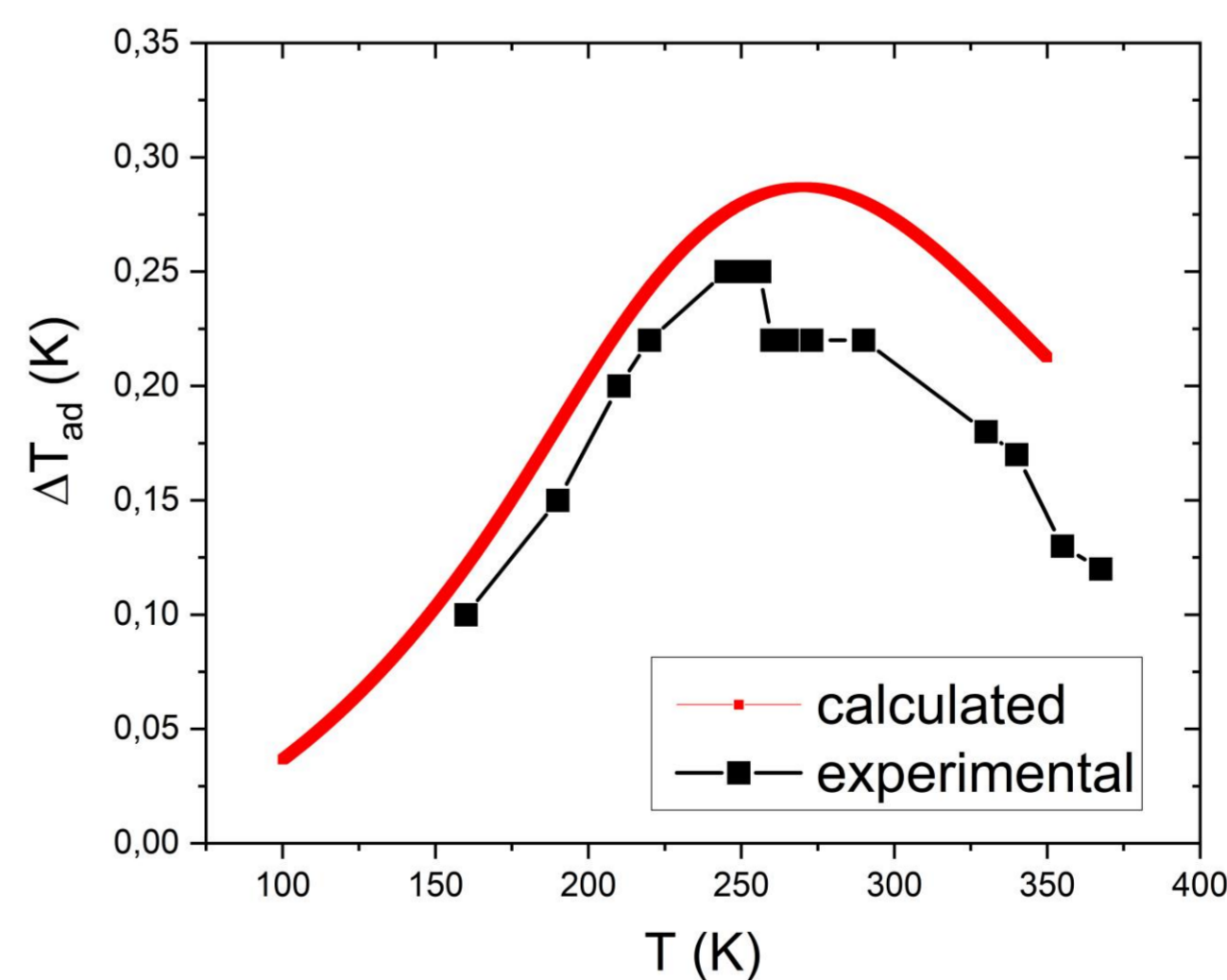


Figure 4. Temperature dependent adiabatic change of temperature for a field variation of 0.05–4 T directly measured and calculated by Maxwell approach $\Delta T_{ad} = - \int_0^H \frac{C_p \Delta T}{T} \left(\frac{\partial M}{\partial T} \right)_H dH$. The full $M(T, H)$ surface reconstructed by Brillouin functions, was executed for dM/dT calculations

Conclusions:

- ✓ The ferromagnetic L2₁-ordered Fe_{51.6}Mn_{17.8}Ga_{30.6} Heusler alloy with Curie temperature $T_c \approx 200 \text{ K}$ shows anomalously high magnetization above T_c , most likely attributed to short-range nanoferrromagnetic clusters characteristic of a Griffiths-like phase.
- ✓ The full $M(T, H)$ surface, reconstructed via Brillouin function fitting of a limited set of experimental $M(T)$ curves using shared parameters $J = 1.7$ and $\lambda = 4$, provides a reliable basis for calculating the magnetocaloric response through the Maxwell relation in this alloy.
- ✓ The adiabatic temperature change ΔT_{ad} calculated indirectly shows good agreement with directly measured values, validating the Brillouin-function based reconstruction for magnetocaloric assessment in this alloy. This reconstruction scheme is shown to be applicable not only in the vicinity of and below T_c , but also at temperatures well above T_c , where anomalously high magnetization attributed to short-range nanoferrromagnetic clusters (Griffiths-like phase) sustains a non-negligible magnetocaloric response.