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Effect of Temperature Step Size on Calculating the Magnetic Entropy Change

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The magnetic entropy change, Δs , is a key parameter in magnetocaloric research. The magnetic entropy change dictates the amount of heat a material may absorb or release upon a magnetic field change. This property may be characterised by indirect[1] or direct methods[2]. One of the indirect methods is the field integration of the derivative of magnetisation with respect to temperature. This calculation is based on a Maxwell relation $(ds/dH)_T = (dM/dT)_H$, where s , H , T and M , are entropy, magnetic field, temperature and magnetisation, respectively. However, due to the finite resolution of temperature and field in real experiments, this calculation will rely on a numerical approximation, which gives the equation $\Delta s(T_j, \Delta H_i) = \mu_0 \sum_i (M(T_{j+1}, H_i) - M(T_{j-1}, H_i)) / (T_{j+1} - T_{j-1}) \Delta H_i$, where μ_0 is the vacuum permeability. We have observed, in recent publications, e.g. [3,4], the lack of concern for the implications of this approximation. In this context, we study the effect of the temperature step, $dT = T_{j+1} - T_j$, on the calculated Δs for 3 different materials: Gd, $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ and $\text{La}(\text{Fe}, \text{Mn}, \text{Si})_{13}\text{H}_y$. We evaluate it by means of magnetisation measurements at different values of dT . We observe, for $\text{La}(\text{Fe}, \text{Mn}, \text{Si})_{13}\text{H}_y$, that with a dT as large as 3.0 K $\Delta s_{\text{max}}(T, \Delta H=0.75 \text{ T})$ may be $\sim 25 \%$ smaller than the one calculated from $dT=1.0 \text{ K}$. This effect decreases for materials with smoother transitions, such as $\text{La}_{0.67}\text{Ca}_{0.33}\text{MnO}_3$ and Gd ($\sim 11 \%$ and $\sim 0.8 \%$, respectively), and for increasing fields.

Key Words: Magnetic entropy change, Maxwell relation.

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