

Experimental test of the cooling rate effect Supplementary Material

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October 22, 2020

1 Data correction

A few of the measured demagnetization curves had to be excluded from the analysis, mostly due to reasons relating to the way the MPMS operates: The MPMS measures magnetic moments by physically moving the sample through a set of superconducting coils and measuring the change in the induced current during this process. The way the coils are arranged gives rise to characteristic curve of this current versus sample position with multiple (positive and negative) peaks; a model curve is then fitted to the measured current curve, from which both the magnetic moment and the exact sample position is determined (“iterative fitting routine”). This procedure is intrinsically problematic for measuring magnetic moments close to zero: For these, the amplitude of the induced currents becomes small such that the fitting routine becomes error-prone with respect to both moment and positioning – any incorrect fit in the positioning will lead to an incorrect fit to the magnetic moment.

If this happens, one of two problematic cases can occur: (1) either the MPMS switches to a fall-back algorithm (“linear fitting routine”) that only fits the magnetic moment and assumes in the sample position to be in a certain fixed place, or (2) the MPMS fits both moment and positioning, but not to the correct peak of the model curve, leading to an offset in both positioning and magnetic moment.

In the first case, analysis of the raw current curves showed that the positioning is almost certainly wrong, and therefore the inferred magnetic moment is almost certainly wrong – these data points had to be excluded from the analysis. In the second case, the positioning and the magnetic moment are both incorrect, but are simply offset by a fixed amount. As long as the fitting was incorrect in a consistent way, the data could therefore be corrected as described in the following. Often, the first data points, when the remanence was strong, were of good quality with correctly fitted moments and positions. When the remanence approached zero, the MPMS tended to use the fall-back algorithm with fixed positioning, but after a certain time it switched back to the primary fitting routine. Supposedly, this is because for a certain range of moments, it cannot unequivocally identify the primary peak amongst the peaks in the current curve, but at some point, the primary fitting routine succeeds in selecting one of the current peaks as “the primary peak” – even though it may not be the correct one. In this area, the selected “incorrect peak” tended to be chosen in a very consistent way from there on. These data points could therefore be corrected by choosing a constant offset ΔM , adding it to the section of incorrectly fitted data, to match up the correctly fitted section of the $M(t)$ curve with the incorrectly fitted section $M(t) + \Delta M$ (more precisely, total $M(t)$ curve (consisting of the correctly fitted data without offset, followed by the incorrectly fitted data with the added offset) was fitted to the logistic curve, and then ΔM was iteratively adjusted to optimize the fit-quality of the logistic curve).

The procedure of adding a constant offset to parts of the curve does in fact not impact the results of the experiments: the relaxation times are determined on the basis of \dot{M} , which is calculated from the derivatives of the magnetization curves – the constant offset does not impact the derivative. Nevertheless, the following figures show all the raw data together with the corrected data (where applicable). In some cases, a number of data points before and after the MPMS switched from the primary to the fall-back fitting routine (and) back were removed, too, since these tended to be very noisy; these cases are clearly listed below.

2 Data rejection criteria

2.1 MFn1

- 33 K, 3000s: Deleted first 5 data points since they are outliers.
- 36 K, 1500s: Deleted ca. 20 data points before and 50 data points after the area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 36 K TRMs: Are all excluded because the total time t_{tot} for cooling from 36 to 35 K is shorter than the effective time t_{eff} , hence the cooling rate equation is not applicable:
 - 36 K, 0.16 K/min: $t_{tot} = 375$ s, $t_{eff} = 551$ s

- 36 K, 0.08 K/min: $t_{tot} = 750$ s, $t_{eff} = 1071$ s
- 36 K, 0.04 K/min: $t_{tot} = 1500$ s, $t_{eff} = 2085$ s
- 36 K, 0.02 K/min: $t_{tot} = 3000$ s, $t_{eff} = 4060$ s
- 36.5 K, 0.32 K/min:
- 37 K, 0.16 K/min: Deleted ca. 20 data points around area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 37 K, 0.08 K/min; 37 K, 0.04 K/min; 35 K, 12000 s: Excluded, since they did not fully demagnetize anyways.

2.2 TC04-12-01K

- 57 K, 3000 s: Excluded, since obviously some thing went completely wrong; possibly the sample moved during the experiment.
- 53 K, 6000 s: Deleted ca. 20 data points around area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 53 K, 12000 s: Deleted ca. 20 data points before and 50 after area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 54 K, 6000 s: Deleted ca. 50 data points around area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 54 K, 3000 s: Excluded, since it appears that the positioning was wrong from the very beginning.
- 55 K, 400 s: Excluded, since acquisition time was very short.
- 55 K, 1500 s: Deleted ca. 20 data points around area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 55 K, 6000 s: Deleted ca. 100 data points around area where the MPMS could not iteratively fit the position of the sample, since these data points were very noisy.
- 55 K, 12000 s: Excluded, since it did not fully demagnetize anyways.
- 56 K, 3000 s; 56 K, 6000 s; 57 K, 6000 s: Excluded, since they were measured with the linear fitting routine of the MPMS.
- 57 K, 0.04 K/min: Excluded, since measured with automatic readjustments to the positioning every 10 minutes.
- 57 K, 0.06 K/min: Excluded, since from 1700 s there is no clear signal / positioning any more.

3 Raw data and corrected data

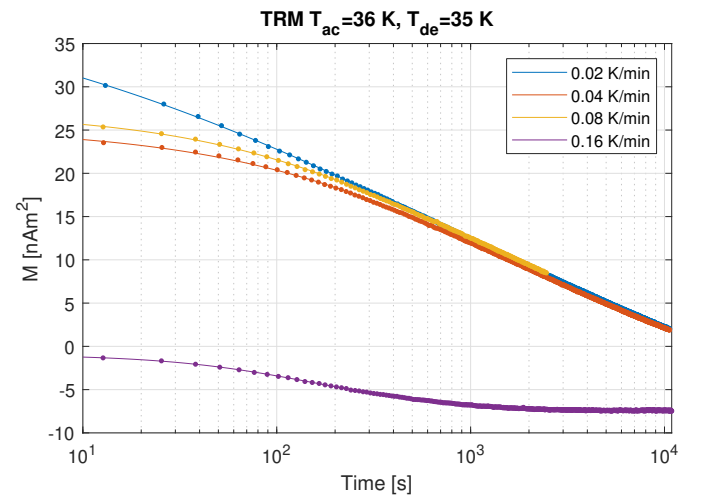
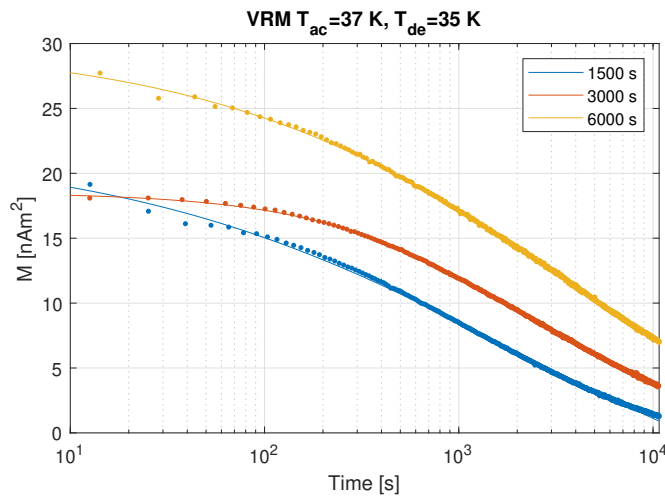
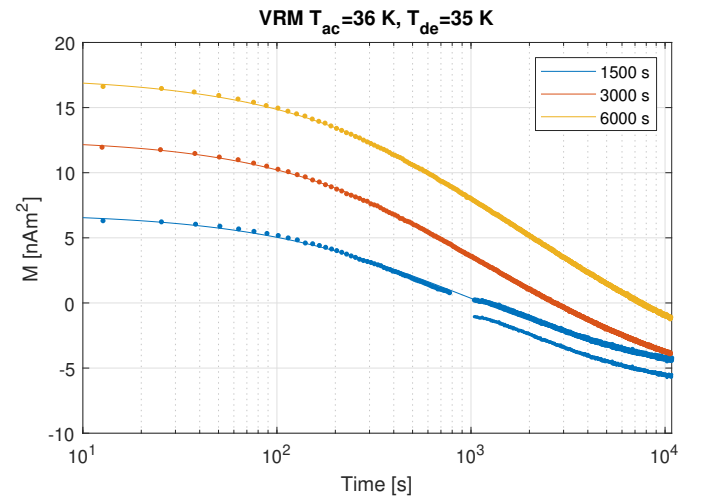
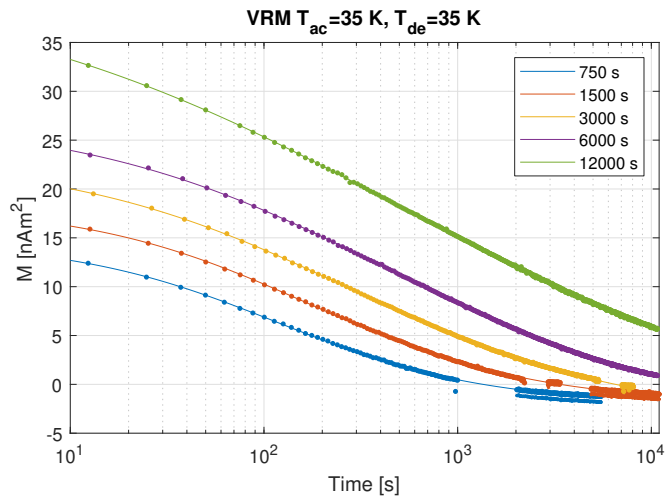
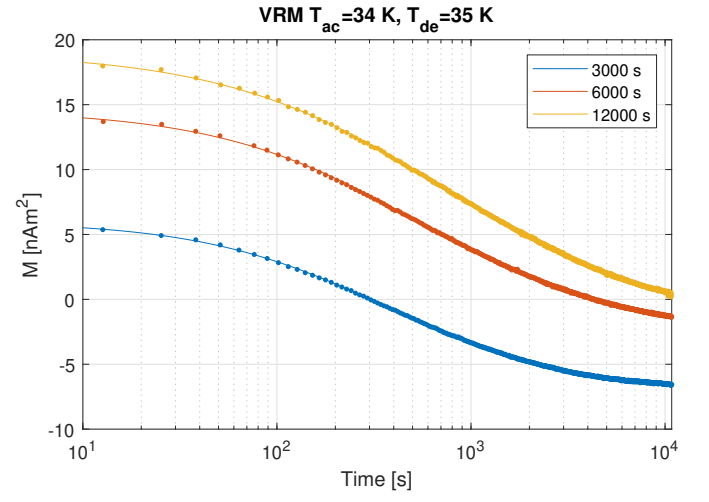
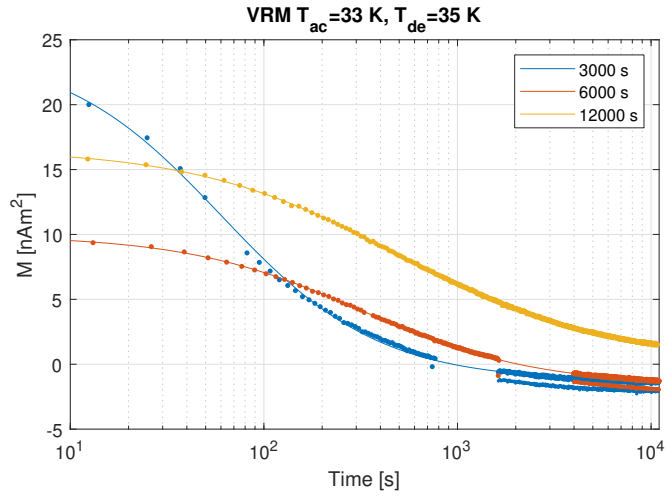


Figure S1: Raw data of viscous demagnetization plots for sample MFn1. Large dots indicate data corrected for positioning errors, small dots indicate uncorrected raw data. Lines indicate smoothed data (logistic function fit).

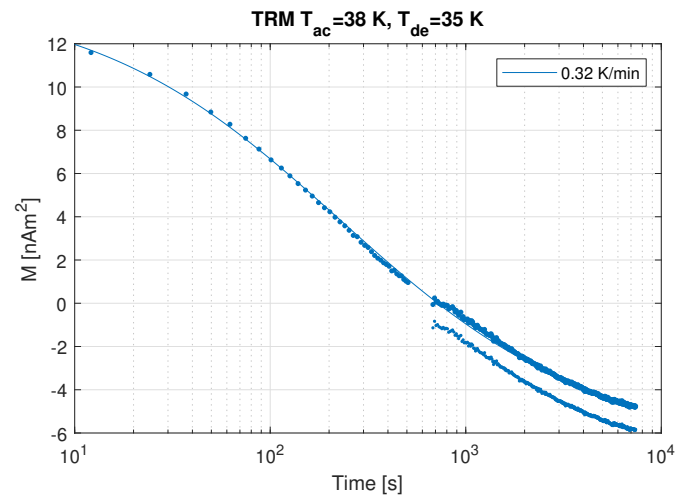
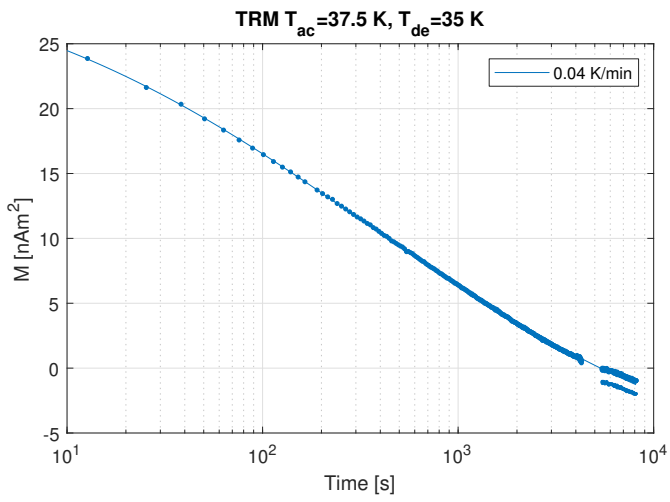
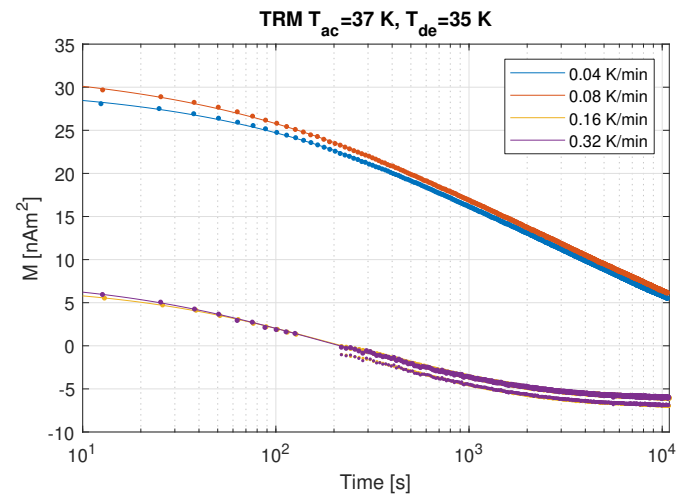
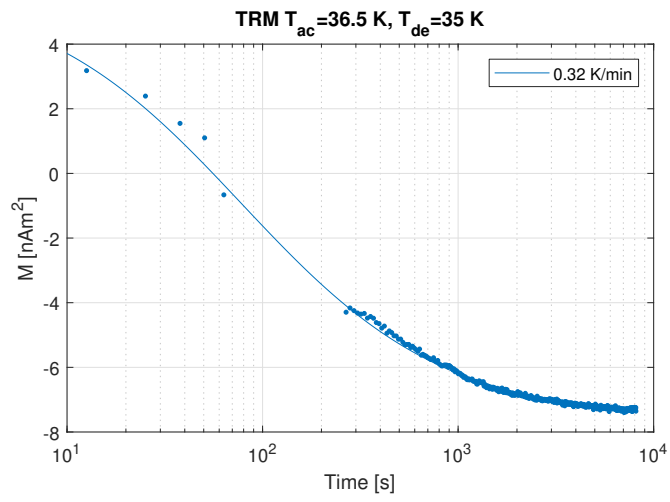


Figure S2: (continuation of Fig. S1)

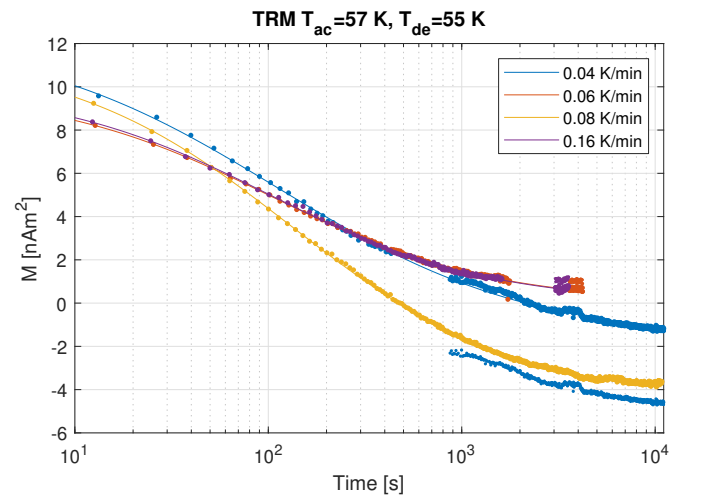
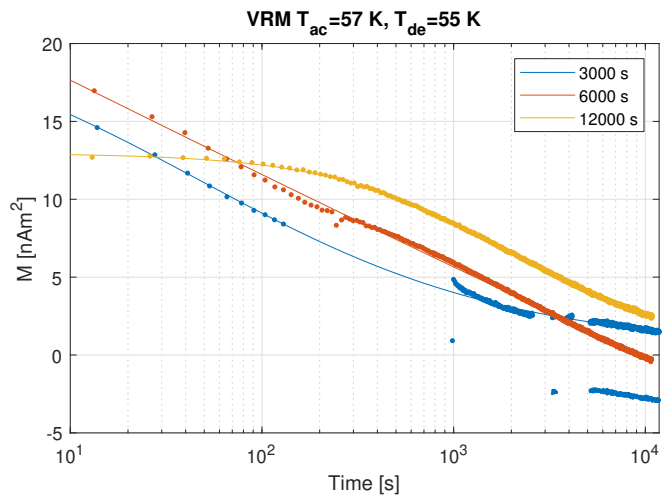
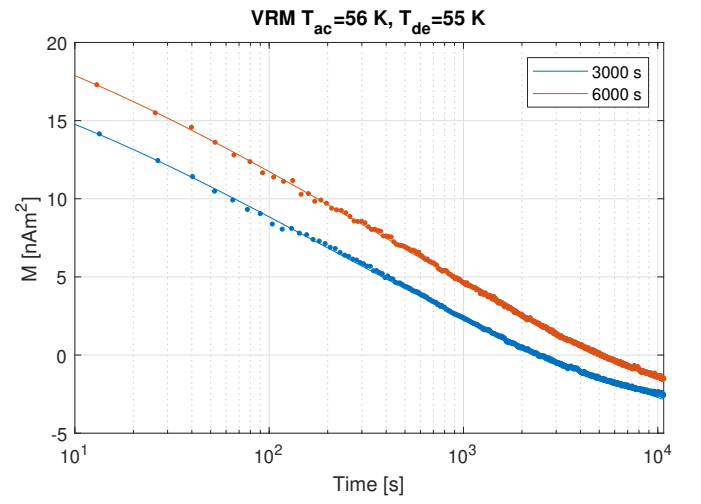
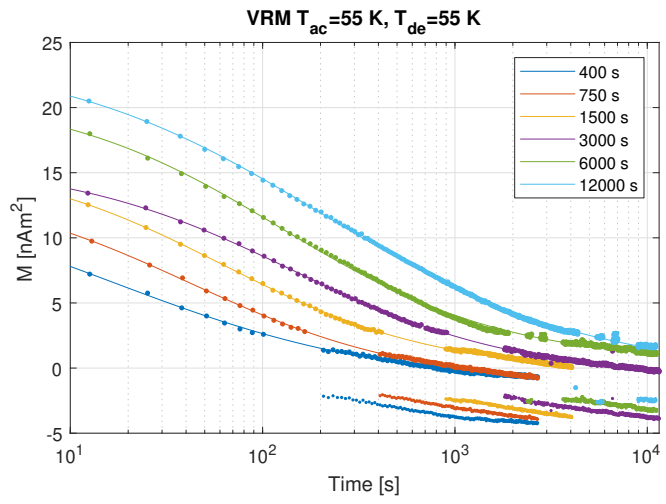
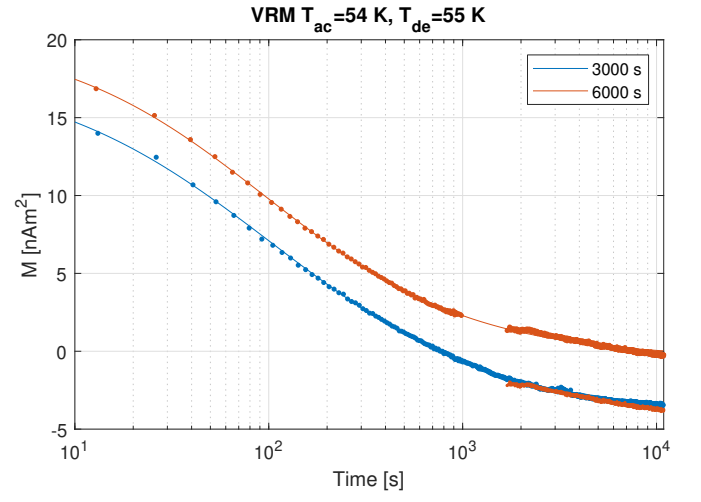
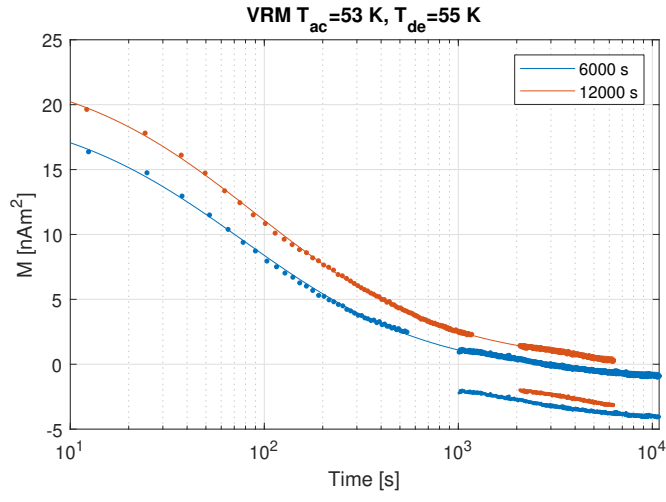


Figure S3: Raw data of viscous demagnetization plots for sample TC04-12-01K. Large dots indicate data corrected for positioning errors, small dots indicate uncorrected raw data. Lines indicate smoothed data (logistic function fit).

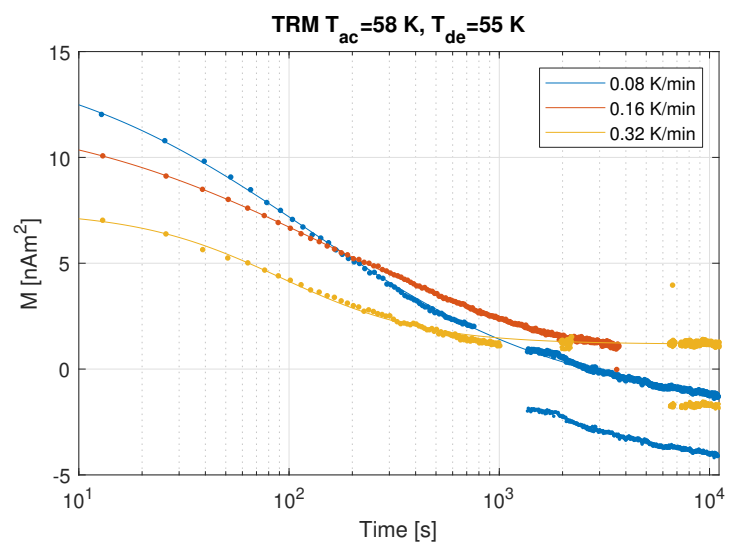


Figure S4: (continuation of Fig. S3)