

3 - 17 The Drifts of CSRe Dipole Magnetic Field Caused by Temperature Fluctuations*

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The stability of the magnetic fields is of vital importance to the success of the precision experiments conducted in the experimental Cooler Storage Ring (CSRe) in Lanzhou. In the CSRe, the electromagnets are cooled using room-temperature water. We monitored the magnetic field strength B of one of the dipole magnets, as well as the DC current I of the power supply and the temperature T of the cooling water for a long term. The data were recorded every one minute and the results over one day are shown in the left panels of Fig. 1. It can be seen that, as expected, the B varies following a similar pattern of the I variation. However, the B drifted by $\delta B/B \approx 1 \times 10^{-5}$ after 24 hours although the I and T returned to their original values. We assumed the following relation for the sequential data:

$$B_{i+1} = B_i * \frac{I_{i+1}}{I_i} * \begin{cases} 1 + k_1(T_{i+1} - T_i), & \text{if } T_{i+1} > T_i \\ 1 + k_2(T_{i+1} - T_i), & \text{if } T_{i+1} < T_i \end{cases} \quad (1)$$

If the temperature-caused drifting coefficients ($k = \delta B/B/dT$) differ between the heating and cooling process, i.e. $k_1 \neq k_2$, then B will drifts after one cycle (usually with a period of 24 h) of temperature fluctuations. The fitting results are shown as blue line in Fig. 1(a) and the fitting residuals are shown in Fig. 1(d). The obtained k_1 and k_2 parameters are shown in Fig. 1(e). It is clear that k_1 and k_2 are correlated and they are different from each other. In total, the k -coefficients were measured everyday and the results over 4 weeks are summarized in Fig. 1(f). Inferred from these results, besides from stable power supply at the level of $dI/I < \pm 1 \times 10^{-6}$, the temperature fluctuation during the experiments needs to be strictly controlled to a level of $\Delta T < \pm 0.1^\circ\text{C}$ in order to achieve a long-term (over weeks) stable magnetic field $\Delta B/B < \pm 1 \times 10^{-6}$ at CSRe.

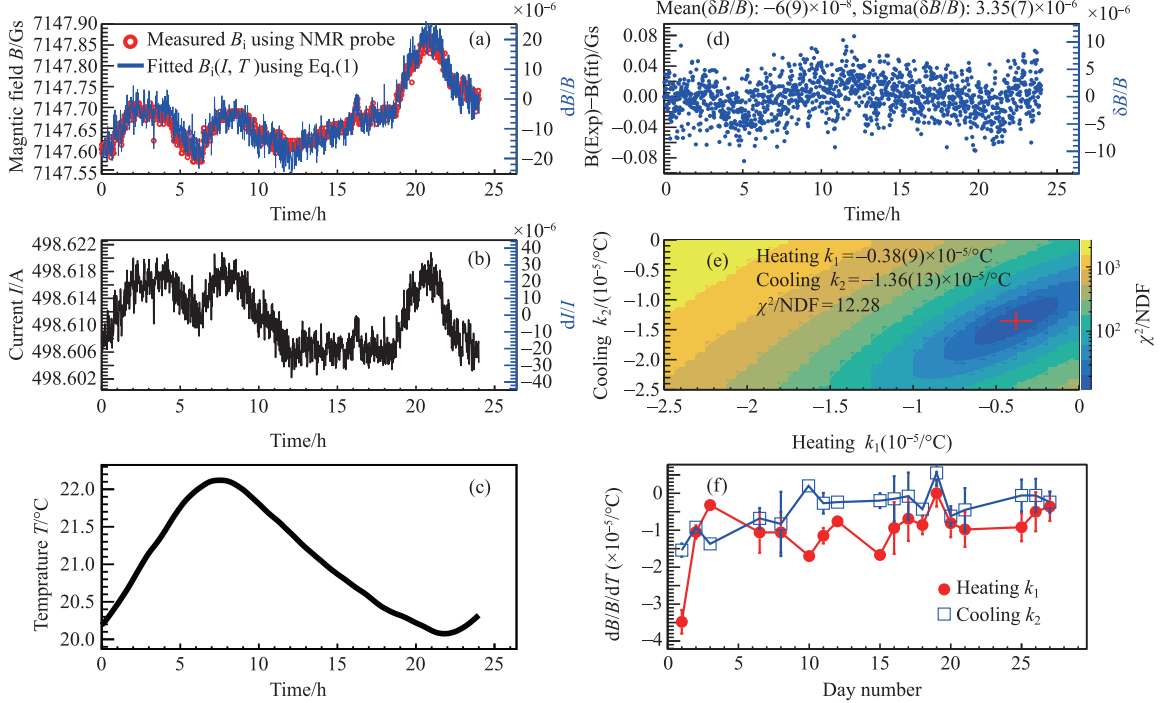


Fig. 1 (color online) Left panels: B, I, T of the CSRe dipole magnet monitored over 24 h with a DAQ rate of 1/60 Hz: (a) Red hollow circles: the magnetic field B measured by a PT2026 NMR-probe, blue lines: the best fitting $B(I, T)$ using Eq (1), (b) The DC current of the dipole magnet measured with a DCCT device, (c) The temperature of the cooling water at the exit port. Right panels: (d) The fitting residual from (a), (e) The $\chi^2/NDF = \sum_{i=1}^{1441} [B(\text{exp}) - B(\text{fit})]^2 / 0.007\text{Gs}^2 / 1439$ as a function of k_1 and k_2 ; (f) the k_1 and k_2 measured over 4 weeks. Note that $\sigma(k)$ were not amplified by $\sqrt{\chi^2/NDF}$.

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