Magnetic moment distribution analysis software with SVD method for MNPs (Version 1.00E) Basic manual

Kyushu University

Faculty of Information Science and Electrical Engineering

T. Sasayama, T. Yoshida, and K. Enpuku

1. Outline

This software can obtain the distribution of the magnetic moment of nanoparticles (MNPs) by using the singular value decomposition (SVD) method. Furthermore, this software can obtain the distributions of the particle size of MNPs, and the M-H curve that is reconstructed from the distributions of the magnetic moment (Figure 1). In the calculation, MNPs are assumed to be superparamagnetic, and the interference between MNPs are ignored.
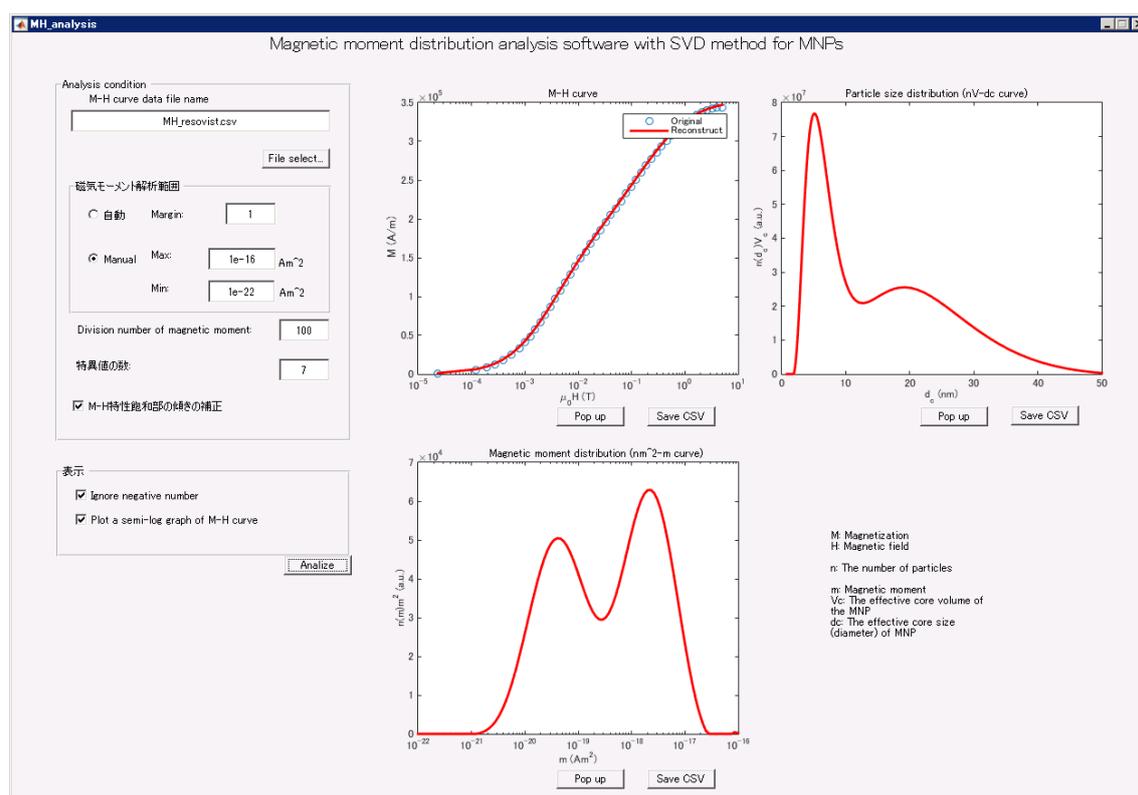

Fig. 1.   Overview of the analysis software

2. System requirements

MATLAB Runtime (MATLAB R2014b)

(Checked environment: Windows 7 (64 bit), Windows Server 2008 R2 Enterprise)

MATLAB Runtime can be downloaded from below.

http://www.mathworks.com/products/compiler/mcr/

3. Install

Download the file "MH_analysis32e.exe" (for 32 bit OS) or "MH_analysis64e.exe" (for 64 bit OS) and execute it

4. Uninstall

Only delete the file "MH_analysis32e.exe" or "MH_analysis64e.exe"

5. Usage rules

5.1 Outline

1) Analysis setting

Click the "File select…" button and select the M-H curve data file (CSV format), or manually type the file name of the data file. Subsequently, set the analysis parameters and analysis conditions. (The detail is described in Section 5.3).

2) Viewer setting

Set the display method of the results. (The detail is described in Section 5.4).

3) Analysis

Click the "Analyze" button. If "Pop up" button below figures is clicked, the figure show in the other window. If "Save CSV" button is clicked, the CSV data of the graph can be exported.

5.2 The data format of the M-H curve

This software can read the M-H curve data saved as CSV format. First column is the magnetic field (Unit: T), and second column is magnetization (Unit: A/m) (Figure 2). The M-H curve data in the first quadrant should be contained, and M and H should be in ascending order*. Both exponential notation and floating-point notation can be used.

*The negative values of M and H are ignored.

```
e.g. MH_resovist.csv

2.35E-05,1076

0.00012249,5622.7

0.00019177,8771.9

          .

          .

          .

5, 364000
```

Fig. 2.   The data format of the M-H curve

5.3 Analysis parameter and condition

- Analysis range of the magnetic moment

   "Auto" radio button

Automatically calculate the range of the magnetic moment using the maximum magnetic field $H_{\max}$ and minimum magnetic field $H_{\min}$ (in the assumption that $H_{\min} \leq 1$ T) as follows:

$$\text{Minimum of the magnetic moment; } m_{\min} = \frac{k_B T}{H_{\max}} \cdot \frac{1}{\alpha}$$

$$\text{Maximum of the magnetic moment; } m_{\max} = \frac{k_B T}{H_{\min}} \cdot \alpha$$

   k_B: Boltzmann constant (1.38×10^{-23} J/K)

   T: Absolute temperature ($T = 300$ K)

   α: Margin (default: 1)

   "Manual" radio button

Automatically set the range of the magnetic moment.

- Division number of magnetic moment

Determine the division number of the magnetic moment K, and calculate the calculation points of magnetic moments as follows:

$$m_k = m_{\min} \left(\frac{m_{\max}}{m_{\min}}\right)^{(k-1)/(K-1)}, k = 1, 2, \ldots, K$$

- The number of singular values

Set the number of singular values for calculation. In general, as the number becomes larger, the more accurate result would be obtained. However, if the number is too large, the numerical calculation becomes unstable. Therefore, an appropriate number should be selected.

- Correct M-H curve at saturation part

Correct the gradient at the highest magnetic field to 0 under the assumption that the M-H curve saturates at this point.

$$M_{\text{new}}(H) = M_{\text{old}}(H) - H \cdot \left.\frac{\mathrm{d}M_{\text{old}}}{\mathrm{d}H}\right|_{H=H_{\max}}$$

5.4 View

- Ignore negative number

The minus values that are obtained from the distribution calculation becomes 0.

- Plot a semi-log graph of M-H curve

Choose semi log scale or not in the M-H curve graph.

6. license agreement

This software is free software, but copyright subsists in Teruyoshi Sasayama, Takashi Yoshida, and Keiji Enpuku (Kyushu University, Japan). We do not bear all responsibility for the damage that we occurred by installation, use of this software.

7. Development Environment

Windows Server 2008 R2 Enterprise

MATLAB R2014b (8.4) 32 bit/64 bit

8. Contact information

Kyushu University

Faculty of Information Science and Electrical Engineering

Teruyoshi Sasayama

E:mail: sasayama@sc.kyushu-u.ac.jp