

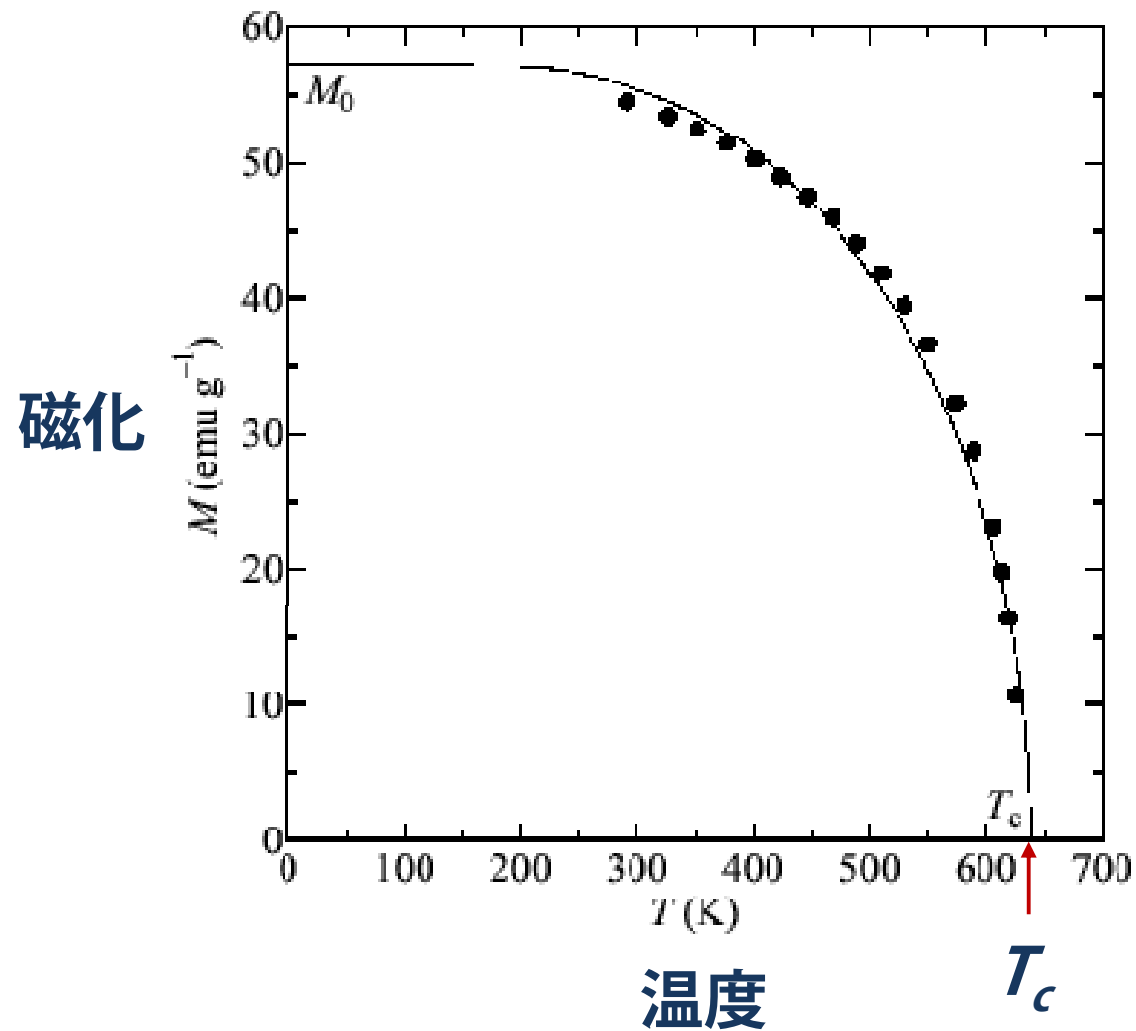
<http://www.ktf-split.hr/periodni/en/>

Relative atomic mass is shown with five significant figures. For elements that have no stable nuclides, the value enclosed in brackets indicates the mass number of the longest-lived isotope of the element.

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ニッケル金属の自発磁化



転移点付近の振る舞い

$$Z_{MF} = \text{Tr } e^{-\beta H_{MF}} = [2 \cosh\{\beta J m N_D\} \exp(-\beta |J| N_D m^2)]^N$$

エネルギー

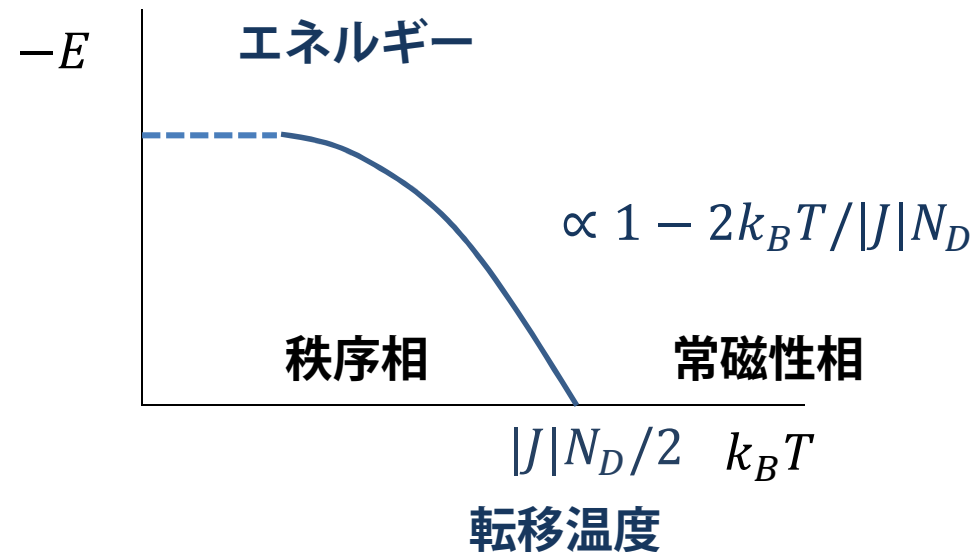
$$E = -\frac{\partial \ln Z_{MF}}{\partial \beta} = -\frac{\partial}{\partial \beta} (N \ln[2 \cosh\{\beta J m N_D\}] - N N_D \beta |J| m^2)$$

$$= -N J m N_D \tanh\{\beta J m N_D\} + N N_D |J| m^2$$

転移点付近

$\beta \sim 2/|J|N_D$ より

$$\sim -N |J| m N_D 2m + N N_D |J| m^2 = -N N_D |J| m^2$$



転移点付近の振る舞い

比熱

$$m = \tanh\{\beta|J|mN_D\}/2$$

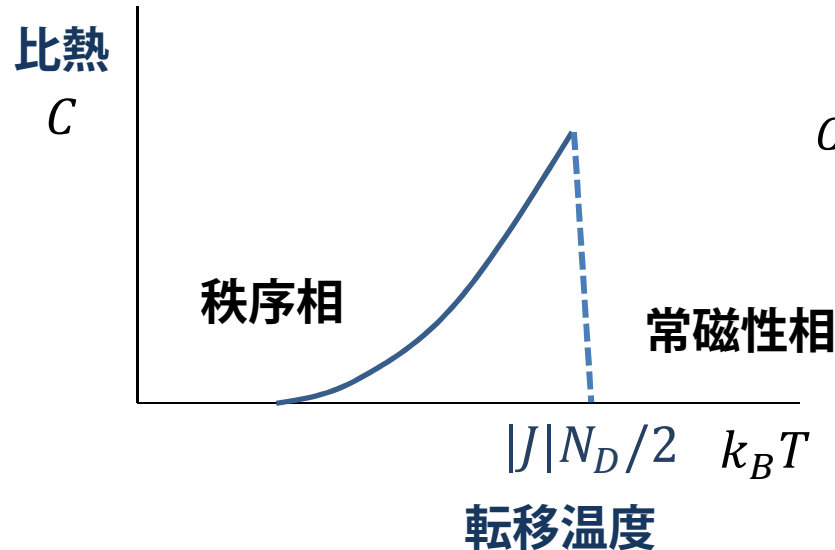
$$1 - \tanh^2 x = \frac{1}{\cosh^2 x}$$

$$C = \frac{\partial E}{\partial T} = -2NN_D|J|m \frac{\partial m}{\partial T} = 2NN_D|J|m \frac{1}{k_B T^2} \frac{\partial m}{\partial \beta}$$

$$E = -NN_D|J|m^2$$

$$\frac{\partial m}{\partial \beta} = \frac{1}{2} \frac{\partial}{\partial \beta} \tanh\{\beta|J|mN_D\} = -\frac{1}{2} \frac{JmN_D}{\cosh^2\{\beta|J|mN_D\}} + \frac{1}{2} \frac{\beta|J|N_D}{\cosh^2\{\beta|J|mN_D\}} \frac{\partial m}{\partial \beta}$$

$$\frac{\partial m}{\partial \beta} \left\{ 1 - \frac{\beta|J|N_D}{2} (1 - 4m^2) \right\} = -\frac{1}{2} (1 - 4m^2) JmN_D \quad \frac{\partial m}{\partial \beta} = \frac{(1 - 4m^2) JmN_D}{(1 - 4m^2) \beta|J|N_D - 2}$$



$$C = Nk_B \left(\frac{N_D J}{2k_B T} \right)^2 \frac{4m^2(1 - 4m^2)}{(1 - 4m^2) \frac{N_D |J|}{2k_B T} - 1}$$

$$4m^2 = \frac{3}{\left(-\frac{JN_D}{2k_B T} \right)^3} \left(\frac{|J|N_D}{2k_B T} - 1 \right)$$

転移点付近の振る舞い

帯磁率

$$1 - \tanh^2 x = \frac{1}{\cosh^2 x}$$

$$m = \tanh\{\beta(|J|mN_D + H)\}/2$$

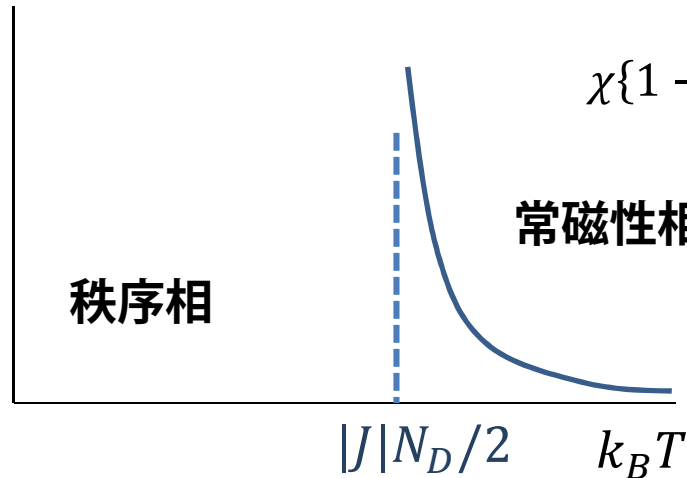
$$m_0 + \chi H = \tanh\{\beta\{|J|N_D(m_0 + \chi H) + H\}\}/2 = \tanh\{\beta\{|J|N_D m_0 + H(1 + |J|N_D \chi)\}\}/2$$

$$= \tanh\{\beta|J|N_D m_0\}/2 + \frac{1}{2\cosh^2\{\beta|J|N_D m_0\}} H\beta(1 + |J|N_D \chi) + \dots$$

$$\chi H = \frac{H\beta(1 + |J|N_D \chi)}{2\cosh^2\{\beta|J|N_D m_0\}} = H\beta(1 + |J|N_D \chi)(1 - 4m_0^2)/2$$

帯磁率

χ



$$\chi\{1 - (1 - 4m_0^2)|J|N_D\beta/2\} = (1 - 4m_0^2)\beta/2$$

$$\chi = \frac{1}{|J|N_D} \frac{1}{\frac{1}{1 - 4m_0^2} \left(\frac{k_B T}{2|J|N_D} \right) - 1}$$

キュリー・ワイス則

転移温度

バナジウム酸化物 CdVO_3 の帯磁率と磁化

