The use of cgs units in magnetism

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Here we discuss the cgs units of parameters related to the magnetic properties, such as the charge of electron, magnetization, Bohr magneton, magnetic susceptibility, and so on.

(1) The coulomb energy: $\varepsilon = \frac{e^2}{r}$.

$$\text{erg} = \frac{[e^2]}{\text{cm}}, \qquad [e^2] = \text{erg} \cdot \text{cm}$$

(2) Planck constant: $\hbar$

$$[\hbar] = \text{erg} \cdot \text{sec}$$

(3) Zeeman energy: $\varepsilon = -\mu_B B$ (erg)

$$[\mu_B] = [\text{emu}] = [\frac{\text{erg}}{G}],$$

(4) Bohr magneton: $\mu_B = \frac{e\hbar}{2mc}[\frac{\text{erg}}{G}],$

$$[\text{e}] = \frac{[\mu_B][mc]}{[\hbar]} = [\frac{\text{erg}}{\text{G} \cdot \text{erg} \cdot \text{s}}]\,[\frac{\text{erg} \cdot \text{s}}{\text{cm}}] = [\frac{\text{erg}}{\text{cm} \cdot \text{G}}]$$

(5) Structure fine constant: $\alpha = \frac{e^2}{\hbar c}$

$$[\alpha] = [\frac{e^2}{\hbar c}] = \frac{[\text{erg cm}]}{[\text{erg s}][\text{cm/s}]} = \text{dimensionless constant}$$

(6) Energy from magnetic field

$$\varepsilon = \frac{1}{8\pi}\int \boldsymbol{B}^2 d\boldsymbol{r} \qquad [\text{erg}]$$

leading to $[\text{erg}] = [\text{G}^2\ \text{cm}^3]$.

(7) Unit of [emu]

$$[\text{emu}] = [\frac{\text{erg}}{G}] = [\frac{\text{G}^2\ \text{cm}^3}{G}] = [\text{G cm}^3]$$

(8) $B = H + 4\pi M$

$$[H] = [G] = [\frac{\text{emu}}{\text{cm}^3}]$$

$$[M] = [H] = [\frac{\text{emu}}{\text{cm}^3}]$$

When $B = 0$ (complete diamagnetism) for superconductivity, the susceptibility is obtained as

$$\chi = -\frac{1}{4\pi}\ (\text{emu/G cm}^3)$$

Conventionally, we use the unit of χ as (emu/cm^3), instead of (emu/G cm^3).

(9) Magnetic susceptibility

We use the unit of H as [Oe]=[G], and the unit of M as [emu/cm^3]. The unit of the magnetic susceptibility is obtained as

$$\chi = \frac{M}{H} = [\frac{\text{emu}}{\text{cm}^3\text{G}}] = [\frac{\text{emu}}{\text{cm}^3\text{Oe}}]$$

(10) Magnetic susceptibility

Experimentally, we measure the magnetization of the system(1 mole of magnetic ions) in the units of emu in the presence of magnetic field. The magnetic susceptibility is evaluated as

$$[\chi] = [\frac{\text{emu}}{\text{G mol}}] = [\frac{\text{cm}^3}{\text{mol}}]$$

(11) Magnetic quantum flux (fluxoid, or fluxon)

$$\Phi_0 = \frac{hc}{2e} \qquad (\text{G cm}^2)$$

$$[\Phi_0] = [\frac{hc}{2e}] = \text{G cm}^2$$

leading to

$$[e] = \frac{\text{erg}}{\text{G cm}}$$