Magnetic Monopoles

Maxwell's equations cry out for monopoles

1) Dirac 1931 argues that if monopoles exist
they imply charge quantization (from ang. mom. quantization)

2) Monopoles are predicted to exist in some
GUT models (but may be diluted by inflation)

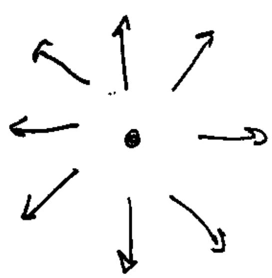
$$\therefore \quad \frac{B}{g} = \frac{g_m}{G m_p}$$

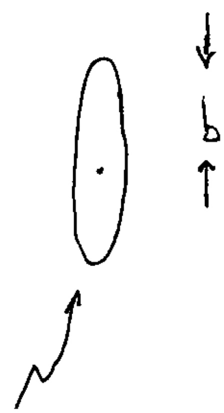
$$\text{or} \quad g_m < \frac{1\,\text{Gauss} \times G m_p}{10^3\ \text{cm}/\text{s}^2}$$

$$< 10^{-34}\ \text{e.s.u.}$$

$$\text{or} \quad \frac{g_m}{|e|} < 2 \times 10^{-23}$$

Detection





$$\vec{B} = g\,\hat{r}$$

$$\int \vec{E}\cdot d\vec{l} = -\frac{1}{c}\frac{dF}{dt}$$

consider charge in loop of mass m, charge q

$$\oint \vec{E}\cdot d\vec{l} = 2\pi b E = 2\pi b \times \frac{m}{e}\frac{dv}{dt}$$

v speed of charge in loop

$$= -\frac{1}{c}\frac{dF}{dt}$$

$$2\pi b \frac{m}{e}(v_f - v_i) = -\frac{1}{c}(F_f - F_i)$$

let $v_i = 0$

$F_i = 0$ monopole far from loop

$$F_f = \oint_S da\, \hat{n}\cdot\vec{B}$$

$$= \oint R^2 d\Omega \cdot \frac{g}{R^2} = 4\pi g$$

$$\frac{mbv}{e} = -\frac{2g}{c}$$

$$mvb = L =$$ ang. momentum of charge in loop

$$= -\frac{2ge}{c}$$

$$= n\hbar \quad \Rightarrow \quad |e| = \frac{n\hbar c}{2g}$$

Limit on magnetic monopole density in galaxy

Galactic field 3×10^{-6} G Age 3×10^{17} s

Monopoles would short-circuit this field!

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First Results from a Superconductive Detector for

in their independent uncertainties.

Consider a single monopole in uniform field B

$$\frac{dp}{dt} = gB$$

$$\simeq mc \quad \text{on timescale} \quad \tau = \frac{mc}{gB}$$

$$= \frac{mc}{eB} \times \frac{e}{g}$$

$$= \frac{9\times10^{-27}\,g\ \ 3\times10^{10}\,cm/s}{4.8\times10^{-10}\,esu\ \ 3\times10^{-6}\,G}\ \frac{e}{g}$$

$$= 0.2S \times \frac{e}{g}$$

$$\frac{dE}{dt} \simeq gBc$$

Suppose there are N_g monopoles/cm^3

$$\frac{du}{dt} = \text{change in energy density} \simeq gBcN_g = -\frac{d}{dt}\frac{B^2}{8\pi}$$

$$\frac{1}{B^2}\frac{dB^2}{dt} \simeq \frac{8\pi g c N_g}{B}$$

$$\tau_{B,\mathrm{decay}} \simeq \frac{B}{8\pi g c N_g} > 3\times 10^{17}\,s$$

$$N_g < \frac{B}{8\pi e c\, 3\times 10^{17}\,s}\;\frac{e}{g}$$

$$< 3\times 10^{-26}\,cm^{-3}\;\frac{e}{g}$$

ISM $N_N \simeq 1\,cm^{-3}$