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Erratum: Dark-matter electric and magnetic dipole moments [Phys. Rev. D 70, 083501 (2004)]

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In preparing this paper a transcription error was made when computing the experimental limits on direct detection of dark matter from Ref. [1]. Consequently, the upper limits on the dipole moments due to direct detection derived in this paper were underestimated by a factor of $\sim$100. Furthermore, we have uncovered a relative-sign error in our computation of the matrix element for dipole-charge scattering that led us to erroneously conclude that the cross sections for dipole-charge scattering and dipole annihilation to pairs were identical for both magnetic and electric dipole moments. In fact, the annihilation cross section $\sigma_{\chi\bar{\chi}\to f\bar{f}}$ shown in Eq. (4) on page 3 of this paper is valid only for *magnetic* dipole moments and the differential scattering cross section shown in Eq. (5) on page 4 of this paper is valid only for *electric* dipole moments. Note that dipole-photon cross sections are unaffected.

The results and discussion in this paper pertaining to electric dipole moments remain essentially valid. Here, in Fig. 1 we summarize the limits to the electric dipole moment of dark matter—including the revised direct detection limit and the electric dipole relic abundance curve. The annihilation cross section shown below in Eq. (3) was used to produce this relic abundance curve using standard methods and details will be discussed in Ref. [2].

We caution the reader that many of the results of this paper pertaining to magnetic dipole moments require significant revision. Only the constraints from precision measurements at accelerators, and the GLAST and EGRET gamma-ray annihilation results are valid for magnetic dipoles. Other constraints derived in this paper will be (in some cases substantially) revised and discussed elsewhere [2].

We list here, to lowest order in the relative velocity v, the *correct* cross sections for a spin-$1/2$ particle χ with electric or magnetic dipole moments $\mathcal{D}$ or $\mathcal{M}$ interacting with a charged particle f of charge Ze. The charged particle has mass m while the dipole has mass m_χ.

Electric dipole charge scattering $\chi f \to \chi f$:

$$\frac{d\sigma}{d\Omega} = \frac{Z^2 e^2 \mathcal{D}^2}{16\pi^2 v^2} \csc^2\left(\frac{\theta}{2}\right). \tag{1}$$

Magnetic dipole charge scattering $\chi f \to \chi f$:

$$\frac{d\sigma}{d\Omega} = \frac{Z^2 e^2 \mathcal{M}^2}{16\pi^2} \left[\csc^2\left(\frac{\theta}{2}\right) + 1 - \frac{m(m + 4m_\chi)}{(m + m_\chi)^2}\right]. \tag{2}$$

Electric dipole annihilation to charged pairs $\chi\bar{\chi} \to f\bar{f}$:

$$\sigma v = \frac{Z^2 e^2 \mathcal{D}^2 v^2}{48\pi}\left[1 - \frac{3m^4}{8m_\chi^4}\right]. \tag{3}$$

Magnetic dipole annihilation to charged pairs $\chi\bar{\chi} \to f\bar{f}$:

$$\sigma v = \frac{Z^2 e^2 \mathcal{M}^2}{4\pi}\left[1 - \frac{3m^4}{8m_\chi^4}\right]. \tag{4}$$

Here, Eqs. (3) and (4) are correct in the limit $m \ll m_\chi$.

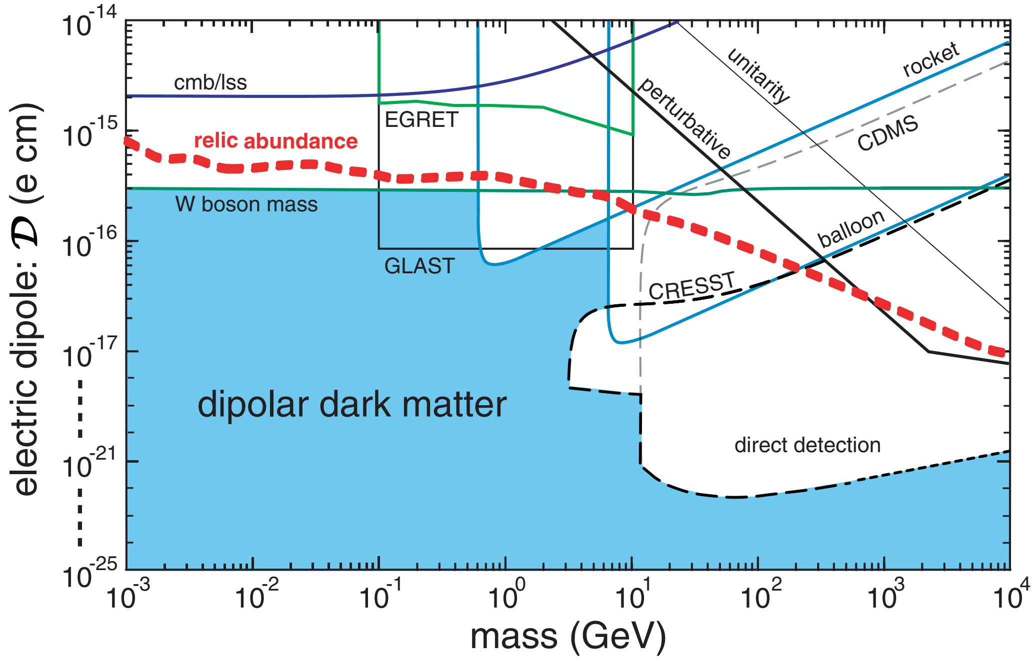

FIG. 1 (color online). Constraints on the electric dipole parameter space $[m_\chi, \mathcal{D}]$. See this paper for a description of the labels.

[1] D. S. Akerib *et al.* (CDMS Collaboration), Phys. Rev. Lett. **93**, 211301 (2004).
[2] K. Sigurdson, M. Doran, A. Kurylov, R. R. Caldwell, and M. Kamionkowski (unpublished).