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Erratum

Erratum to: Search for non-relativistic magnetic monopoles with IceCube

IceCube Collaboration

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In the analyses, published in Ref. [1], the exclusion limits are calculated in dependence of the mean free path of the magnetic monopole - nucleon catalysis interaction λ_{cat}. The values of the latter are set as defined point of measurement for the analyses. For comparison with previous limits, the mean free path is converted to the catalysis cross section σ_{cat} via

$$\sigma_{\text{cat}} = \frac{1}{n \cdot \lambda_{\text{cat}}} \tag{1}$$

where n is the number density of contributing targets, the nucleons of the water molecule H_2O.

Nucleons bound in various nuclei contribute differently to the total catalysis cross section which can be expressed by the following calculation of the catalysis cross section σ_{cat}

$$\sigma_{\text{cat}} = \frac{\sigma_0}{\beta} \left[\frac{2}{18} f_H(\beta) + \frac{16}{18} f_O(\beta) \right] \tag{2}$$

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where σ_0 is the speed independent cross section (introduced in Ref. [4], β is the speed as fraction of the speed of light, and f_i is the form factor accounting for the contribution of nucleons bound in a nucleus i to the cross section. An exemplary calculation of the form factor f can be found in Ref. [2].

In Ref. [1] the number of hydrogen nucleons

$$n_{2H} = \frac{2\rho N_A}{m_H} \tag{3}$$

is used as target density instead of the valid number density of nucleons

$$n_n = \frac{\rho N_A}{m_n} = 9 \cdot n_{2H} \tag{4}$$

required in Eq. 1 where N_A is the Avogadro constant, ρ is the mass density of the ice and m is the molar mass of two hydrogen nucleons or all nucleons. Therefore the exclusion limits apply to a factor 9 smaller catalysis cross section as depicted in Fig. 1.

The analyses are based on the detection and reconstruction of light produced by magnetic monopoles. Increasing speed or increasing cross section result in brighter signatures. Thus, an exclusion limit implicitly not only excludes higher rates but also larger cross sections. Therefore the corrected limits still exclude the same flux vs. cross section area as published before. However, it extends by a factor of 9 to smaller cross sections. In comparison to the MACRO limits, which is also shown in Fig. 1, the originally published limit in Ref. [1] is weaker than the corrected limit which is calculated using the nucleon density n_n.

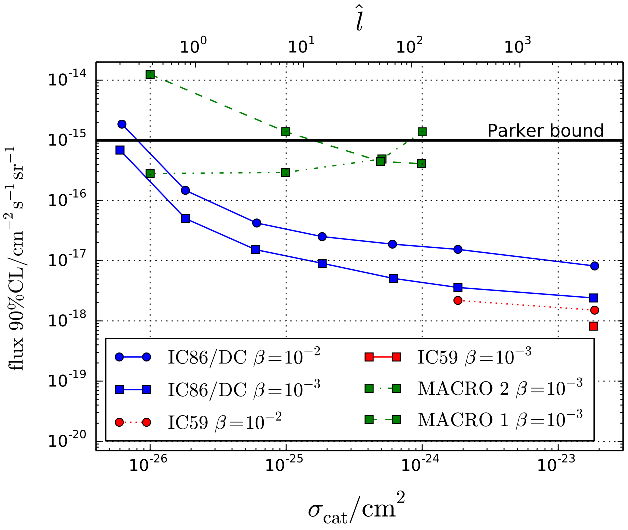

Fig. 1 Correction of Fig. 20 in Ref. [1] showing the upper limits on the flux of non-relativistic magnetic monopoles depending on the speed β and catalysis cross section σ_{cat} of the IC-59 analysis and IC-86/DeepCore analysis. The dashed lines are limits published by the MACRO experiment [3]. The catalysis cross section σ_{cat} is derived from the simulated mean free path λ_{cat} using the number density of nucleons in the water molecule in Eq. 1. Thus, the cross section, shown here, can be interpreted as the number averaged cross section per nucleon. The theoretical catalysis cross section of nucleons bound in hydrogen and oxygen is different and dependent on the monopole velocity, see Eq. 2 and Ref. [2]. Here, MACRO 1 is an analysis developed for monopoles catalyzing the proton decay. MACRO 2 is the standard MACRO analysis, which is sensitive to monopoles ionizing the surrounding matter. Additionally, the IceCube limits are shown as a function of $\hat{l}$ which is proportional to the averaged Cherenkov photon yield per nucleon decay (not valid for MACRO limits)

All values of the cross section given in descriptions and captions of Ref. [1] have to be divided by a factor of 9 throughout the paper. Thus, the IC86-DC analysis of Ref. [1] improves the flux limits published previously above $\sigma_{\mathrm{cat}} = 10^{-25}\,\mathrm{cm}^2$ corresponding to $\lambda_{\mathrm{cat}} < 3\,\mathrm{m}$ by more than one order of magnitude. The IC-59 analysis is sensitive for bright monopoles with $\sigma_{\mathrm{cat}} = 1.9 \cdot 10^{-24}\,\mathrm{cm}^2$.

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