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Erratum

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

**IceCube Collaboration**

**M. G. Aartsen[2], R. Abbasi[29], M. Ackermann[45], J. Adams[15], J. A. Aguilar[23], M. Ahlers[29], D. Altmann[22], C. Arguelles[29], T. C. Arlen[42], J. Auffenberg[1], X. Bai[33,c], M. Baker[29], S. W. Barwick[25], V. Baum[30], R. Bay[7], J. J. Beatty[17,18], J. Becker Tjus[10], K. -H. Becker[44], M. L. Benabderrahmane[45,b], S. BenZvi[29], P. Berghaus[45], D. Berley[16], E. Bernardini[45], A. Bernhard[32], D. Z. Besson[27], G. Binder[7,8], D. Bindig[44], M. Bissok[1], E. Blaufuss[16], J. Blumenthal[1], D. J. Boersma[43], C. Bohm[36], D. Bose[38], S. Böser[11], O. Botner[43], L. Brayeur[13], H. -P. Bretz[45], A. M. Brown[15], R. Bruijn[26], J. Casey[5], M. Casier[13], D. Chirkin[29], A. Christov[23], B. Christy[16], K. Clark[39], L. Classen[22], F. Clevermann[20], S. Coenders[32], S. Cohen[26], D. F. Cowen[41,42], A. H. Cruz Silva[45], M. Danninger[36], J. Daughhetee[5], J. C. Davis[17], M. Day[29], J. P. A. M. de André[42], C. De Clercq[13], S. De Ridder[24], P. Desiati[29], K. D. de Vries[13], M. de With[9], T. DeYoung[42], J. C. Díaz-Vélez[29], M. Dunkman[42], R. Eagan[42], B. Eberhardt[30], B. Eichmann[10], J. Eisch[29], S. Euler[43], P. A. Evenson[33], O. Fadiran[29], A. R. Fazely[6], A. Fedynitch[10], J. Feintzeig[29], T. Feusels[24], K. Filimonov[7], C. Finley[36], T. Fischer-Wasels[44], S. Flis[36], A. Franckowiak[11], K. Frantzen[20], T. Fuchs[20], T. K. Gaisser[33], J. Gallagher[28], L. Gerhardt[7,8], L. Gladstone[29], T. Glüsenkamp[45], A. Goldschmidt[8], G. Golup[13], J. G. Gonzalez[33], J. A. Goodman[16], D. Góra[22], D. T. Grandmont[21], D. Grant[21], P. Gretskov[1], J. C. Groh[42], A. Groß[32], C. Ha[7,8], C. Haack[1], A. Haj Ismail[24], P. Hallen[1], A. Hallgren[43], F. Halzen[29], K. Hanson[12], D. Hebecker[11], D. Heereman[12], D. Heinen[1], K. Helbing[44], R. Hellauer[16], S. Hickford[15], G. C. Hill[2], K. D. Hoffman[16], R. Hoffmann[44], A. Homeier[11], K. Hoshina[29,d], F. Huang[42], W. Huelsnitz[16], P. O. Hulth[36], K. Hultqvist[36], S. Hussain[33], A. Ishihara[14], E. Jacobi[45], J. Jacobsen[29], K. Jagielski[1], G. S. Japaridze[4], K. Jero[29], O. Jlelati[24], B. Kaminsky[45], A. Kappes[22], T. Karg[45], A. Karle[29], M. Kauer[29], J. L. Kelley[29], J. Kiryluk[37], J. Kläs[44], S. R. Klein[7,8], J. -H. Köhne[20], G. Kohnen[31], H. Kolanoski[9], L. Köpke[30], C. Kopper[29], S. Kopper[44], D. J. Koskinen[19], M. Kowalski[11], M. Krasberg[29], A. Kriesten[1], K. Krings[1], G. Kroll[30], J. Kunnen[13], N. Kurahashi[29], T. Kuwabara[33], M. Labare[24], H. Landsman[29], M. J. Larson[40], M. Lesiak-Bzdak[37], M. Leuermann[1], J. Leute[32], J. Lünemann[30], O. Macías[15], J. Madsen[35], G. Maggi[13], R. Maruyama[29], K. Mase[14], H. S. Matis[8], F. McNally[29], K. Meagher[16], A. Meli[24], M. Merck[29], T. Meures[12], S. Miarecki[7,8], E. Middell[45], N. Milke[20], J. Miller[13], L. Mohrmann[45], T. Montaruli[23], R. Morse[29], R. Nahnhauer[45], U. Naumann[44], H. Niederhausen[37], S. C. Nowicki[21], D. R. Nygren[8], A. Obertacke[44], S. Odrowski[21], A. Olivas[16], A. Omairat[44], A. O'Murchadha[12], T. Palczewski[40], L. Paul[1], J. A. Pepper[40], C. Pérez de los Heros[43], C. Pfendner[17], D. Pieloth[20], E. Pinat[12], J. Posselt[44], P. B. Price[7], G. T. Przybylski[8], M. Quinnan[42], L. Rädel[1], M. Rameez[23], K. Rawlins[3], P. Redl[16], R. Reimann[1], E. Resconi[32], W. Rhode[20], M. Ribordy[26], M. Richman[16], B. Riedel[29], S. Robertson[2], J. P. Rodrigues[29], C. Rott[38], T. Ruhe[20], B. Ruzybayev[33], D. Ryckbosch[24], S. M. Saba[10], H. -G. Sander[30], M. Santander[29], S. Sarkar[19,34], K. Schatto[30], F. Scheriau[20], T. Schmidt[16], M. Schmitz[20], S. Schoenen[1,a], S. Schöneberg[10], A. Schönwald[45], A. Schukraft[1], L. Schulte[11], O. Schulz[32], D. Seckel[33], Y. Sestayo[32], S. Seunarine[35], R. Shanidze[45], C. Sheremata[21], M. W. E. Smith[42], D. Soldin[44], G. M. Spiczak[35], C. Spiering[45], M. Stamatikos[17,e], T. Stanev[33], N. A. Stanisha[42], A. Stasik[11], T. Stezelberger[8], R. G. Stokstad[8], A. Stößl[45], E. A. Strahler[13], R. Ström[43], N. L. Strotjohann[11], G. W. Sullivan[16], H. Taavola[43], I. Taboada[5], A. Tamburro[33], A. Tepe[44], S. Ter-Antonyan[6], G. Tešić[42], S. Tilav[33], P. A. Toale[40], M. N. Tobin[29], S. Toscano[29], M. Tselengidou[22], E. Unger[10], M. Usner[11], S. Vallecorsa[23], N. van Eijndhoven[13], J. van Santen[29], M. Vehring[1], M. Voge[11], M. Vraeghe[24], C. Walck[36], M. Wallraff[1], Ch. Weaver[29], M. Wellons[29], C. Wendt[29], S. Westerhoff[29], B. J. Whelan[2], N. Whitehorn[29], K. Wiebe[30], C. H. Wiebusch[1], D. R. Williams[40], H. Wissing[16], M. Wolf[36], T. R. Wood[21], K. Woschnagg[7], D. L. Xu[40], X. W. Xu[6], J. P. Yanez[45], G. Yodh[25], S. Yoshida[14], P. Zarzhitsky[40], J. Ziemann[20], S. Zierke[1], M. Zoll[36]**

[1] III. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany
[2] School of Chemistry and Physics, University of Adelaide, Adelaide, SA 5005, Australia
[3] Department of Physics and Astronomy, University of Alaska Anchorage, 3211 Providence Dr., Anchorage, AK 99508, USA
[4] CTSPS, Clark-Atlanta University, Atlanta, GA 30314, USA

[5] School of civistic Astrophysics, Georgia Institute of Technology, Atlanta, GA 30332, USA
[6] Department of Physics, Southern University, Baton Rouge, LA 70813, USA
[7] Department of Physics, University of California, Berkeley, CA 94720, USA
[8] Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA
[9] Institut für Physik, Humboldt-Universität zu Berlin, 12489 Berlin, Germany
[10] Fakultät für Physik & Astronomie, Ruhr-Universität Bochum, 44780 Bochum, Germany
[11] Physikalisches Institut, Universität Bonn, Nussallee 12, 53115 Bonn, Germany
[12] Université Libre de Bruxelles, Science Faculty CP230, 1050 Brussels, Belgium
[13] Vrije Universiteit Brussel, Dienst ELEM, 1050 Brussels, Belgium
[14] Department of Physics, Chiba University, Chiba 263-8522, Japan
[15] Department of Physics and Astronomy, University of Canterbury, Private Bag 4800, Christchurch, New Zealand
[16] Department of Physics, University of Maryland, College Park, MD 20742, USA
[17] Department of Physics and Center for Cosmology and Astro-Particle Physics, Ohio State University, Columbus, OH 43210, USA
[18] Department of Astronomy, Ohio State University, Columbus, OH 43210, USA
[19] Niels Bohr Institute, University of Copenhagen, 2100 Copenhagen, Denmark
[20] Department of Physics, TU Dortmund University, 44221 Dortmund, Germany
[21] Department of Physics, University of Alberta, Edmonton, AB T6G 2E1, Canada
[22] Erlangen Centre for Astroparticle Physics, Friedrich-Alexander-Universität Erlangen-Nürnberg, 91058 Erlangen, Germany
[23] Département de physique nucléaire et corpusculaire, Université de Genève, 1211 Geneva, Switzerland
[24] Department of Physics and Astronomy, University of Gent, 9000 Gent, Belgium
[25] Department of Physics and Astronomy, University of California, Irvine, CA 92697, USA
[26] Laboratory for High Energy Physics, École Polytechnique Fédérale, 1015 Lausanne, Switzerland
[27] Department of Physics and Astronomy, University of Kansas, Lawrence, KS 66045, USA
[28] Department of Astronomy, University of Wisconsin, Madison, WI 53706, USA
[29] Department of Physics and Wisconsin IceCube Particle Astrophysics Center, University of Wisconsin, Madison, WI 53706, USA
[30] Institute of Physics, University of Mainz, Staudinger Weg 7, 55099 Mainz, Germany
[31] Université de Mons, 7000 Mons, Belgium
[32] T.U. Munich, 85748 Garching, Germany
[33] Bartol Research Institute and Department of Physics and Astronomy, University of Delaware, Newark, DE 19716, USA
[34] Department of Physics, University of Oxford, 1 Keble Road, Oxford OX1 3NP, UK
[35] Department of Physics, University of Wisconsin, River Falls, WI 54022, USA
[36] Oskar Klein Centre and Department of Physics, Stockholm University, 10691 Stockholm, Sweden
[37] Department of Physics and Astronomy, Stony Brook University, Stony Brook, NY 11794-3800, USA
[38] Department of Physics, Sungkyunkwan University, Suwon 440-746, Korea
[39] Department of Physics, University of Toronto, Toronto, ON M5S 1A7, Canada
[40] Department of Physics and Astronomy, University of Alabama, Tuscaloosa, AL 35487, USA
[41] Department of Astronomy and Astrophysics, Pennsylvania State University, University Park, PA 16802, USA
[42] Department of Physics, Pennsylvania State University, University Park, PA 16802, USA
[43] Department of Physics and Astronomy, Uppsala University, Box 516, 75120 Uppsala, Sweden
[44] Department of Physics, University of Wuppertal, 42119 Wuppertal, Germany
[45] DESY, 15735 Zeuthen, Germany

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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 $\lambda_{cat}$. 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 $\sigma_{cat}$ via

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

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 $\sigma_{cat}$

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

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[a] e-mail: schoenen@physik.rwth-aachen.de
[b] e-mail: mohamed.lotfi.benabderrahmane@desy.de
[c] Physics Department, South Dakota School of Mines and Technology, Rapid City, SD 57701, USA
[d] Earthquake Research Institute, University of Tokyo, Bunkyo, Tokyo 113-0032, Japan
[e] NASA Goddard Space Flight Center, Greenbelt, MD 20771, USA

where $\sigma_0$ is the speed independent cross section (introduced in Ref. [4], $\beta$ 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, $\rho$ 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

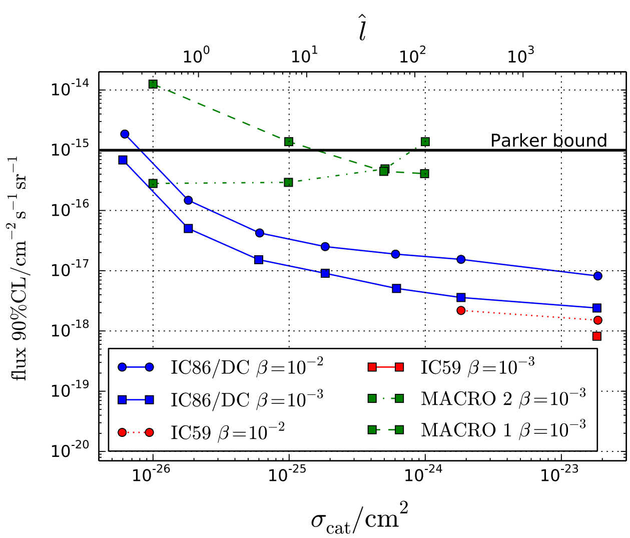


**Fig. 1** Correction of Fig. 20 in Ref. [1] showing the upper limits on the flux of non-relativistic magnetic monopoles depending on the speed $\beta$ and catalysis cross section $\sigma_{cat}$ of the IC-59 analysis and IC-86/DeepCore analysis. The dashed lines are limits published by the MACRO experiment [3]. The catalysis cross section $\sigma_{cat}$ is derived from the simulated mean free path $\lambda_{cat}$ 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)

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 $n_n$.

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 $\sigma_{cat} = 10^{-25}\,\mathrm{cm}^2$ corresponding to $\lambda_{cat} < 3\,\mathrm{m}$ by more than one order of magnitude. The IC-59 analysis is sensitive for bright monopoles with $\sigma_{cat} = 1.9 \cdot 10^{-24}\,\mathrm{cm}^2$.

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