Erratum: Constraints on long-range spin-gravity and monopole-dipole couplings of the proton [Phys. Rev. D 96, 075004 (2017)]

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In the paper, there was an error in Table I that listed existing experimental constraints on the spin-gravity coupling parameter k_i, where i denotes the particle species: electron ($i = e$), neutron ($i = n$), or proton ($i = p$). The corrected Table I is shown below, where the result for electrons from Ref. [1] has been revised by a factor of 1000. The dimensionless parameter k_i, originally introduced in Ref. [2], describes the relative strength of the spin-gravity interaction in comparison to the usual Newtonian gravitational force between masses:

$$H_g = k_i \frac{\hbar}{c} \boldsymbol{\sigma}_i \cdot \boldsymbol{g} = \chi_i \boldsymbol{\sigma}_i \cdot \boldsymbol{g} = \hbar \Omega_{gi} \boldsymbol{\sigma}_i \cdot \hat{\boldsymbol{g}}, \tag{1}$$

$\boldsymbol{\sigma}_i$ is the intrinsic spin of particle i in units of $\hbar$, $\boldsymbol{g} = g\hat{\boldsymbol{g}}$ is the acceleration due to gravity from the relevant source mass (which we note could be, for example, the Earth, Sun, or a local source mass in the laboratory), $\chi_i = k_i \hbar / c$ is the particle's gyro-gravitational ratio, and Ω_{gi} is the particle's spin precession frequency due to the spin-gravity coupling. The equivalent Eq. (1) from the paper neglected the final factor of $\boldsymbol{\sigma}_i \cdot \hat{\boldsymbol{g}}$ on the right-hand side of the expression, which should be present to account for the fact that the corresponding Zeeman shifts along the direction of the local gravitational field for a spin-$1/2$ particle would be $\pm\hbar\Omega_{gi}/2$, leading to a spin-precession frequency of Ω_{gi}. Also, importantly, if the local gravitational field is not along the measurement axis of the experiment, there is a suppression of the spin-dependent energy shift. While this was, in fact, accounted for in the analysis of the experiment described in the paper as can be seen from Eqs. (4) and (5), it was not properly accounted for in our interpretation of the results described in Ref. [1]. The leading constraints for electrons [1] are now derived from coupling to the gravitational field of the Sun, whereas the most stringent constraints for protons (in the paper) and neutrons [3] are derived from their coupling to the gravitational field of the Earth. It should also be noted that Ref. [4] derives a different value for the energy difference between a spin-up and spin-down neutron in Earth's gravitational field as compared to that published in Ref. [3], which strengthens the constraint on k_n by about a factor of two. This is not reflected in Table I, as it is based on the result published in Ref. [3].

Note that Eq. (3) in the paper, which describes the relationship between the spin-gravity coupling parameter k_i and the more commonly used scalar-pseudoscalar (monopole-dipole) parametrization (see, for example, Refs. [6–8]) is valid in general regardless of the source mass distribution. This follows from the fact that in the considered limit where the range of the new force λ is much larger than the size of the source mass and the distance from the source mass to the spins, the monopole-dipole interaction described by Eq. (2) in the paper is approximately a $1/r^2$ force, and the corresponding field is proportional to the gravitational field from the source mass.

All other conclusions and results of the paper are unaffected by this correction.

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TABLE I. Constraints (at the 90% confidence level) on the dimensionless spin-gravity coupling parameter k [Eq. (1)].

Particle	Upper limit on k	Experiment
Electron	10^4	Ref. [1]
Neutron	10^3	Ref. [3]
Proton	3×10^8	Ref. [5]
Proton	2×10^5	Original paper

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