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Searching for Spin-Dependent Exotic Interactions

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The fifth force may arise due to “new physics” beyond the Standard Model. We focus on the spin-dependent fifth forces [1] that are mediated by new particles, such as spin-0 particles (axion and axion-like particles) and spin-1 particles (e.g., light Z' particle or massless paraphoton). These new ultralight particles are also candidates for dark matter and dark energy, and may also break fundamental symmetries. Spin-dependent interactions between fermions have been extensively searched for in experiments, employing methods such as comagnetometers, nitrogen-vacancy spin sensors, and precision measurements of atomic and molecular spectra. Our research involves a theoretical reassessment of exotic spin-dependent forces. It produces a systematic and complete set of interaction potentials expressed in terms of reduced coupling constants. We conduct an extensive analysis of the existing body of experimental literature on spin-dependent fifth forces, which produces systematic exclusion plots. This leads to a comprehensive understanding of the current research landscape and provide insights for further research.

[1] L. Cong, W. Ji, P. Fadeev, F. Ficek, M. Jiang, V. V. Flambaum, H.S. Guan, D. F. Jackson Kimball, M. G. Kozlov, Y. V. Stadnik, D. Budker. Spin-dependent exotic interactions, accepted by RMP, arXiv:2408.15691 (2024). * Equal contribution.

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