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Searching for New Interactions at Sub-micron Scale Using the Mossbauer Effect

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A new technique to search for new scalar and tensor interactions at the sub-micrometer scale is presented. The technique relies on small shifts of nuclear gamma lines produced by the coupling between matter and the nuclei in the source or absorber of a Mossbauer spectrometer. Remarkably, such energy shifts are rather insensitive to electromagnetic interactions that represent the largest background in searches for new forces using atomic matter. This is because nuclei are intrinsically shielded by the electron clouds. Additionally, electromagnetic interactions cause energy shifts by coupling to nuclear moments that are suppressed by the size of the nuclei, while new scalar interactions can directly affect these shifts. Finally, averaging over unpolarized nuclei, further reduces electromagnetic interactions. We discuss several possible configurations, using the traditional Mossbauer effect as well as nuclear resonant absorption driven by synchrotron radiation. For this purpose, we examine the viability of well known Mossbauer nuclides along with more exotic ones that result in substantially narrower resonances. We find that the technique introduced here could substantially improve the sensitivity to a variety of new interactions and could also be used, in conjunction with mechanical force measurements, to corroborate a discovery or explore the new physics that may be behind a discovery.

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