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Exploring Exotic Spin-Dependent Interactions Beyond the Standard Model

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New interactions mediated by novel particles propose solutions to several important questions in modern physics.
Axions serve as examples of such particles; they are lightweight and interact weakly with ordinary matter.
This category of particles, including those similar to axions—termed Axion-Like Particles (ALPs)—emerges from diverse theoretical frameworks, including the Peccei-Quinn mechanism addressing the strong CP problem, string theory, and spontaneous supersymmetry breaking.
Given their light mass and weak coupling, ALPs are also possible candidates for cold dark matter.
Introducing these new interactions mediated by novel particles not only tackles several challenges in modern physics but also raises a crucial question: Are there undiscovered interactions beyond the Standard Model?
Many of the interactions predicted by these theories are spin-dependent, which is the primary focus of this review.
In this review, we initially outline the theoretical foundations for investigating exotic spin-dependent interactions, highlighting their importance in various models that go beyond the Standard Model.
We examine the potential roles of new lightweight particles in mediating these interactions, which may enhance our understanding of dark matter.
Relevant formulas derived from theoretical models are included to support experimental investigations.
Following this theoretical framework, we conduct a detailed review of recent experimental efforts aimed at detecting these exotic interactions.
A systematic review of current constraints on these interactions is provided, alongside an assessment of various detection approaches.

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