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Detecting Nanometer-Scale New Forces with Coherent Neutron Scattering

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Significant effort has been devoted to searching for new fundamental forces of nature. At short length scales (below approximately 10 nm), the strongest experimental constraints come from neutron scattering from individual nuclei in gases. The leading experiments at longer length scales instead measure forces between macroscopic test masses. We propose a hybrid of these two approaches: scattering neutrons off of a target that has spatial structure at nanoscopic length scales. Such structures will give a coherent enhancement to small-angle scattering, where the new force is most significant. This can considerably improve the sensitivity of neutron scattering experiments for new forces in the 0.1 - 100 nm range. We discuss the backgrounds due to Standard Model interactions and a variety of potential target structures that could be used, estimating the resulting sensitivities. We show that, using only one day of beam time at a modern neutron scattering facility, our proposal has the potential to detect new forces as much as four orders of magnitude beyond current laboratory constraints at the appropriate length scales.

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