Atomic Force Microscopy as a Probe of Quantum Vacuum Fluctuations

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Quantum vacuum fluctuations are transient electromagnetic field excitations that arise from Heisenberg's uncertainty principle, and underpin numerous physical effects such as Casimir forces, the Lamb shift, and spontaneous emission. However, directly detecting vacuum fluctuations remains an experimental challenge because of their transient nature [1][2]. Recent advances across experimental domains ranging from electro-optic sampling to tunneling junction noise analysis have enabled new methods of probing these fluctuations [1][2]. Nevertheless, directly measuring the mechanical effects of vacuum fluctuations with nanoscale resolution remains an open frontier. Hence, this project proposes using Atomic Force Microscopy (AFM) as a novel tool to probe vacuum fluctuations directly. The interaction between the AFM tip and the sample depends strongly on tip geometry, material dielectric properties, and separation distance, potentially providing distinct signatures of quantum vacuum effects [3]. Finally, this poster seeks to present a systematic literature review covering candidate materials for AFM detection along with the advantages and disadvantages of each setup.

Reference

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