Realization of a Complete Stern-Gerlach Interferometer: Towards a Test of Quantum Gravity

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The Stern-Gerlach effect, found a century ago, has become a paradigm of quantum mechanics. Unexpectedly, until recently, there has been little evidence that the original scheme with freely propagating atoms exposed to gradients from macroscopic magnets is a fully coherent quantum process. Several theoretical studies have explained why a Stern-Gerlach interferometer is a formidable challenge. Here, we provide a detailed account of the realization of a half- [1-3] and full- [4-5] loop Stern-Gerlach interferometer for single atoms [6] and use the acquired understanding to show how this setup may be used to realize an interferometer for macroscopic objects doped with a single spin [5]. We will also describe unique decoherence channels such as those relating to phonons [7,8] and rotation [9], which must be considered in such a challenging experiment. The realization of such an experiment would open the door to a new era of fundamental probes, including the realization of previously inaccessible tests of the foundations of quantum theory and the interface of quantum mechanics and gravity, including the probing of exotic theories such as the Diosi-Penrose gravitationally induced collapse.

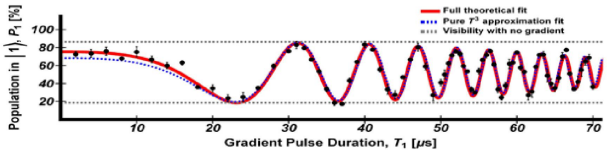

Figure 1: Spin population oscillations due to interference in a full-loop Stern-Gerlach interferometer at BGU [4]

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