Experimental report

07/09/2022

Proposal: **3-14-415**

Council: 4/2021

Title: Weak Equivalence Principle Test with Neutrons

Research area: Physics

This proposal is a new proposal

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Samples:

Instrument	Requested days	Allocated days	From	To
PF2 UCN	100	50	24/08/2021	13/10/2021

Abstract:

The weak equivalence principle (WEP), stating that all objects fall in the same way in a gravitational field, regardless of their composition, is a postulate underlying Einstein's theory of relativity. It has been tested with increasing precision throughout history. However, recent proposals to explain dark energy (such as the string-motivated dilaton) predict apparent violation of the WEP. Here, we propose to perform a full test of the WEP using neutrons and 87Rb atoms by measuring the differential acceration between the two species in qBounce and a mobile atom interferometer operated at the same place and time. The large difference in masses between n and 87Rb improves the sensitivity on the test of the differential acceleration by a factor ~100. Moreover, this would be the first WEP test using single hadrons, and the best present test of the Newton equivalence principle (equivalence of inertial and gravitational mass) using neutrons (hadrons) only.

3-14-412:

The goal of this beamtime was the precision measurement of a transition to improve the previous results obtained by the qBounce collaboration. The focus was put on the transition $|1\rangle \rightarrow |6\rangle$ since this transition had not been observed previously. Additionally the transition $|2\rangle \rightarrow |7\rangle$ was observed at $f \approx 865$ Hz (Fig, 3).

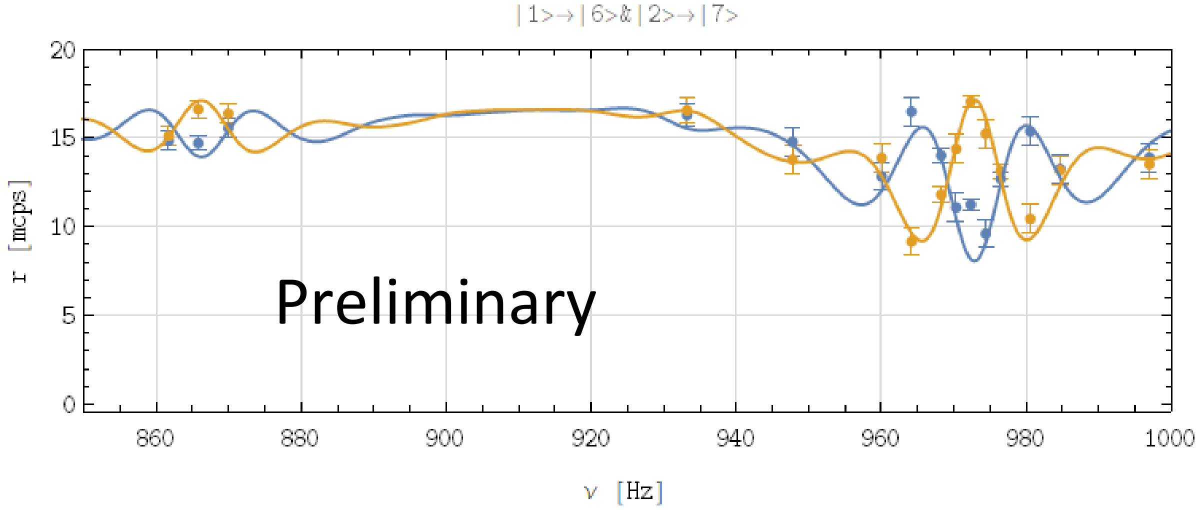

Figure 1: Observed transitions |1->|6> and |2->|7>. 0° phase seen in Blue 180° in orange. The expected theory function shown for comparison.

After this transition has been observed, the setup was changed to incorporate a spin dependent detector. With the help of a guide field inside the vacuum chamber the transmission rate for neutrons which have a spin in the direction of and opposite to the local acceleration of gravity could be measured. Because of difficulties with the detector these measurements had to be cut short. The detector had to be adjusted and compared to the second, non polarizing detector to find a potential unforeseen drop in the overall efficiency.