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Precision measurement of quantum states of neutrons in the terrestrial gravity

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Quantum states of matter in gravitational fields are expected as well as those in electromagnetic fields and nuclear fields. However, the gravitational force is extremely week compared with the forces from the others fields. Therefore, the observation of the quantum effect of gravity is very challenging. UCNs are the best candidates as a probe for the gravitational force because of their neutral charge and long lifetime. They can be reflected on a normal material surface, so can be trapped and make quantum states on the bottom mirror in the terrestrial gravity. The scale of the quantum effect is around 10 microns in length. It is in measurable order. By observing the discriminative spatial distribution in vertical, the quantum effect can visibly be demonstrated. Currently, only a few experiments that demonstrate quantum effects are reported. Keys of the experiments are UCN's flux, position resolution of a UCN detector, and fine neutron guides that select proper quantum states. I will present the initiating experiment done at the Institute Laue-Langevin in France. Then I will show our ongoing experiment using the position sensitive detector with fine spatial resolution of 3 microns. Details of the detector development will be presented. The quantum states are sensitive to non-Newtonian gravity and/or sensitive to the gravity-like force which reaches approximately 10 microns. The precision measurement has potential to search for such exotic forces.