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UCN for Testing Fundamental Symmetries

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For the field of neutron physics, standard model of particle physics requires two parameters, the quark mixing CKM matrix element V_{ud} and the ratio of axial vector to vector coupling constant λ for nuclear β decay, which are obtained from neutron life time and beta decay correlation measurements. Nuclear astrophysics requires the neutron life time to explain nucleosynthesis in the early Universe after the Big-Bang. Theories beyond the standard model, which may explain the baryon asymmetry in the universe, require neutron EDM measurement. Ultracold neutrons (UCN), which are very low energy neutrons, have a unique role in these measurements, because UCN are confined in a material bottle and a magnetic bottle, where the neutron life time, the neutron EDM and also the β decay correlation are measured. In the experimental bottle, UCN are distributed to a phase space, where the volume of the bottle as well as the maximum UCN energy is limited. Therefore, UCN phase space density is very important for these measurements. A number of groups are developing new generation UCN sources in the world. The new generation UCN sources use phonon phase space for cold neutron cooling so that the UCN phase space density is not limited by Liouville's theorem, and then increases above the value of the Maxwell-Boltzmann distribution for the cold neutrons. Experiments with the new generation UCN sources will greatly develop the field of fundamental neutron physics.