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Review of two-phase emission detectors R&D (dedicated to the memory of Prof. B.A. Dolgoshein)

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This is a review of a two-phase emission detector technology and recent progress in development of experimental programs based on this technology and goaled to search for dark matter, for novel neutrino physics and for double beta-decay. The review is dedicated to the 90th anniversary of the outstanding experimental physicist Boris Anatolyevich Dolgoshein, in whose laboratory exactly 50 years ago the first two-phase emission detector has been created. Today two-phase emission detectors found the best application in the most sensitive at the moment experiments searching for cold dark matter in the form of weakly interacting massive particles (WIMPs). A number of successful experiments arranged by ZEPLIN, XENON, LUX and PandaX collaborations with LXe emission detectors during 10 years period reduced allowed region of existence for WIMPs with mass of 40-50 GeV/c2 from 8.8⊠10-44cm2 (reported by XENON-10 collaboration in 2006) down to 1.1⊠10-46cm2 (reported by LUX collaboration at the end of 2016). Detector LZ of the second generation (G2) will be installed at Davis' cage of the Homestake mine by joint collaboration of former LUX and ZEPLIN experiments and will use 6 ton LXe active mass emission detector in order to reach sensitivity below 10-47 cm2 for spin-independent WIMP-nucleon interactions. With the increasing detector mass and sensitivity, solar neutrino interactions become an irreducible source of background for WIMP search experiments. Multiton active mass WIMP detectors of the upcoming G3 generation shall become, even with naturally occurring isotope abundances, sensitive to double-beta decay at the modern level of sensitivity and solar neutrinos interactions via elastic coherent scattering off xenon nuclei. Detectors of G3 generation such as DarkSide-20k can achieve spin-independent cross sections for WIMPs as low as ~ 7.4⊠10-48cm2 (6.9⊠10-47cm2) for WIMPs of 1TeV/c2 (10TeV/c2) mass. The RED-100 detector constructed at NRNU MEPhI can be used for investigation of recently discovered the elastic coherent electron neutrino scattering off heavy nuclei. The detector can be installed practically on the Earth's surface in vicinity to low energy neutrino sources such as NPP nuclear reactors or accelerators such as the Spallation Neutron Source. The new LBNO (Long Baseline Neutrino Observatory) experiment intends to use large Liquid Argon (LAr) double-phase time projection chamber (DLAr TPC) as one of the detectors. The consortium at CERN is now active in the construction of a large demonstrator LBNO-DEMO DLAr TPC of 3x3x1 m3 active volume. Thus the detector technology invented at MEPhI 50 years has demonstrated a great potential to be used in a variety of fundamental research programs.

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