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Recent progress in development of two-phase emission detectors to search for dark matter, novel neutrino physics and double beta-decay

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This report reviews recent progress in development of two-phase emission detector technology to search for dark matter, novel neutrino physics and double beta-decay. At the moment the 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 a 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. Multi-ton 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 recently constructed at NRNU MEPhI has been constructed for the first observation of the elastic coherent electron neutrino scattering off xenon nuclei when the detector is installed practically on the Earth's surface in vicinity to low energy neutrino source such as NPP nuclear reactor or Spallation Neutron Source. The 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 almost 50 years has demonstrated a great potential to be used in a variety of fundamental research programs.

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