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Fundamental and applied physics with reactor neutrinos

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Neutrino continue to be a source of scientific discoveries in nuclear physics, elementary particle physics, and cosmology. Two main conclusions of numerous experiments performed over past decades based on a variety of methods and with different sources of neutrinos are: i) neutrinos have nonzero mass, and ii) there is significant mixing between individual neutrino mass states. Despite these major breakthroughs, further experimental studies based on new experimental methods and using unexplored processes are urgently needed to go beyond the Standard Model, which, as we know from cosmology and particle physics, must be extended.

The history of neutrino physics is continuously linked with the reactors. It all started with the reactor based experiment [1], which first confirmed the existence of neutrinos. It is well known, that in a modern type WWER1000 reactors, an average of 200 MeV of energy is released per fission. At the same time, each fission is accomplished with emission on average of ˜ 6 electron antineutrinos. Thus, a modern reactor, for example one at Kalinin NPP, emits ˜ 6×1020 electron antineutrinos per second, having a continuous energy spectrum with maximum energies up to ˜ 10 MeV. Therefore, even at a distance of tens of meters from the reactor, it remains the most powerful available source of antineutrinos, two orders of magnitude larger than the neutrino flux from the Sun. Given that neutrinos are only weakly coupled with other particles, a huge reactor antineutrino flux is often the only way to study the properties of neutrinos.

Russian science has a fruitful history of conducting experiments with reactor neutrinos at Rovno (Rivne NPP), Krasnoyarsk and Udomlya (Kalinin NPP) (works leading by L.A. Mikaelyan, A.A. Borovoy, V.P. Martemyanov and others). The talk will provide a general overview of Russian and some international neutrino experiments at reactors. The focus will be on experiments with the latest types of semiconductor, cryogenic and scintillation detectors. It will be demonstrated that by developing of fundamental tasks of neutrino detection, the possibility of applied use of neutrinos for remote monitoring of reactors is provided.

Keywords: neutrino, fundamental problems of modern physics, detectors.

Bibliography

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