Neutrons in interdisciplinary and nuclear studies

R. Prokopowicz, M. Gryziński

National Centre for Nuclear Research, Otwock–Świerk, Poland

The MARIA nuclear reactor is high neutron flux research facility. It is operated by National Centre for Nuclear Research in Świerk near Warsaw. It is open pool, pressurized fuel channel, beryllium moderated reactor. Its nominal thermal power of 30 MW and high thermal neutron flux make it one of the highest performance research reactor in the world. For the last 14 years the reactor is being operated continuously, working over 4500 h per year. Unlike most of research reactors in the world being currently shutting-down, the MARIA reactor is expected to be operated until 2050.

The MARIA reactor is equipped with a number of various vertical channels located inside the reactor core. The vertical channels are used to expose targets to neutrons. The neutron energy spectrum in reactor is stretched from fast fission neutrons (ca. 1-2 MeV) down to thermal neutrons (i.e. in thermal equilibrium with surroundings – ca. 25 meV). The neutron flux and energy spectrum vary from channel to channel. Some channels are devoted to fast neutrons only, whereas others have well thermalized or broad spectrum. Thermal neutron flux achieves $2 \cdot 10^{14}$ $cm^{-2}s^{-1}$, whereas fast neutron flux achieves $3 \cdot 10^{13}$ $cm^{-2}s^{-1}$ inside reactor core. Beside of standard channels, the thermal neutron driven 14 MeV neutron source is located inside the core.

Thermal neutrons are used for activation whereas fast neutrons – mostly for material modification. The in-core channels can be used to investigate or verify neutron reaction cross-sections, e.g. by restoring conditions occurred during s-process considered in nuclear astrophysics.

The reactor is also equipped with seven horizontal channels guiding thermal (six channels) or fast neutrons (one channel) outside the reactor. The horizontal channels are used to investigate solid states properties, neutron diffraction, interference. They are also used to neutronography, autoradiography, work of art or device investigation, bio-medical research and for industrial applications.

It is also considering to install cold neutron source inside the MARIA reactor core. Cold neutrons are to be guided long-distance from reactor building. They can be used to investigate neutron quantum properties, including its impact on such research fields like Standard Model, baryogenesis, gravity interaction in quantum scale, dark matter and dark energy quests.

It should be also noticed that nuclear reactor can be used in nuclear physics research as a strong positron source (guided outside facility). Beside of that the reactor is very strong antineutrino source. With yield of $5 \cdot 10^{18}$ s^{-1} it exceeds solar neutrinos impact in 25 m distance from the reactor core. Such source can be used to neutrinos investigations, e.g. neutrino oscillations.