

INSTRUMENTS AND EQUIPMENT

Powerful Pulsed Neutron Sources for Research with a Pulsed Magnetic Field

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Abstract—The prospects for neutron investigations into the magnetic properties of condensed media with the use of powerful pulsed neutron sources [Japan Spallation Neutron Source (JSNS) (Tokai, Japan), TIRAN (Zababakhin All-Russia Research Institute of Technical Physics, Russian Federal Nuclear Center, Snezhinsk, Russia), Large Hadron Collider (LHC) (CERN)] and pulsed magnetic fields are considered. It is demonstrated that the diffraction measurements of the magnetic states induced by a magnetic field of up to 700–1000 kOe can be performed at the TIRAN reactor and the neutron source that can be developed on the basis of the LHC accelerator.

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At present, the maximum magnetic fields used in neutron investigations in the majority of cases have not exceeded 120–130 kOe and superconducting permanent magnets with field strengths up to 160 kOe have been employed at only two laboratories [1–3]. There exists only one spectrometer designed for performing neutron investigations with the use of pulsed magnetic fields, namely, the SNIM-2 spectrometer [4, 5] at the IBR-2 pulsed reactor of periodic operation (the reactor operates at a repetition rate of 5 pulses/s). It should be noted that the IBR-2 reactor is superior to all the other existing pulsed sources of periodic operation in conditions for the performance of experiments with pulsed fields up to 250–300 kOe.

The main factor that prevents a further increase in the field strength in experiments consists in failing magnets at high current pulses. This does not allow one to accumulate sufficient information in neutron scattering.

Therefore, the employment of pulsed neutron sources that provide peak thermal neutron fluxes higher than those at the IBR-2 reactor will permit one to obtain necessary information with a smaller number of current pulses and, hence, to expand the range of magnetic fields used.

In this paper, we consider the following three neutron sources that ensure or can ensure the most intense neutron fluxes and hold promise for investigations into the magnetic properties of materials with the use of superstrong magnetic fields:

(1) the Japan Spallation Neutron Source (JSNS) (Tokai, Japan), which should be put in operation in 2007 [6, 7];

(2) the TIRAN reactor (the reactor complex of one-time action Bars-5 with the reactor multiplier of neutrons; this reactor exists at the Zababakhin All-Russia Research Institute of Technical Physics, Russian Federal Nuclear Center, Snezhinsk, Russia) [8, 9]; and

(3) the LHC neutron source [this source will be developed on the basis of the Large Hadron Collider (LHC), CERN] [10–12].

The experimental conditions at these sources are comparable to the experimental conditions of operation with the SNIM-2 spectrometer.

The planned arrangement of the diffractometer at the TIRAN reactor is schematically shown in Fig. 1. The component of the complex, i.e., the reactor multiplier of neutrons, which is depicted in section in Fig. 2, is essentially the third reactor core and represents a cylindrical assembly of fuel elements with the inside diameter of 25 cm.

The two main synchronously operating reactor cores and the reactor multiplier of neutrons generate a fast neutron burst with a duration of approximately 90 μ s. A neutron moderator [a poly(ethylene) or water layer 30–50 mm in thickness] is placed inside the reactor multiplier of neutrons. The vacuum neutron guide and the mirror neutron guide of total internal reflection are located between the moderator and a sample.

The single crystal oriented with respect to the diffraction reflection from a specified crystallographic plane is placed inside the magnet located at a distance of 20 m from the moderator. When the field pulse is synchronized with the neutron source burst, it is possible to obtain a time-of-flight spectrum similar to that depicted in Fig. 3. A change in the magnetic structure

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