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Control system of filling of chamber for cryogenic moderator of IBR-2 research reactor

A. Bogdzel, A. Verhoglyadov, V. Zhuravlev, S. Kulikov, F. Levchanovsky, E. Litvinenko, A. Petrenko, A. Sirotin, A. Churakov, E. Shabalin
Joint Institute for Nuclear Research, Dubna, Russia

E-mail: verhoglyadov_al@mail.ru

Abstract. High-performance cold neutron moderator for the IBR-2 reactor is manufactured at the Frank Laboratory of Neuron Physics and operates in normal mode at present. Material for cold moderator is mixture of mesitylene and m-xylene in the form of solid beads with diameter of about 3-4mm. These beads are replaced in the moderator's chamber periodically. Uniformity of chamber volume filling is one of the problems of moderator operation. Observation of filling process is realized by acquisition of 2D images of moderator on two coordinate PSD by the method of "camera-obscura". Ready-built monitoring system allows controlling the level of working medium in chamber of moderator, to measure neutron spectra and to control of warming and drain of used mesitylene. At the present time monitoring system is installed at 8th channel of IBR-2 reactor, it detects 12- times gain of 6-10Å neutron flux with using of new moderator. Also absence of appreciable spectrum degradation was observed.

1. Introduction

The unique system of cryogenic neutron moderators is being installed on research pulsed reactor IBR-2 at the Joint Institute for Nuclear Research in Dubna at present time [1,2]. Slow, «cold» neutrons with wavelength higher than 0.2-0.3 nm is necessary instrument for research of new complicated nanostructures by the methods of neutron scattering, including organic materials and biological objects. Original design of new of new cryogenic moderator on solid mesitylene with its high parameters will provide the leadership of research reactor IBR-2 between worlds pulsed neutron sources.

High-performance cold neutron moderator for the IBR-2 reactor operates in normal mode at present. Material for cold moderator is mixture of mesitylene and m-xylene in the form of solid beads with diameter of about 3-4mm. These beads are replaced in the moderator's chamber periodically. Uniformity of chamber volume filling is one of the problems of moderator operation. Observation of filling process is realized by acquisition of 2D images of moderator on two coordinate PSD by the method of "camera-obscura".

2. Observation system of CM chamber

In the process of operation of cryogenic moderator a number of tasks related to the control of the moderator chamber occur:

1. Receive two-dimensional images of the loaded mesitylene to control the filling of the chamber.
2. Measure the neutron spectrum from the moderator at different temperature of the working medium. Record the change of neutron spectrum within the cycle of the reactor (degradation of the spectrum).

3. Control the process of annealing and drain of the working medium after the cycle of the reactor. Control the level of mesitylene and neutron spectrum.

Two-dimensional image of the surface of a moderator is formed on a position-sensitive detector when thermal and cold neutrons from the moderator pass through a small (about Ø0.5 mm) horizontal slit in cadmium diaphragm [3]. Fig. 1 presents simplified scheme of experiment of control system of cold moderator filling with using the method of "camera-obscura". Two-dimensional image of moderator's surface is formed on position-sensitive detector by transmission of thermal and cold neutrons through small (about Ø0,5mm) horizontal slit in cadmium diaphragm. Obtained image gives reverse one-dimensional distribution of neutron flux on the surface of moderator in vertical direction. The image is averaged out in horizontal direction. Scale of image is determined by distances between PSD, diaphragm and moderator. The distances A and B on the Fig.2 are realistic and images come out smaller than actual size of moderator (reduction k=A/B≈0,295). The shield of PSD and collimators of borated polyethylene (brown color on figure) are used for reduction of background. Vacuum volume occupies most part of neutrons' trajectory and decreases neutron losses in the air.

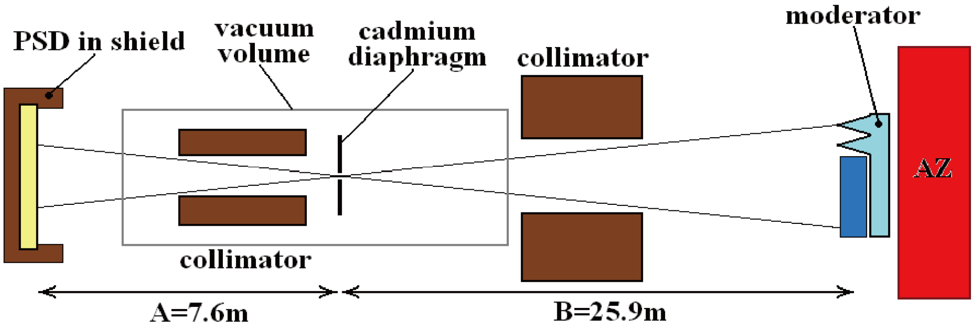

Figure 1. Layout of the experiment with a gap on 8th channel of IBR-2.

Neutron spectrum is measured by time-of-flight method.

Equipment is installed at 8th channel of IBR-2 reactor, which axis is orthogonal to the face plane of moderator. Position-sensitive detector [4] has a working area of 180x180mm. It is placed so that the centre of the detector is on the horizontal axis of spectrometer (Fig 2).

Figure 2. PSD in shield is installed on 8th channel.

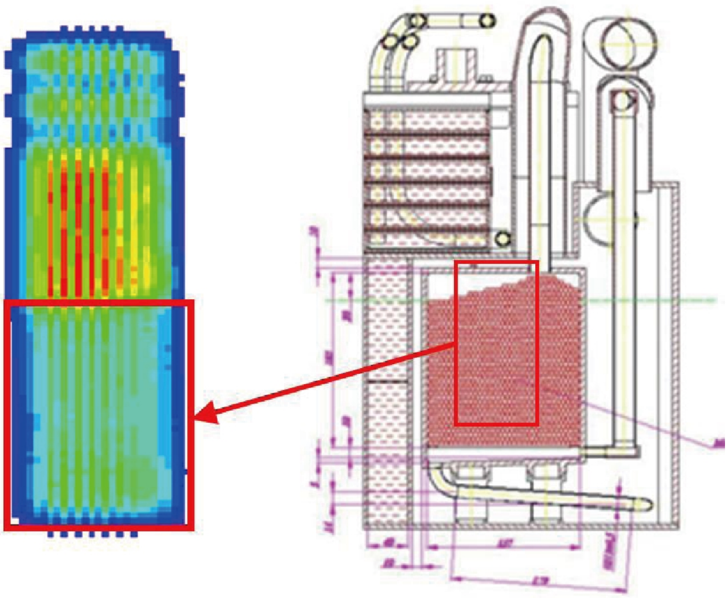

Figure 3. Correspondence between image and moderator chamber. Rectangle shows the working medium of the moderator. The image is obtained with neutrons λ = 0.7Å and higher.

The electronic block of data acquisition consists of discriminator, high voltage unit, block of delays and power supply, installed in a rack. Signal from rack together with signals of reactor starts are transmitted to the PC where they are processed by software DeLiDAQ [5].

3. Results

The obtained two-dimensional image for thermal neutrons is shown in Fig. 3. The figure shows the correspondence between image and real moderator chamber.

On Fig. 3 one can clearly see the level of mesithylene in the chamber.

2D images and spectra of new cryogenic moderator were obtained in experiments on the beam. The gain of cold neutron flux and decrease of thermal neutron flux were determined for temperature of mesitylene equal 30K and 100K.

Control system for chamber of cryogenic moderator with method of "camera-obscura" is created and operates in normal mode on IBR-2 at present.

The first results of operation of cold moderator are described in [6]. Neutron spectra of cryogenic moderator were measured at different temperatures of mesithylene (Fig. 4). Addition of cold moderator to the water premoderator gives gain-factor of cold neutrons of about 13. 2D images of moderator's working substance were obtained, it allowed to control of filling and draining of chamber.

4. Conclusion

The system of control and measuring equipment, designed for cryogenic moderator IBR-2 reactor, satisfies all the requirements and is simple to use. All control subsystems are combined in two personal computers, so all information about the state of the system is displayed and saved. Access to the system of measuring instruments is organized via network. The first working cycles of moderator confirmed the reliability and stable operation of the whole control system.

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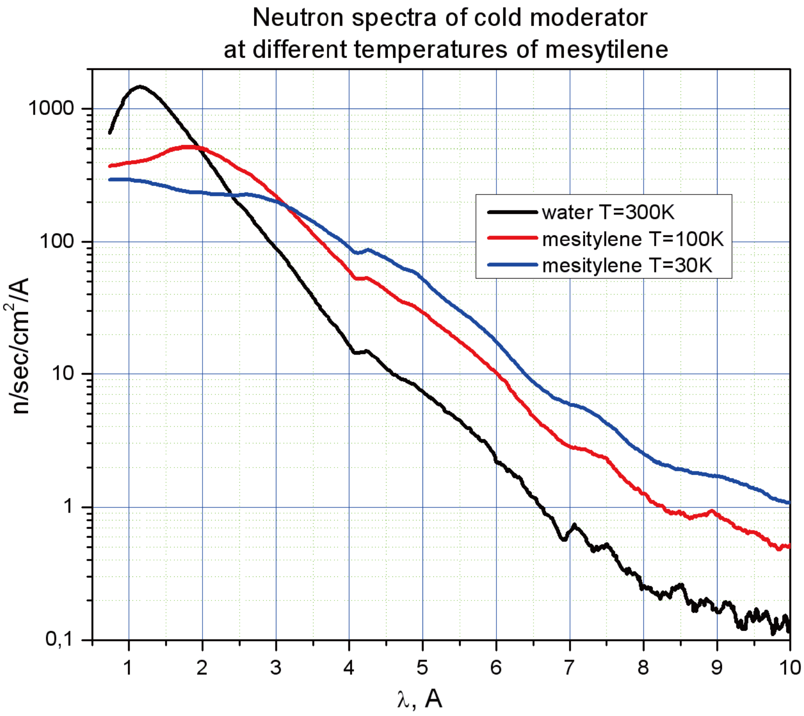

Figure 4. Neutron spectra obtained from the surface of the cryogenic moderator.

The main results, obtained by using of system:
- neutron spectra of cryogenic moderator
- gain-factor of cold neutrons is about 10-12
- 2D images of moderator's chamber
- control of filling and draining of chamber.

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