NEUTRON FILTERED BEAM TECHNIQUE AT THE KYIV RESEARCH REACTOR (KRR)

Description

The neutron filter technique is characterized by the transmission of neutron beams emanating from nuclear research reactors through relatively thick (up to 2–2.5 m) layers of materials with deep interference minimums in the total neutron cross sections. As a result of passing through these interference minimums, narrow energy range "filtered" neutrons emerge as quasi-monochromatic beams. Figure 1 below provides a cross-sectional view of the proposed neutron filer as located in the reactor's horizontal experimental channel.

Quasi-monochromatic neutron beams emerge from the filters with the following energies and half-widths: E_n(keV) = 1.86 (1.46), 3.57 (1.68), 7.5 (0.1), 12.67 (1.2), 24.34 (1.8), 56.37 (0.55); 58.8 (2.7), 133.3 (2.8), 148.3 (14.8).

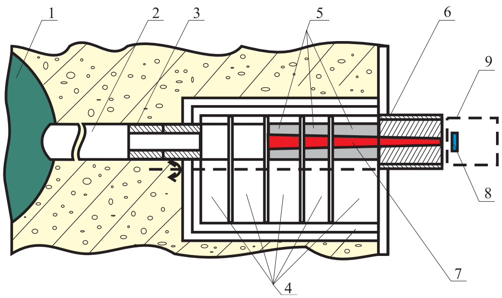

Fig. 1. Schematic of neutron filtered beam facility (1 – beryllium reflector; 2 – horizontal channel tube; 3 – preliminary collimator; 4 – beam shutter disks; 5 – filter-collimator assembly; 6 – outer collimator; 7 – filter components; 8 – research samples; 9 – device for samples removing.)

Innovative Aspect and Main Advantages

The KRR has specialized in neutron filters for more than 20 years, with a very significant amount of knowledge and experience accumulated-characterized by the following:

- The filtered neutron beams emerging are of among the highest flux values in the world for the kiloelectron volt energy range: 105–108 neutrons/sec·cm^2. This provides an opportunity to conduct unique and very precise measurements.
- Large quantities of highly enriched (stable) iso-tope (such as ^{52}Cr, ^{54,56,57}Fe, ^{58,60}Ni, etc) are available at the KRR facilities for designing and constructing specific energy-range filters which provide very high neutron fluxes within narrow (i.e., "clean") energy bands.

Areas of Applications

1. High precision measurements (0.1–0.01 %) of total and partial cross sections for fundamental neutron-nuclear investigations.
2. Precise measurements (to 1 %) of neutron cross sections to obtain averaged nuclear parameters (σ_t, σ_s, σ_γ, σ_f, S_o, S_1, S_2, R_o, R_1, D, $<\Gamma_\gamma>$).
3. Measurements of neutron capture gamma-spectra.
4. Measurements of σ_{inel} for the first exited levels of heavy nuclides.
5. Measurements of activation cross sections.
6. Isomeric ratio investigations.
7. Doppler-Effect Investigations.
8. Time-of-flight method used for precise cross section measurements of σ_t, σ_γ, σ_{inel}.
9. Research of radiation damage energy dependence in materials.
10. Neutron radiography and tomography.
11. Biomedical investigations.
12. Neutron and Boron-neutron capture therapy.
13. Measurements of the average energy loss $W(E)$ for ion-pair generation.
14. Prompt Gamma-ray Activation Analysis (PGAA).
15. Development of standard fluxes for neutron-dosimetry.
16. Energy calibration of proton recoil counters.

(1–8 refer to scientific research areas, while 9–16 pertain to technological applications)

Stage of Development

Naturally-occurring and enriched isotopes used in the development of neutron filters include:
Natural: Si, Al, V, Sc, S, Mn, Fe, B, Ti, Mg, Co, Ce, Rh, Cd, LiF.
Enriched: ^{52}Cr (99.3), ^{54}Fe (99.92), ^{56}Fe (99.5), ^{57}Fe (99.1), ^{58}Ni (99.3), ^{60}Ni (92.8–99.8), ^{62}Ni (98.04), ^{80}Se (99.2), ^{10}B (85), ^{7}Li (90).

Three horizontal channels at the KRR are currently equipped with such neutron filters and with experimental installations for the precise measurement of total, scattering and capture cross sections. There is also the possibility to study capture gamma ray spectra with a Ge spectrometer characterized by its high resolution and angle distribution of scattered neutrons. Each of the filters is easily replaced by another to meet beam characteristic requirements, and the development of new filters is currently in progress for producing neutron energies up to 1000 keV.

Contact Details

Olena Gritzay, Ph.D.
Institute for Nuclear Research National Academy of Sciences of Ukraine
Neutron Physics Department
Prospect Nauky, 47, Kyiv 03680, UKRAINE
phone: (380-44) 525-3987; **fax:** (380-44) 525-4463
E-mail: ogritzay@kinr.kiev.ua