5.3. CURRENT RESEARCH WORK AT THE TRIGA REACTOR IN LJUBLJANA, M. Najžer and V. Dimic (Ljubljana, Yugoslavia)

1. Introduction

The research programmes at our TRIGA reactor cover quite broad and different research fields. They can be grouped in the following topics: reactor dynamics and operation, neutron activation analysis, solid state physics research, reactor dosimetry, radiography and fuel burn-up determination. In this presentation a short overview is given of those investigations which are not described in detail in separate papers.

2. Reactor dynamics and operation

The research work is presented in three separate contributions: "Digital Reactivity Meter", "Power Spectra of Stochastic Signals in Reactor TRIGA" and "Improvements of the TRIGA Mark II Instrumentation and the Direct Digital Control by Microprocessors".

3. Neutron activation analysis

A review of this work is given in the contribution: "Research Work at the Nuclear Chemistri Section of the J.Stefan Institute".

4. Solid state physics research

For the investigations in the field of solid state physics at the reactor TRIGA the following instruments are used: the slow neutron time of flight spectrometer with rotating monocrystal of lead, the cold neutron source with a solid methane as a moderator in order to increase the slow neutron flux and the neutron diffractometer.

Since the last TRIGA Conference the studies by neutron scattering technique of dynamics and the positions of the water molecules in biological samples of LiDNA and NaDNA with different content of H_2O and D_2O have been finished (1). The water molecules in the samples were found to be arranged in a more or less regular way. Thus the water molecules could be considered as "bound" to hydrogen bonding sites at the surface of the DNA molecule. It was also concluded that the mobility of the water molecules in the NaDNA film was considerably smaller than in bulk water.

The slow neutron scattering investigation of anisotropic liquids is a tittle of the project with IAEA which is carried out at the reactor. A detaile investigation of liquid crystal Cholesteryl Propionate, Cholesteryl Myristate and others is performed. To this effect the temperature dependence of neutron scattering spectra in cholesteric solid and isotropic liquid phase were obtained.

With the neutron diffractometer the hydration of different types of cement was investigated. It was found that it is possible to estimate physical behaviour (strenght etc.) of the

concrete within few hours.

A new research programme has started very recently. This involves studies of the molecular dynamics of a macromolecule polyethylene oxide in aqueous and non-aqueous solutions and of the influences of the macromolecule on the molecular dynamics of water molecules.

5. Reactor dosimetry

Investigations are concentrated to three topics: Measurements of fission spectrum averaged activation cross-sections, study of spectrum unfolding methods and aplication of fast neutron spectrometry. Using ^{235}U fission neutron source located in the exposure room integral activation cross-sections for reactions $^{27}Al(n,p)$, $^{27}Al(n, alpha)$, $^{115}In(n, n')$, $^{64}Zn(n, p)$, $^{56}Fe(n, p)$, $^{24}Mg(n, p)$ and $^{19}F(n, 2n)$ were determined. A recent measurement of the Np-In integral cross-section ratio is presented in a separate paper. Results of developement of spectrum unfolding programs is given in the paper "Present Developement and Use of the ITER-II Based Unfolding Programmes". Using a set of fifteen activation and fission detectors the fast neutron spectrum in TIF (TRIGA Irradiation Facility), described at Pavia TRIGA Conference, was determined. The tissue fast neutron dose calculated from the neutron spectrum and neutron energy kerma conversion factors was found to be in good agreement with the dose measured directly by a pair of ionization chambers. Both TIF and fission neutron source are used as reference neutron fields for investigation and calibration of personal neutron dosimeters.

6. Radiography

Most efforts were devoted to the development of neutron induced autoradiography and its application for boron determination. It was shown that the sensitivity of the method is greatly dependent on the irradiation conditions and is as low as 1 ppm of boron using our exposure room. The spatial resolution of the method was measured using a knife-edge test object and was found to be strongly dependent on the size of the tracks in the solid state track detector used as the recording material. Resolution of approximately 4 um can be achieved employing thin LR-115 detector. Results of a study of detectability of the method are given in the separate paper "Estimation of the Smallest Detail Discernible in Track-Etch Autoradiography". The method was applied to the determination of microdistribution of boron in steel and aluminium samples.

Recently a new technique for radiography of surface layer has been developed. It is described in contribution "Beta-Ray Backscatter Radiography in the Surface Topography Investigation of Mineralogical and Ore Samples".

7. Fuel burn-up determination

Concentration and axial distribution of the fission product ^{137}Cs was measured in a TRIGA fuel element by a Ge-Li spectrometer. The element was in the C-ring of the core for about five years and then cooled before scanning for six years. The ^{235}U content of the fresh element was 37 grams. The axial distribution of the burn-up is unsymmetrical being higher at the lower end of the element. The highest burn-up of about 10 % is in the middle of the element falling down to about 4 % at the upper end. Some ^{137}Cs activity was found also in that part of the element filled with graphite reflector.

List of papers *

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2. B.Mavko, Reference Power Spectra of Some Stochastic Signals in Reactor TRIGA, ibid.,
3. U.Dahlborg, V.Dimic, Slow neutron scattering from oriented DNA films, to be published,
4. V.Dimic, Investigations of Dynamical and Structural Properties in Solid State Physics by Thermal Neutrons, ibid.,
5. V.Dimic, Radioactive Isotope Production in the Reactor TRIGA, ibid.,
6. M.Najžer et al., Development and Utilization of Experimental Methods in Reactor Dosimetry, ibid.,
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8. R.Ilić et al., Neutron Induced Autoradiography as a Non-Destructive Testing Method, ibid.,
9. J.Rant et al., The Development of Neutron Radiography at the TRIGA Mark II Reactor in Ljubljana, ibid.,
10. G.Pregl et al., Nondestructive Examination of TRIGA Reactor Fuel Elements, ibid.,
11. M.Najžer and J.Rant, Spectrum Averaged Cross-Section Measurements in the Fast Neutron Field of a Uranium Fission Plate, Neutron Cross-Sections for Reactor Dosimetry, Proc. of a Consultants' Meeting, Vol.II,247,IAEA, Vienna 1978,

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* Papers on neutron activation analysis are listed in a separate contribution

12. M.Najžer, On the Possibility of Unfolding Simultaneously Data from Multiple Foil, Proton Recoil and Other Neutron Spectrometers by the SAND II Type Unfolding Codes, ibid 411,

13. M.Čopič et al., Autoradiography of Uranium Ores, Proc. XXI. Yug. Conf. ETAN, Banja Luka (1977),

14. R.Ilić et al., Utilization of SSTD Detectors in Metallurgy, Yug. Symp. on Metallurgy, Beograd 1977,

15. A.Podgornik et al., Bestimmung der Verteilung von Bor in Aluminium mit der Methode der Neutronen Induzierter Autoradiographic, III. Aluminium Konferencia, Szikesfehervar, April 1978,

16. R.Ilić et al., Grain Refinement of Aluminium with Boron and Titanium, III. Yug. Symp. on Aluminium, Šibenik, April 1978,

17. R.Ilić et al., Grain Refinement of Aluminium with Titanium and Boron, 4th International Congress for the Study of Bauxites, Alumina and Aluminium, Athens, Oct.1978.