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Neutron Scattering at Australia's Replacement Research Reactor

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On August 25^{th} 1999, the Australian government gave final approval to build a research reactor to replace the existing HIFAR reactor at Lucas Heights. The replacement reactor, which will commence operation in 2005, will be multipurpose with capabilities for both neutron beam research and radioisotope production. Cold, and thermal neutron sources are to be installed and supermirror guides will transport cold and thermal neutron beams into a large modern guide hall. The reactor and associated infrastructure is to be built by INVAP, SE and subcontractors under contract. The neutron beam instruments will be developed by ANSTO in consultation with the Australian user community and interested overseas parties. We review the planned scientific capabilities, give a description of the facility and a status report on the activities so far.

KEYWORDS: facilities, neutron sources, research reactors

§1. Introduction

Neutron beam science began in Australia with the commissioning of the HIFAR research reactor at the Lucas Heights Research Laboratories in 1958. Over its lifetime HIFAR has operated with HEU fuel generating 10 MW thermal power and a thermal neutron flux of 1×10^{14} n/cm^2/s and providing neutrons for science, radioisotope production and NTD silicon. ANSTO is now working to replace the HIFAR research reactor by the end of 2005. The new reactor is to be a multipurpose reactor operating with LEU fuel at 20 MW thermal power and a thermal neutron flux (unperturbed) of 4 $\times10^{14}$ n/cm^2/s. It will have improved capabilities for neutron beam research and for the production of radioisotopes for pharmaceutical, scientific and industrial use. The neutron beam facility is intended to cater for Australian scientific, industrial and medical needs well into the 21^{st} century.

§2. The Scientific Capabilities

The scientific capabilities of the neutron beams at the replacement reactor were planned in consultation with representatives from academia, industry and government research laboratories to address the scientific priorities of the Australian research community. The aim is to provide a facility for condensed matter research, not only in the traditional disciplines of physics, chemistry and materials science, but also for the expanding areas of life sciences, engineering and earth sciences. Cold and thermal neutron sources are to be installed from the beginning, with provision for a hot neutron source in the future. Neutron guides will be used to position most of the neutron beam instruments in a neutron guide hall outside the reactor confinement building. Eight instruments are planned for 2005, with a further three to be developed by 2010. The initial suite of instruments will build on the traditional strengths of the Australian neutron scattering community in the areas of cry stallography, materials science and polarised-neutron techniques, and will expand into cold neutron techniques such as small-angle neutron scattering and reflectometry and instruments with an industrial focus, such as residual stress. Subject to support from special interest groups in Australia and overseas, other neutron beam instruments may also be developed.

§3. Description of the Facility

The reactor and all the associated infrastructure, with the exception of the neutron beam instruments, is to be built to ANSTO's specifications by an accredited reactor builder INVAP, SE and their subcontractors in a turnkey contract. Subcontractors involved in the construction of the neutron beam facility include the St. Petersburg Nuclear Physics Institute for the cold neutron source and Mirrotron for neutron guide systems. The cold neutron source will be a vertical liquid deuterium thermosyphon. It will be $\sim$ 20 litres in volume and re-entrant in the direction of the cold neutron guides. The budget for construction of the facility is AU$278M, including cold neutron source and neutron guides.There is a separate budget for construction of the neutron beam instruments. The layout for the neutron beam facility is illustrated in the Fig. 1. The facility will be based, as far as possible, around a neutron guide hall that will be served by two thermal and two cold neutron guides. This removes the space restrictions that tend to limit the development of reactor face instruments and offers the benefit of a substantial reduction in background radiation. Separation of the neutron beam facility from the reactor operations and the irradiation facilities will also reduce congestion and access restrictions that hamper scientific activities at the HIFAR reactor. As the facility is expected to provide a basis for high quality neutron beam research for the first half of the twenty first century, the design includes considerable flexibility to cater for potential

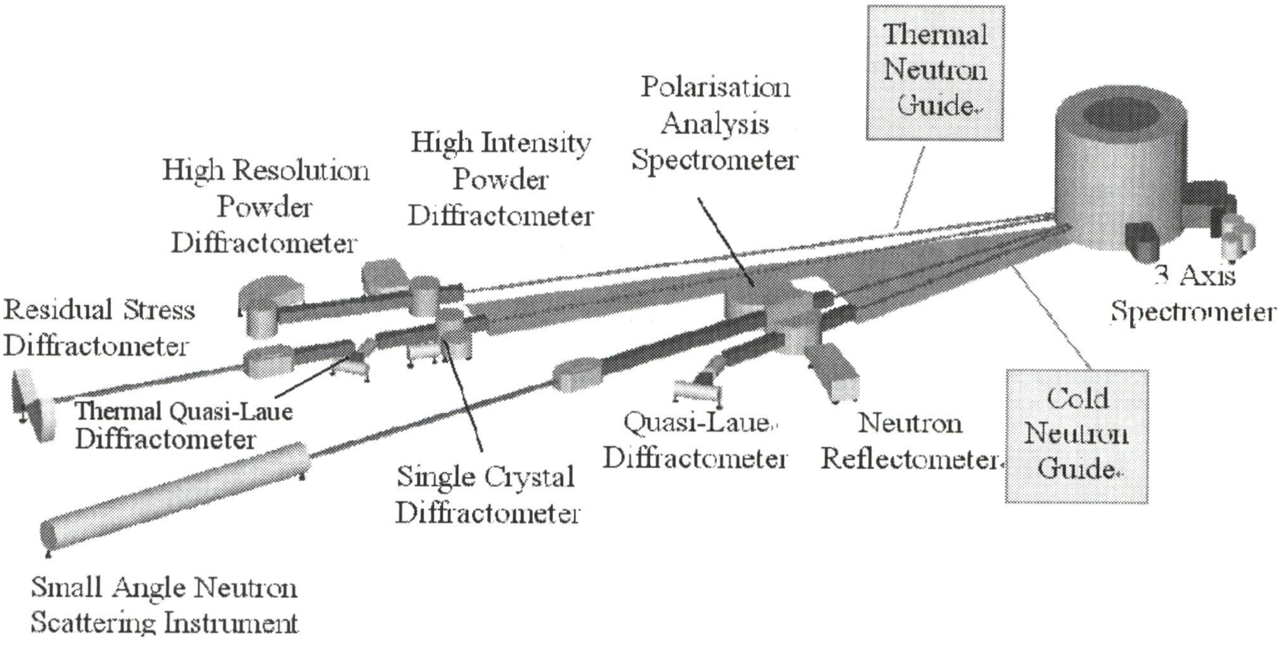

Fig. 1. The neutron beam facility at the Australian Replacement Research Reactor.

Table I. Planned Instrument configuration for Australia's Replacement Research Reactor. Solid circle (•) and open circle (○) represent instruments to be ready at reactor startup and currently under review, respectively.

Beam line	Planned Neutron Beam Instruments	Guide characteristics	Calculated Neutron flux (n/cm^2/sec)	Wavelength peak (Å)
TG1	•High Intensity Powder Diffractometer •High Resolution Powder Diffractometer ○Neutron Radiography	300 mm × 50 mm m=3 supermirrors radius of curvature 4.5km	$\sim 1.5 \times 10^9$	1.3
TG2	(stop at reactor face)	150mm × 50 mm m=3 supermirrors radius of curvature 4.5km		
TG3	•Residual Stress Diffractometer ○Four Circle Diffractometer •Thermal Neutron Quasi-Laue Diffractometer			
TG4	•Thermal Neutron Triple Axis Spectrometer	200mm × 50 mm m=3 supermirrors	$\sim 2.6 \times 10^{10}$	1.1
CG1	•Polarisation Analysis Spectrometer •Small Angle Neutron Scattering Instrument	200mm × 50 mm m=3 supermirrors coating top and bottom and m=2 supermirror coating on sides radius of curvature 1.3km	$\sim 4 \times 10^9$	3.9
CG2	(stop at reactor face)			
CG3	•Neutron Reflectometer ○Cold Neutron Quasi-Laue diffractometer			
CG4	○Cold Neutron Triple Axis Spectrometer		$\sim 1.3 \times 10^{10}$	3.3
HB1 & HB2	Not Decided	200mm × 50 mm collimators only (no reflecting coatings)	$\sim 3 \times 10^{10}$	1.1

changes in utilization. Capacity beyond the initial suite of instruments will be achieved by building neutron guides on extra cold and thermal beam lines that terminate at the reactor face. Provision has also been made in the design to replace the thermal and cold neutron beams opposite the neutron guide hall in the reactor hall with neutron guides to transport beams to a second guide hall. This would allow for a more substantial expansion of the facility. Provision has also been made for later installation of a hot neutron source that would feed two neutron beams at the reactor face.

§4. The Neutron Transport System and Beam Instruments

Efficient transportation of thermal and cold neutrons to the guide hall requires the use of modern *super-mirror* reflecting guides. By installing *super-mirror* guides we expect to deliver beam fluxes to the instruments that are comparable, and in some cases exceed, those enjoyed at the world's leading facilities. The characteristics of the neutron beamlines, ANSTO's estimates of neutron flux and the location of the planned neutron beam instruments are summarized in Table 1. The eight instruments that are to be ready at reactor startup have a solid circle and those that are under review have an open circle. The neutron beam instruments will be developed by ANSTO and other contracted organizations in consultation with the user community and interested overseas scientists. Conceptual design and recruitment of scientists for the instrument development has begun and will proceed throughout 2001. Further information on the neutron beam instrument development program can be found at the website 'http://www.ansto.gov.au/neut/'.