Report of the Working Group on Applications

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Cold moderators on pulsed sources serve a dual purpose: to provide low energy neutrons for direct application in research and to improve the pulse shape in what is conventionally called the “thermal” energy regime for better resolution in time-of-flight measurements. While the latter was originally the main driving force behind the use of cold moderators on pulsed sources, the former has become increasingly important in the past several years and has helped to make pulsed sources strong competitors in this field to reactors with cold moderators. The science and research in which cold neutrons can be applied with great advantage has been broadly covered in many publications, the most recent ones being the proceedings of workshops held on behalf of AUSTRON in 1994 [1], the Oak Ridge Spallation Neutron Source in 1997 [2] and, in particular in the scientific case drawn for the European Spallation Source project (volume 2 of the feasibility study) [3] and the Autrans study [4].

For these reasons, the working group did not consider it beneficial to reiterate these well treated subjects but tried to pay attention to applications a bit off the main stream and, in particular, pay attention to opportunities relatively small accelerator-based neutron sources might offer.

Several areas of applications were discussed by this group. Bauer brought up the use of cold neutron radiography for determining B concentration in thin tissue samples as a test facility for BNCT. This would use track etching to form high resolution spatial distribution measurements. Radiography for engineering is another possibility, but increased contrast may come at the expense of decreased penetration. Neither of these techniques requires a pulsed source however, although in the radiography case it may be helpful.

Lucas mentioned use of cold neutrons for detection of flaws in e.g., welds, but issues of source strength and time required to make measurements may make this impractical. This could extend to industrial use such as measurement and identification of stress in component parts under operating conditions. Use of neutron radiography in lubrication studies was also mentioned, although whether cold neutrons offer any advantage here is also not clear.

Shabalin discussed some recent use of cold neutrons for surface studies which require wavelengths longer than thermal neutrons. He also discussed ultra cold neutron production and some interesting results in trapping of UCN in Be metal.

Lanza brought up the development of small accelerator based cold neutron sources. The idea would be to examine the usefulness of systems which could be used by researchers in their own lab rather than traveling to a national facility. Such systems would produce lower source strengths but could be useful in certain applications, particularly if the system were optimized for a limited number of applications. From estimates of reasonable times for SANS experiments (2 hr for 5 x 10^5 counts), he estimated that source strengths (unmoderated) of 10^11 n/s would be required. Candidate accelerators include low energy RFQs for ions e.g. 3 MeV d+ on Be, or photoneutron production using 10 MeV electron LINACS.

Issues include the choice of accelerator type, the time structure of the accelerator, and the determination of the neutron spectrum. Some reactions such as D on Be may have large enhancements of the neutron spectrum in the low energy regime (100 keV or less) and hence smaller moderators could be used.

Brun pointed out that such a system could be thought of as a small bright spot source and would be particularly advantageous for SANS and also for transmission radiography. There was agreement that more detailed calculations are required for such sources. A small system could be used not only for taking data but for testing of samples before going to a larger facility. Small systems may also be closer match to the time scale of many users in terms of total time required to obtain experimental data. The experiences of x-ray diffraction work is that it is often faster to do the preliminary and even final experimental work on a small system rather than travel to a distant synchrotron light source.
It was pointed out that a small pulsed neutron source could be used for design studies on larger cold moderators and also for verification of design methods. For this application, adjustable pulse widths and rep rates would be important. Crawford mentioned the use of small sources which could be used with simple geometries to test kernel and moderator designs.

One obvious opportunity which is completely missing, at present, in the US is an easy test facility for novel concepts for cryogenic moderators. Such a facility exists in the Hokkaido electron linac in Japan and another one is being planned for installation at the COSY synchrotron in Julich, Germany. Rapid uncomplicated access to such a facility is an important ingredient to any cold moderator development program because, especially in this field, computational methods are still far from giving reliable answers in all situations and need to be validated with the help of experimental data. The group briefly considered the opportunity coming up at the AGS in Brookhaven (for more details see the report by the subgroup on Testing Methods and Facilities) and concluded that, while this was a valuable and indispensable opportunity to carry out full scale tests on more or less fully engineered target systems, it did not provide the flexibility required for rapid testing of novel ideas and for the generation of a comprehensive data base on moderator materials. Such an opportunity would, however be highly desirable in the US and could use a relatively low power accelerator.

Crawford discussed several experiments that could be done using a small ($10^4$ n/s) source. SANS appears to be a good use. It appears that with reasonable path lengths (7.5 m) and detectors, data sets could be obtained in hours. He also mentioned chemical spectroscopy of bulk samples. Currently this typically takes about 6 hours on IPNS but a factor of 30 will be possible with new instruments. This may make this a possible application for small sources. Powder diffraction at IPNS is now done in ~ 0.5 hr at high resolution. Relaxing the resolution would also make this possible with a small source. The fact that some real spectroscopy measurements were made at the ZING-P prototype facility at Argonne (~$10^5$ n/s) lends support to the idea of performing chemical spectroscopy with such small sources.

The components are in place to develop such small accelerator-based cold neutron sources. Refrigerators are available capable of about 2 - 3 W at 20° K. This would be a starting point to examine the feasibility of a compact cold source. Small accelerators have been developed which are commercially produced and which could form the basis of systems. Similarly, detectors are also commercial products.

Our conclusion is that small accelerator-based pulsed cold neutron sources could be developed using commercial accelerators and that they could be used by researchers outside of national laboratory sites. These would be particularly suitable for location at a university. There they could be used as an additional tool to support science programs, as well as a tool for training accelerator scientists, nuclear engineers, and neutron scattering scientists.

REFERENCES


