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Report on the International Workshop on Cold Moderators for Pulsed Neutron Sources

J. M. Carpenter
Intense Pulsed Neutron Source
Argonne National Laboratory
Argonne, IL 60439

The International Workshop on Cold Moderators for Pulsed Neutron Sources resulted from the coincidence of two forces. Our sponsors in the Materials Sciences Branch of DOE's Office of Energy Research and the community of moderator and neutron facility developers both realized that it was time. The Neutron Sources Working Group of the Megascience Forum of the Organization for Economic Cooperation and Development offered to contribute its support by publishing the proceedings, which with DOE and Argonne sponsorship cemented the initiative.

This workshop was the second of its kind. The earlier one, the International Workshop on Cold Neutron Sources, took place at Los Alamos National Laboratory March 5-8, 1990 [1].

Although originally our idea was to convene the meeting on the windswept shore of Lake Michigan in February, this and other notions for venues and dates did not work out. Finally we took the waning opportunity to use Argonne's *gemütlich* old Freund Lodge. The workshop took place September 28-October 2, 1997, with meals served in the Lodge and meetings held in the IPNS office area. Participation was by invitation, which, as workshop organizer, I arranged after consulting with my colleagues who are prominent in the field. Thirty-two scientists took part, representing sixteen institutions from eight countries, on four continents in two hemispheres. This demonstrates the 2ⁿ rule of conference organization (an unplanned outcome) and the unity of one world in science. Laura J. Miller served as our super-effective workshop secretary during all phases of workshop planning and execution.

The purposes of the workshop were:

- to recall and improve the theoretical groundwork of time-dependent neutron thermalization
- to pose and examine the needs for and benefits of cold moderators for neutron scattering and other applications of pulsed neutron sources
- to summarize experience with pulsed source cold moderators, their performance, effectiveness, successes, problems and solutions, and the needs for operational data
- to compile and evaluate new ideas for cold moderator materials and geometries
- to review methods of measuring and characterizing pulsed source cold moderator performance
- to appraise methods of calculating needed source characteristics and to evaluate the needs and prospects for improvements
- to assess the state of knowledge of data needed for calculating the neutronic and engineering performance of cold moderators, and
- to outline the needs for facilities for testing various aspects of pulsed source cold moderator performance.

A reception followed by dinner on Sunday evening at the Freund Lodge prepared the participants for the workshop. Plenary sessions consumed the first day and a half, following

which participants met in Working Groups designated to undertake discussions in six topical areas. Some participants offered their presentations as posters.

Bruce Brown, IPNS director, set the workshop in motion at an early hour Monday with his welcoming remarks. After an explanation of the organization of the workshop, Jack Carpenter provided some background information on the development of cold sources and on some fundamentals. Five sessions with twenty-minute talks and ten-minute discussions followed, with overviews given by Kent Crawford on an instrument designer's point of view, and Günter Bauer on pulsed moderator concepts. The second session, on existing pulsed source cold moderators, included presentations by Tim Broome (ISIS), Michi Furusaka (KENS, also describing plans for moderators at the N-arena at the planned JHP), Phil Ferguson (MLNSC), and Alexandre Beliakov (IBR-2). A third session, on existing steady source moderators, comprised talks on the sources at NIST (Bob Williams), Kurchatov (Mikhail Zemlyanov), and SINQ (Harald Spitzer). The subject of the fourth session was new pulsed sources, in which Noboru Watanabe described the plans at JAERI, and Tony Gabriel those at ORNL, while Lowell Charlton reported his recent Monte Carlo results and Trevor Lucas the designs for L-H₂ cold sources for HFIR and SNS.

The fifth session addressed calculations and measurements and included talks by Gary Russell on MLNSC L-H₂ spectral data and calculations, Torben Brun on pulse shapes of the MLNSC L-H₂ moderators and the ortho-para question, Luke Daemen on calculations of the same things, and David Picton on his calculations of the ISIS L-H₂ cold source. Erik Iverson reported on recent measurements and calculations on the IPNS solid and liquid methane moderators. Dinner at the Freund Lodge ended the last session of the day nearly twelve hours after the start.

During breaks for coffee and lunch, participants viewed posters on display. There were five: Erik Iverson's on absolute spectrum measurements of IPNS moderators, Karsten Stendal's on L-H₂ cold moderator systems at GKSS, HMI and Risø, Harry Jones's on the ISIS cold moderators, Hans Ludewig's on the HFBR L-H₂ moderator, and Terry Scott's and Martha Miller's on the IPNS solid methane moderators.

In a laboratory near the break rooms was a moderator zoo, which contained cutaway examples of ISIS L-H₂ and L-CH₄ moderators, an assembled grooved IPNS S-CH₄ moderator, a flat, yet-to-be-assembled, IPNS S-CH₄ moderator and a set of IPNS graphite inner reflector blocks.

The sixth session, on the subject of scattering kernels for cold moderator materials, again began early with a talk by Rolando Granada about his technique for constructing synthetic kernels, and one by Bob MacFarlane on the kernels that he has produced for cold moderator materials. In the seventh session, devoted to new materials, testing, and applications, Yoshiaki Kiyonagi described the facility at the Hokkaido electron linac and recent measurements on mixed polyethylene-L-H₂ moderators, and László Cser brought forward his suggestions for methylated benzene moderators. Genya Shabalin related his results of measurements and theoretical analysis of the burping phenomenon in the cold solid CH₄ moderator at IBR-2. Jack Carpenter stood in for Paul Sokol for his talk on the Cold Neutron Irradiation Facility at the Penn State Reactor, and Dick Lanza surveyed the prospects for small accelerator-based pulsed neutron sources, emphasizing recently developed compact systems.

After lunch, the final talk was by Jack Dorning, who reviewed alternative (to Monte Carlo) methods of calculation, general features of the time-dependent neutron thermalization problem, approaches to moderator characterization that we should but don't now use, and who appraised the general non-linear dynamical problem we call burping.

Participants split up for tours of IPNS for an hour before boarding the bus for an excursion to Chicago. We enjoyed a guided tour of Chicago's new Museum of Contemporary Art and relaxed in the sculpture garden in the shadow of the Hancock Building. Dinner at the Blackhawk Lodge nearby capped the day.

All day Wednesday and Thursday morning, participants broke into working groups for discussions on seven topics. Gary Russell chaired discussions on scattering kernels and

cross sections, Tim Broome chaired a group on the creation of a moderator performance database (to be set up on the Web), Dick Lanza led a group on applications of cold sources, large and small, and Günter Bauer chaired discussions of needs and opportunities for testing facilities. Tony Gabriel led a working group on calculational methods and Noboru Watanabe led the group that worked to define a "round robin" set of standard measurements and methods for characterizing pulsed cold moderators. After dinner on Wednesday, everyone convened for a brainstorming session which Kent Crawford led, listing ideas for new materials and new concepts. It, as well as the scientists' endurance, lasted for two hours.

Everyone willingly worked long, thought hard, and brought a trove of new information and ideas. The full difficulties of some of the tough problems came to light. The difficulties of modeling, characterizing, understanding, measuring, representing the spectra and pulse width characteristics of the mixed ortho- and para- liquid hydrogens were recurring themes. People left with new determination to perform careful measurements and calculations, not least among these, to devise means to determine the ortho/para ratio in situ. Its attractiveness as a moderator and the resistance of cold solid methane to understanding of its unstable behavior continue to absorb those concerned with cold moderator systems. More measurements are needed, and more analytical work. The admittedly small library of cross section data does not stand the tests of measurements. Working groups identified certain changes that will be made in short order and agreed that the workers present represent an eligible testing group who can evaluate new cross section data before widespread dissemination. Another group set in motion the processes of compiling a moderator performance data base and of measuring and inter-comparing pulsed source moderator data worldwide. Some new, hopeful results came to light, namely very likely-looking prospects for a "100 K" (liquid methane-like) moderator; liquid propane, long in successful service at the Kurchatov reactor, and composite systems such as L-H₂+L-H₂O and mixed L-H₂+(CH₂)_n, which may offer prospects for tailoring of performance.

After lunch on the last day, Thursday, the workshop reconvened to hear reports of the Working Groups, delivered by their chairs, then adjourned in mid-afternoon.

We re-formatted most of the submitted manuscripts and carried out a gentle edit, consulting with the authors on what we thought were significant points. Erik B. Iverson served as co-editor with me. The Proceedings will soon be available as a Megascience Forum publication, and in electronic form on the World Wide Web through the IPNS home page.

At the beginning, as Organizer, I charged the participants, "Only rarely has a community such an opportunity as this. We have that opportunity and therefore the obligation TO DEFINE THE STATE OF THE ART OF PULSED SOURCE COLD MODERATOR DESIGN and TO SEND THE FIELD IN A NEW DIRECTION. LET'S DO IT!" They accomplished much toward fulfilling the purposes of the workshop and responding to the charge. I believe that much further will result from the initiatives that were launched and the spirit of collaboration and communication that began there.

REFERENCE

[1.] "International Workshop on Cold Neutron Sources," Los Alamos National Laboratory, March 5-8, 1990, editors G. J. Russell and C. D. West, Los Alamos report LA-12146-C/ UC-413, August, 1991.