PERFECT CRYSTAL NEUTRON OPTICS
ERB-FRMX-CT96-0057

The Participants:

1. ATI	Atominstitut der Österreichischen Universitäten, Wien, AT
2. ILL	Institut Laue-Langevin, Grenoble, FR
3. KFA	Forschungszentrum Jülich GmbH, DE
4. PSI	Paul Scherrer Institut, CH
5. UNIBA	Universita di Bari, IT
6. HMI	Hahn-Meitner Institut, DE
7. UNIDO	Universität Dortmund, DE
8. UNIVIE	Universität Wien, AT
9. WACKER	Wacker Siltronic AG, DE
10. ISIS	Central Laboratory for the Research Councils, GB
11. NPI	Nuclear Physics Institute of the Academy of Sciences of the Czech Republic, CZ
12. UNIOL	Palacky University, Olomouc, CZ
13. RISSP	Research Institute for Solid State Physics of the Hungarian Academy of Sciences, HU
14. UNIERL	Universität Erlangen - Nürnberg, DE

1. Scientific achievements

a) Neutron quantum optics

The cooperation between theorists and experimental physicists is a main goal of the Network. In 2000 this cooperation has strengthened considerable, especially between the participants No. 1, 5 and 12. Questions of dephasing, decoherence, Zeno-like phenomena and non-classical states were in the center of interest. A first neutron state reconstruction experiment is just under progress at the Institute Laue-Langevin (ILL) in Grenoble. A new topic arised in connection with the phenomenon of a boundary induced phase. Related calculations and experiments are in progress.

b) Neutron interferometry

The neutron interferometer set-up at the ILL-reactor in Grenoble has been upgraded and various test measurements have been performed. The whole sample adjustment platform has been decoupled form the interferometer platform to reduce disturbing vibrations. A third axis has been adapted to permit neutron quantum state reconstruction experiments (Fig. 1). Temperature stability especially during summer is still a big problem and a air-condition system only could help to overcome this drawback. A very large interferometer with a beam path length of 21 cm has been tested successfully.

The neutron interferometer set-up at the Rez-reactor was used to improve the precision of coherent scattering length measurements to 0,002 %. The phase grating

interferometer at the very cold neutron beam of the ILL-reactor has been used for novel Aharonov-Bohm and gravity experiments.

Fig. 1: Perfect crystal set-up at the ILL high flux reactor

c) Ultra small angle neutron scattering (USANS)

Perfect crystal ultra small angle cameras are now installed at the ILL-reactor in Grenoble, at the DIDIO-reactor in Juelich, the HMI-reactor in Berlin, the NPI-reactor in Rez, the SINQ-spallation source of the PSI in Villigen and at the TRIGA-reactor in Wien. Thus the Network considerably contributed to the advent of this new high sensitive method. Users from Australia, France, Germany, India and Italy were impressed by the new opportunities provided by this method.

d) Perfect crystal resonator

Although the results of neutron storage experiments with the narrow band neutron resonator VESTA installed at the ISIS-spallation source were impressive it has been decided to change the system from a pulsed magnetic field to a pulsed neutron flipper system (Fig. 2). Therefore, the whole system has been brought to Wien to build and to test the new system. It should be re-installed and operated during this year. It can be anticipated that the performance parameters can be improved by a factor of at least ten. This development may also have an impact on

the instrumentation of new pulsed neutron spallation sources as they are under construction or discussion worldwide.

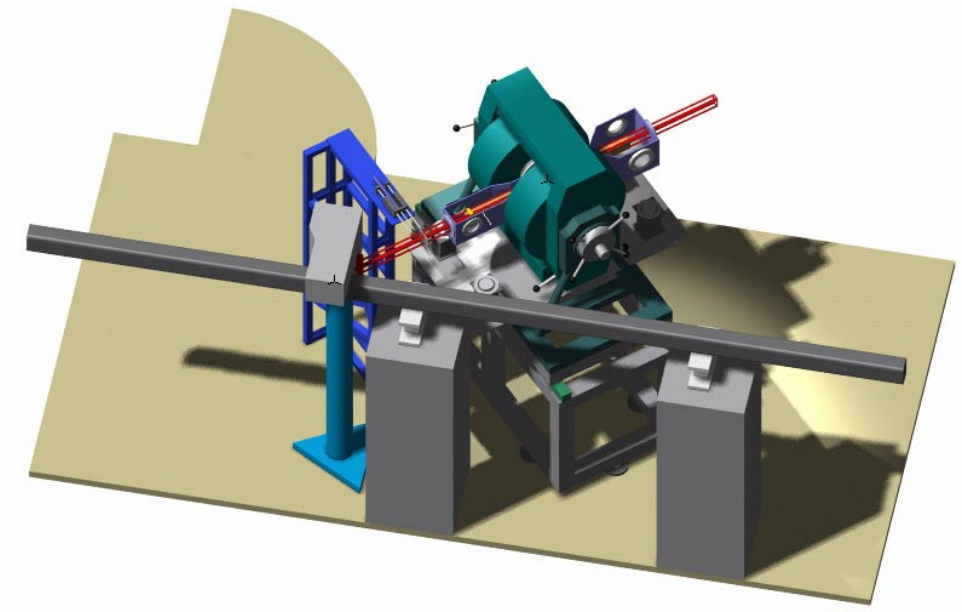

Fig. 2: Proposed set-up based on an active neutron magnetic resonance system placed in the middle of the crystal cavity

2. Organizational items

a) The University Erlangen - Nürnberg has been accepted as a new participant by Amendment No. 2.

The duration of the Network has been extended until the end of 2001 by an Amendment No.3.

b) Workshop

A very fruithful and well organized Workshop took place in Bari 4. - 7. May 2000. 23 talks, 30 participants contributed to this success and stimulated future cooperation (see Attachment).

c) Young researchers

The situation concerning the recruting of young researchers improved during 2000. At the end of the reporting period 8 Young Scientists were employed within the Network.

3. Summary

The successful scientific work within the Network in the year 2000 is documented by 23 papers published and 12 papers submitted for publication.

4. List of publications produced by the Network in 2000

4a. *Published paper:*

[1] Permanent Magnetic Field-Prism Polarizer for Perfect Crystal Neutron Interferometers
G. BADUREK, R.J. BUCHELT, G. KROUPA, M. BARON, M. VILLA
Physica B 283 (2000) 389-392

[2] Neutron Interferometry
G. BADUREK, H. RAUCH
Physica B 276-278 (2000) 964-967

[3] Identification of Nonclassical States in Neutron Precession Experiments
G. BADUREK, H. RAUCH, M. SUDA, H. WEINFURTER
Optics Comm. 179 (2000) 13-18

[4] Decoherence in Neutron Interferometry
P. FACCHI, A. MARIANO, S. PASCAZIO
Physica B 276-278 (2000) 970-972

[5] The New High Resolution Ultra Small Angle Scattering Instrument at the High Flux Reactor in Grenoble
M. HAINBUCHNER, M. VILLA, G. KROUPA, G. BRUCKNER, M. BARON, H. AMENITSCH, E. SEIDL, H. RAUCH
J. Appl. Cryst. 33 (2000) 851-854

[6] Incompatible Observations
Z. HRADIL
Acta Phys. Slovaca 50 (2000) 305-311

[7] Quantum Theory of Incompatible Observations
Z. HRADIL, J. SUMMHAMMER
J. Phys. A.: Math. Gen. 33 (2000) 7607-7612

[8] Reconstruction of the Spin State
Z. HRADIL, J. SUMMHAMMER, G. BADUREK, H. RAUCH
Phys. Rev. A 62 (2000) 014101-1-014101-4

[9] Storage of Multiple Cold Neutron Pulses with Perfect Crystals
E. JERICHA, D.E. SCHWAB, C.J. CARLILE, M.R. JAEKEL, R. LOIDL, H. RAUCH
Nucl. Instr. Meth. A440 (2000) 597-603

[10] Neutron Beam Tailoring by Accumulation between Perfect Crystal Mirrors
E. JERICHA, D.E. SCHWAB, M.R. JAEKEL, C.J. CARLILE, H. RAUCH
Physica B 283 (2000) 414-417

[11] Basic Features of the Upgraded S18 Neutron Interferometer Set-up at ILL
G. KROUPA, G. BRUCKNER, O. BOLIK, M. ZAWISKY, M. HAINBUCHNER, G. BADUREK, R.J. BUCHELT, A. SCHRICKER, H. RAUCH
Nucl. Instr. Meth. A440 (2000) 604-608

[12] Elastically bent Perfect Ge Crystal Analyser
J. KULDA, P. MIKULA, J. SAROUN
Physica B 276-278 (2000) 73-74

[13] Bragg Diffraction Optics in Neutron Diffractometry
P. MIKULA, J. KULDA, P. LUKAS, M. ONO, J. SAROUN, M. VRANA, V. WAGNER
Physica B 283 (2000) 289-294

[14] Instrumentation Components of Focusing Diffraction used in NPI, ILL, KURRI and PTB
P. MIKULA, J. KULDA, P. LUKAS, M. ONO, M. VRANA, V. WAGNER
Physica B 276-278 (2000) 174-176

[15] Testing Operational Phase Concepts in Quantum Optics
J. REHACEK, Z. HRADIL, M. DUSEK, O. HAERKA, M. HENDRYCH
J. Opt. B.: Quantum Semiclass. Opt. 2 (2000) 237-244

[16] Quantum Zeno Effect in a Proben Down-Conversion Process
J. REHACEK, J. PERINA, P. FACCHI, S. PASCAZIO, L. MISTA
Phys. Rev. A 62 (2000) 013804-1-013804-6

[17] Monte Carlo Simulation of Neutron Fluxes on an Absolute Scale - Comparison to Experiments
J. SAROUN, J. KULDA, A. WILDES, A. HIESS
Physica B 276-278 (2000) 148-149

[18] Quantal Phase for Nonmaximally Entangled Photons
B. HESSMO, E. SJÖQVIST
Phys. Rev. A 62 (2000) 062301-1-062301-4

[19] Geometric Phase for Entangled Spin Pairs
E. SJÖQVIST
Phys. Rev. A 62 (2000) 022109-1-022109-6

[20] Anandan-Aharonov-Casher Oscillations in s Simply Connected Region
E. SJÖQVIST
Phys. Lett. A 270 (2000) 10-13

[21] Dispersion Free Measurements in Neutron Interferometry
M. VRANA, P. MIKULA, P. LUKAS, A. IOFFE, W. NISTLER
Physica B 283 (2000) 400-402

[22] Upgrading Scientific Capabilities of the Neutron Interferometer in NPI Rez
M. VRANA, P. MIKULA, P. LUKAS, A. IOFFE, H. RAUCH, V. WAGNER, W. NISTLER
Physica B 276-278 (2000) 172-173

[23] Aharonov-Bohm and Gravity Experiments with the Very-Cold-Neutron Interferometer
G.v.d. ZOUW, M. WEBER, J. FELBER, R. GÄHLER, P. GERTENBORT, A. ZEILINGER
Nucl. Instr. Meth. A440 (2000) 568-574

4b. *Papers submitted or in print*:

[1] Decoherence vs Entropy in Neutron Interferometry
P. FACCHI, A. MARIANO, S. PASCAZIO
(2001) quant-ph/99 06618 v 3

[2] From the Quantum Zeno to the Inverse Quantum Zeno Effect
P. FACCHI, H. NAKAZATO, S. PASCAZIO
(2001)

[3] Stability and Instability in Parametric Resonance and Quantum Zeno Effect
P. FACCHI, H. NAKAZATO, S. PASCAZIO, J. PERINA, J. REHACEK
Phys. Lett. A (in print 2001)

[4] Quantum Zeno Effects with "Pulsed" and "Continous" Measurements
P. FACCHI, S. PASCAZIO
(2001) quant-ph/0101044

[5] Zeno Dynamics Yields Ordinary Constraints
P. FACCHI, S. PASCAZIO, A. SCARDICCHIO, L.S. SCHULMAN
(2001) quant-ph/0101037

[6] Some Novel Bragg Diffraction Optics Elements for Neutron Scattering at Steady State Neutron Sources
P. MIKULA, P. LUKAS, J. SAROUN, M. VRANA, V. WAGNER
ASR 2000

[7] Possible Implementationm of Focusing Based on Bragg Diffraction Optics for TOF neutron Scattering Devices
P. MIKULA, P. LUKAS, M. VRANA
15th Meeting Int. Collaboration on Adv. Neutron Sources (2000) (in print 2001)

[8] Residual Strain/Stress Analysis by Means of Energy-Dispersive Neutron-Transmission Diffraction
P. MIKULA, V. WAGNER, M. VRANA, P. LUKAS
ICRS-6 (2001)

[9] Novel Three Stage Double Directional Focusing Neutron Monochromator
M. ONO, P. MIKULA, S. HARJO, J. SAWANO
ASR 2000

[10] Unavoidable Quantum Losses in Zeno-Like Experiments
H. RAUCH
Cybernetica and Systems (2001 in print)

[11] Iterative Algorithm for reconstruction of entangled states
J. REHACEK, Z. HRADIL, M. JEZEK
ASR 2000 (Submitted Phys. Rev. A)

[12] Neutron Interferometry in NPI Rez
M. VRANA, P. MIKULA, P. LUKAS, A. IOFFE, W. NISTLER
ASR (2000)(in print J. Phys. Soc. Japan)

(Preprints available on request)