



**Slovak Physical Society**

# **21<sup>st</sup> CONFERENCE OF SLOVAK PHYSICISTS**

**7. - 10. 9. 2015**

**Constantine the Philosopher University, Nitra**



## **PROCEEDINGS**

Editors: A. Džubinská, M. Reiffers

## CONTENT

<b>TERABIT COMMUNICATIONS – TASKS, CHALLENGES, AND THE IMPACT OF DISRUPTIVE TECHNOLOGIES</b>	1
I. Glesk, A. Davidson	
<b>PHOTONIC CRYSTAL - ADVANCED PHOTONIC BAND-GAP MATERIAL FOR OPTICS AND OPTOELECTRONICS ON THE CHIP</b>	7
D. Pudiš, D. Jandura, M. Pardelová, I. Lettrichová, L. Suslik, M. Goraus, P. Gaso, S. Slabeyciusová, I. Martinček	
<b>FINGERPRINTS OF THE BEREZINSKII-KOSTERLITZ-THOULESS TRANSITION IN QUASI-TWO-DIMENSIONAL QUANTUM MAGNETS</b>	13
A. Orendáčová	
<b>GRAVITATIO NOSTRA QUOTIDIANA</b>	19
P. Valko	
<b>DIELECTRIC SPECTROSCOPY OF TRANSFORMER OIL-BASED FERROFLUID</b>	25
M. Rajňák, M. Timko, P. Kopčanský, J. Kurimský, B. Dolník	
<b>OPTICAL PHENOMENA IN CHALCOGENIDE GLASSES FROM POINT OF VIEW OF THE BARRIER-CLUSTER-HEATING MODEL</b>	27
I. Baník	
<b>INFLUENCE OF FULLERENE NANOPARTICLES ON BIOMEMBRANES</b>	31
T. Váry, J. Cirák	
<b>THE PROPERTIES AND STRUCTURE OF ATOMIC NUCLEI IN THE RELATIVISTIC MEAN-FIELD THEORY</b>	33
J. Leja, Š. Gmuca	
<b>COMPOSITE MATERIALS COMPOSED OF IRON NANOPARTICLES AND POROUS MATRIX</b>	35
O. Kapusta, A. Zeleňáková, V. Girman, P. Hrubovčák, V. Zeleňák	
<b>STUDY OF RELAXATION PROCESSES OF ALKALINE EARTH METAPHOSPHATE GLASSES</b>	37
J. Bírešová, P. Hockicko	
<b>MAGNETIZATION PROCESSES IN COMPLEX PERMEABILITY SPECTRA OF SOFT MAGNETIC MATERIALS</b>	39
S. Dobák, J. Füzér, F. Fiorillo, C. Beatrice	
<b>MAGNETOCALORIC EFFECT OVER A WIDE TEMPERATURE RANGE DUE TO SPIN REORIENTATION AND MAGNETIC TRANSITION IN NOVEL <math>GdNi_{0.8}Al_{1.2}</math></b>	41
T.P. Rashid, S. Nallamuthu, K. Arun, M. Reiffers, I. Čurlík, S. Il'kovič, A. Džubinská	
<b>PREPARATION AND APPLICATION OF IONIC-LIQUID-BASED NANOCOLLOIDS</b>	43
P. Lobotka, P. Kunzo, G. Radnóczy, I. Vávra, M. Mičušík, A. Cigáň	
<b>APPLICATION OF 3D CAE INFORMATION SYSTEMS TO RESEARCH AREA</b>	45
J. Litecká	
<b>GROUND STATE PROPERTIES OF THE NOVEL <math>EuPdSn_2</math> COMPOUND</b>	47
I. Čurlík, F. Gastaldo, M. Giovannini, M. Reiffers	
<b>PHYSICAL PROPERTIES OF <math>REAgAl_3</math> (<math>RE = La, Ce, Pr, Nd, Sm</math> and <math>Gd</math>)</b>	49
S. Nallamuthu, S. Il'kovič, I. Čurlík, A. Džubinská, R. Nagalakshmi, M. Reiffers, J. Rodriguez Fernandez	
<b>INFLUENCE OF MILLING TIME ON THE MAGNETIC PROPERTIES OF PERMALLOY TYPE MATERIAL</b>	51
L. Ďáková, J. Füzér, M. Strečková, H. Hadraba	
<b>THE INFLUENCE OF LONG-RANGE INTERACTIONS ON MAGNETIZATION PROCESSES IN RARE EARTH TETRABORIDES</b>	53
J. Jurečková, P. Farkašovský	

**UF<sub>1-x</sub>Sb<sub>2</sub> SINGLE CRYSTAL AND MAGNETISM**

A.P. Gonçalves, M. S. Henriques, J. C. Waerenborgh, I. Čurlík, S. Il'kovič, M. Reiffers, J. Ruzs  
55

**LED - INTERESTING AND ATTRACTIVE LIGHT SOURCE IN TEACHING PHYSICS (YEAR 2015 INTERNATIONAL YEAR OF LIGHT)**

D. Klivanec, M. Hanáková 57

**EXPERIMENT WITH HELMHOLTZ RESONATORS FOR UNDERGRADUATES**

M. Kovaľáková, M. Kládiová 59

**MAPPING OF THE STRUCTURAL DEFECT DENSITY OF STATES IN P3HT**

K. Gmucová, V. Nádaždy, F. Schauer, M. Kaiser, E. Majková 61

**BLAST WAVE FITS WITH RESONANCES TO p<sub>t</sub> SPECTRA FROM NUCLEAR COLLISIONS AT THE LHC**

I. Melo, B. Tomášik 63

**WHERE NUCLEAR PHYSICS APPLIES TO BIOSCIENCES**

N. Kučerka 65

**SMALL-ANGLE NEUTRON SCATTERING STUDY OF ELECTRIC FIELD DRIVEN ASSEMBLY IN TRANSFORMER OIL-BASED FERROFLUIDS**

M. Rajňák, M. Timko, P. Kopčanský, V.I. Petrenko, M.V. Avdeev, O.I. Ivankov, A. Feoktystov  
67

**LIPOPLEXES FORMATION: KINETICS BY SANS**

D. Uhríková, A. Búcsi, L. Hubčík, D. Gallíková, O. Ivankov, T. Murugova, J. Teixeira 69

**THE CRYSTAL STRUCTURE OF THE COMPLEX (MEPH3P)[Ni(BDTCL2)] FROM X-RAY AND NEUTRON DATA**

P. Herich, M. Fronc, J. Kožíšek, S. Mason 71

**DESTABILIZATION OF MODEL MEMBRANE BY SURFACTANTS. A SANS STUDY**

J. Gallová, S. Huláková, D. Uhríková, F. Devínsky, A. Ivankov, T. Murugova, P. Balgavý  
73

**THE EFFECTIVE FIELD THEORY APPROACH TO HIGGS PHYSICS BEYOND THE STANDARD MODEL**

M. Gintner 75

**MAGNETIC PROPERTIES OF COMPACTED Ni-Fe POWDERED MATERIALS IN AC MAGNETIC FIELDS**

F. Onderko, M. Jakubčín, S. Dobák, D. Olešáková, P. Kollár 77

**THERMODYNAMIC PROPERTIES OF THE QUASI-TWO-DIMENSIONAL S=1 HEISENBERG ANTIFERROMAGNET Ni(pz)<sub>2</sub>Br<sub>2</sub>**

K. Ráczová, E. Čižmár, S.A. Zvyagin, A. Feher 79

**THERMODYNAMIC AND MAGNETIC PROPERTIES OF ANION-RADICAL BASED SYSTEM Ni(bipy)<sub>3</sub>(TCNQ)<sub>4</sub>·(CH<sub>3</sub>)<sub>2</sub>CO**

D. Šoltésová, E. Čižmár, erik.cizmar@upjs.sk, A. Feher, G. Vasylets, V. Starodub 81

**MUSICAL INSTRUMENT CAJON – MATERIAL – FFT ANALYSIS AT INVESTIGATION OF SOUND QUALITY**

A. Danihelová 83



## WHERE NUCLEAR PHYSICS APPLIES TO BIOSCIENCES

Norbert Kučerka

[kucerka@fpharm.uniba.sk](mailto:kucerka@fpharm.uniba.sk), Faculty of Pharmacy at Comenius University in Bratislava, SR and  
[kucerka@nf.jinr.ru](mailto:kucerka@nf.jinr.ru), Frank Laboratory of Neutron Physics at Joint Institute for Nuclear Research in Dubna, RF

### INTRODUCTION

Biological membrane mimetics, such as liposomes, lipid bilayers and model membranes, are used in a broad range of scientific and technological applications due to the unique physical properties of these amphiphilic aggregates. They serve as platforms for studying the soft matter physics of membranes and membrane dynamics, interactions of bilayers with drugs or DNA, and effects of various additives or environmental changes. The modern state-of-the-art research takes advantage of joining brilliance of X-ray scattering sources with some peculiar properties of neutrons, and combines results with the power of computer simulations. The advances in chemistry, and deuteration possibilities in particular, allow for better experimental spatial resolution and possibility to pin-point labels within membranes. It is only a matter of time for many biological functions that occur at the membrane interface to be matched with the structural properties of these membranes.

The experimental technique of scattering should be pointed out with regards to the structural biology. Scattering techniques, especially those of X-rays, have traditionally been used to determine the structure of 3D crystals on atomic levels. However, advances achieved over past decades developed to an extent that scattering approaches can successfully characterize the physical properties of disordered materials such as biomimetic membranes. The X-ray and neutron scattering methods are now applied to elucidate the material properties previously thought to be the domain of other techniques, and even provide possibilities not present in any other methods. In particular, neutron diffraction can determine the distribution of water or individual components through deuterium labeling. The ability to isolate

individual molecular groups at atomic level of detail is unique among biophysical techniques. Furthermore, discovery of the center of mass distribution of a chemical group is information directly comparable to molecular model simulations.<sup>1</sup>

### NEUTRON SOURCES

The discovery of neutron in 1932 by English physicist James Chadwick<sup>2</sup> started an era of neutron scattering. Its properties and advantages for condensed matter research were recognized quickly, while creating a need for the sources of these *mysterious* particles. The two nuclear reactions in which neutrons are produced were described soon after. The relatively more accessible fission became utilized in nuclear reactors, which however provide a low efficiency outcome and are becoming publicly unpopular due to several nuclear disasters. More promising then appears to be spallation sources that do not require dangerous fissile material, and provide much higher efficiency due to the nuclear spallation reaction and also due to the pulsed nature of such sources. Their disadvantage on the other hand is an involvement of highly sophisticated and complex systems, relevant of course to the construction cost.

In addition to the two above mentioned neutron sources spread widely around the world, there is a third type combining the advantages of both. The pulsed fast reactor (IBR)<sup>3</sup> constructed in Dubna, Russia was designed to take advantage of relatively simple and energetically inexpensive nuclear fission reaction. The wide range of neutron wavelengths combined with time-of-flight method then allows increasing the facility efficiency to and above the most modern neutron facilities around the world.<sup>4</sup>

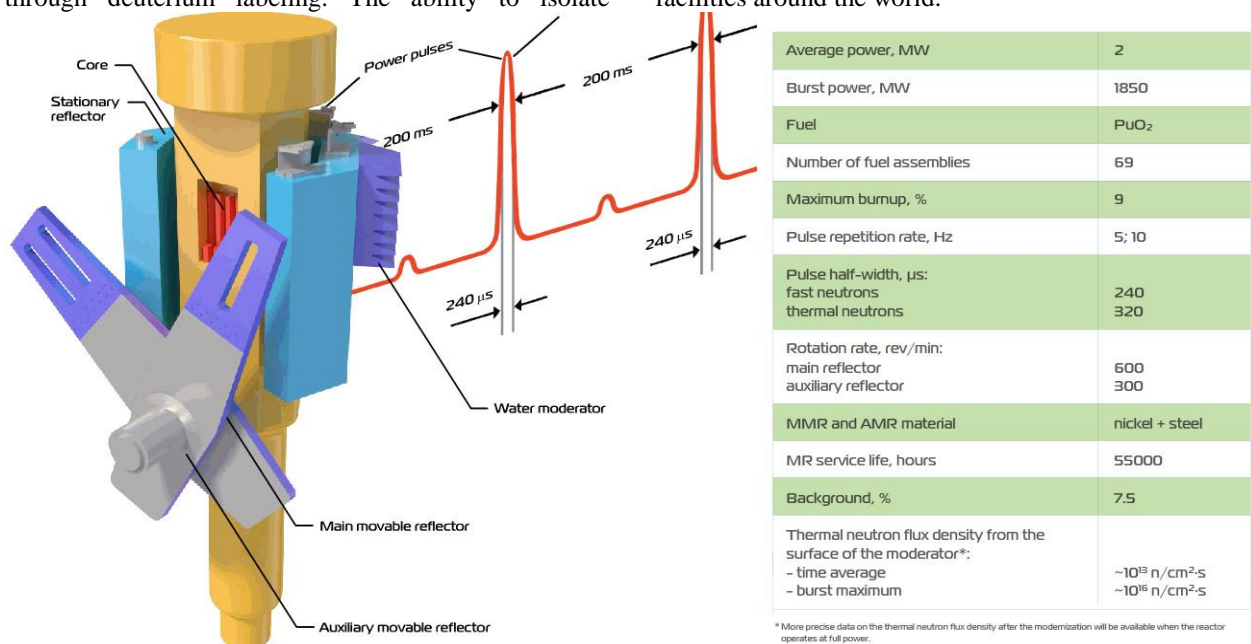


Figure 1: Design and parameters of high-flux pulsed reactor IBR-2M.<sup>4</sup>

## BIOMIMETIC SYSTEMS

Owing to Clifford G. Shull and Bertram N. Brockhouse who developed neutron scattering techniques for studies of condensed matter,<sup>5</sup> the interest in neutron scattering on biologically related soft matter systems received an increased attention. Structural studies of lipid membranes and their changes due to the environmental and compositional changes, affected by cholesterol in particular, fell in a focus from the very beginning. The thickening of lipid bilayers upon the addition of cholesterol has been observed in various lipid systems. However perhaps more interesting are the recent results on the location of cholesterol in membranes of various lipid composition. In contrast to ordered bilayer composed of saturated lipids (e.g., DMPC) or those of a small degree of unsaturation (e.g., POPC), where cholesterol adopts its canonical orientation parallel with lipid chains, more disordered bilayers containing polyunsaturated fatty acids (PUFA) orient cholesterol parallel to the bilayer plane.<sup>6</sup>

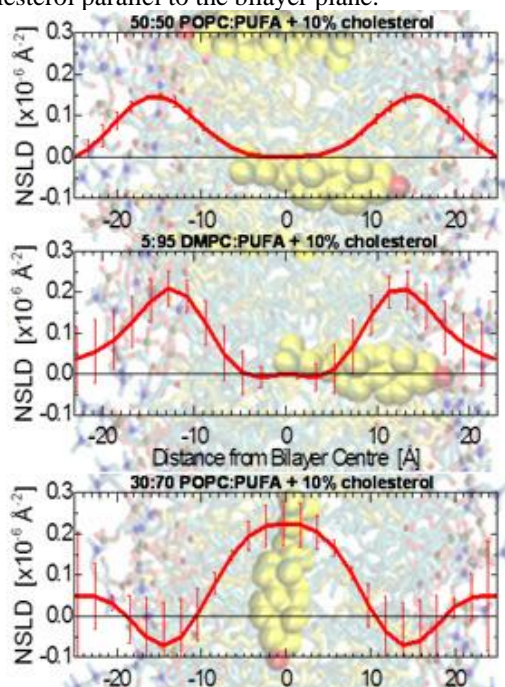


Figure 2: Neutron diffraction results revealed the location of the cholesterol's labelled head outside the hydrophobic region of more saturated bilayers (top and middle panels), while in the center of polyunsaturated bilayers (bottom panel). Adopted from Ref. 6.

The significance of the preference of cholesterol for different lipids may also be rationalized in terms of what we presently know of biological systems. For example, in plasma membranes saturated lipids are primarily located in the outer monolayer whereas unsaturated phospholipids are more abundant in the inner leaflet. By pushing cholesterol to the center of the membrane, a PUFA-rich domain on one side would enhance the transfer of the sterol to a lipid raft on the other. It is even possible to imagine this mechanism resulting in the formation of functionalised domains that could facilitate biosynthetic pathways of cholesterol and its transport to and from cells.<sup>6</sup>

The cell membrane plays an important role also in the molecular mechanism of Alzheimer's disease (AD). Its chemical composition and the incorporation of cholesterol have been linked to increased amyloid toxicity, while melatonin has been shown to have a protective role. Although the underlying molecular mechanism is not well understood, recent results of neutron diffraction shine some light on the membrane's structural properties. Both the experimental and theoretical data show that the effect of melatonin on bilayer properties is opposite to that of cholesterol, which has the ordering effect. In contrast, melatonin decreases the order and thus inducing the increased fluidity in the model membrane.<sup>7</sup>

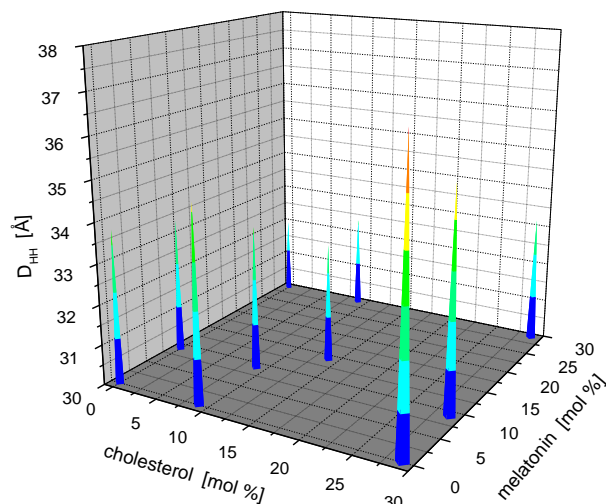


Figure 3: Bilayer thickness  $D_{HH}$  as a function of cholesterol and/or melatonin concentration reveals the thickening effect of cholesterol while the opposing effect is caused by the addition of melatonin.

## CONCLUSIONS

Neutron scattering proves its ability to support bio-relevant studies with data not accessible to other techniques. In particular, the specific deuteration and contrast variation techniques can reveal even subtle details. Most importantly, such structural studies help to further our understanding of critical biological process taking place in biomembranes.

**ACKNOWLEDGMENT:** The author is grateful to acknowledge John Katsaras, Drew Marquardt, Zoya Leonenko, and Elizabeth Drolle for their contributions.

## REFERENCES

1. Harroun TA, Kučerka N, Nieh MP, and Katsaras J, *Soft Matter* **5**, 2694 (2009).
2. Chadwick J, *Proc. R. Soc. Lond. A* **136**, 692 (1932).
3. <http://flnp.jinr.ru/34/>
4. IAEA-TECDOC-1439 (2005).
5. The Nobel Prize in Physics (1994).
6. Kučerka N, Marquardt D, Harroun TA, Nieh M-P, Wassall SR, Katsaras J, *JACS* **131**, 16358 (2009).
7. Drolle E, Kučerka N, Hoopes MI, Choi Y, Katsaras J, Karttunen M, Leonenko Z, *BBA* 1828 (2013).

21<sup>st</sup> CONFERENCE OF SLOVAK PHYSICISTS  
PROCEEDINGS

Editors: Bc. Andrea Džubinská, prof. RNDr. Marián Reiffers, DrSc.

All papers were anonymously reviewed

Published: Slovak Physical Society  
Printed: EQUILIBRIA, s.r.o., Košice  
Košice 2015

ISBN 978-80-971450-7-1  
EAN 9788097145071