

# EMAR- Science meeting 3204

## Scientific report

Third International Symposium on Dynamic Nuclear Polarization  
EPFL, Lausanne, Switzerland  
7- 10 September 2011

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### Summary

The Third International Meeting on Dynamic Nuclear Polarization followed the highly successful meetings in Nottingham (2007) and Königstein (2009) and was held on 7-10th September 2011, at EPFL Lausanne, Switzerland.

An array of key players of this emerging field assessed the present state of the art and the participants were encouraged to reveal and discuss the current issues and new trends in dynamic nuclear polarization (DNP), including the developments in Overhauser effect, dissolution DNP, gyrotrons, magic angle spinning, low temperature DNP, radical chemistry, and hyperpolarized *in vitro* and *in vivo* magnetic resonance spectroscopy and imaging.

Due to the wide variety of applications of DNP techniques, the aim of the organizing committee was to ensure that all areas of this rapidly expanding field would be represented. There were 24 invited talks and an additional 15 speakers were selected from the submitted abstracts. A total of 155 people participated in the symposium.

In addition to the support of the ESF, the Swiss National Science Foundation, the Swiss Chemical Society as well as 7 private companies sponsored the symposium.

The clearest message the organizing committee received throughout informal conversations during the symposium was that the participants definitely wish to keep the proposed format (3 day long meeting with speakers from the different research areas) for the next international DNP symposiums. Bringing all the researchers involved in DNP together every other year thus seems to be a fruitful initiative that most participants would support.

## Scientific Content and Discussion

There were a total of 7 oral sessions chaired by several participants that were selected by the organizing committee at the beginning of the symposium. There were also 2 poster sessions organized before lunch.

### "Overview and challenges" session

The idea of this opening session was to highlight the important issues and perspectives of the DNP techniques for current and future applications. It started with a presentation given by Jan Henrik Ardenkjaer-Larsen who was the lead author on the publication that first introduced the dissolution DNP technique. The prototype of the future commercial machine for clinical applications was presented and the various challenges were discussed. Daniella Goldfarb talked about the importance of understanding the electron spin resonance parameters of specific radicals to understand the DNP mechanisms. Thomas Prisner demonstrated that despite the common assumption that the Overhauser effect becomes small with increasing magnetic field, it is possible to achieve high-enhancement at high-field ( $\epsilon=30$  at 9.2T and 300K). Miquel Pons showed that quadrupolar nuclei such as chlorine play an important role in solid-state polarization. In fact, they can be used to understand the dynamics driven by spin diffusion. Kevin Brindle presented the latest developments and the perspectives and potential of dissolution DNP to follow cancer treatment. He emphasized that it is crucial to develop several hyperpolarized substrates because a single biomarker will not lead to the full understanding of cancer metabolism. The last presentation was given by Huiming Zhang, a program director of the National Cancer Institute (NCI) of the US National Institute of Health. She clearly stated that dissolution DNP could play a fundamental role in cancer research and the possibility to follow real-time metabolism *in vivo* should be further developed. The NCI is thus considering supporting this area of research.

The conclusion of this session was that DNP techniques have very wide applications and that the field requires developments in a wide range of areas, including Physics, Chemistry, Biology and Medicine.

### "Liquid state DNP techniques" session

The speakers presented the state of the art in the two main liquid-state methods, namely dissolution DNP and Overhauser effect, including the so-called "shuttle DNP" technique. These session's presentations demonstrated that the developments in liquid-state DNP allow measuring fast chemical reactions that would be otherwise invisible using standard NMR techniques. Applications in chemistry and biochemistry as well as methods to improve the signal enhancement and its lifetime were presented. Walter Köckenberger also presented his new theoretical model to simulate the solid-state DNP processes.

### "Instrumentation and design" session

This session and the two "Solid state DNP techniques" sessions were mostly about what we can call "Gyrotron DNP", that is high-field solid-state DNP coupled to solid-state NMR techniques such as magic angle spinning (MAS). It brought together the designers and

builders of high-power microwaves sources (mainly gyrotrons) and the solid-state NMR community.

Different new designs and implementations of high-power microwave elements, including gyrotrons and amplifiers were presented in the "Instrumentation and design session". One of the main challenges in the field is to provide enough power at fields commonly used in solid-state NMR, i.e. 14.1 T or above, that is at frequency of about 400 GHz or above. Two speakers talked about DNP applications in particle physics: Patrick Hautle presented an innovative neutron spin filter based on a photo-excited triplet state DNP molecule and Li Wang a target in which deuterons are highly polarized via DNP using various paramagnetic centers.

### **"Solid state DNP techniques I & II" sessions**

These two sessions were focused on the applications of solid-state DNP techniques. In order to obtain the highest enhancement possible, it is highly important to identify optimal paramagnetic centers for a given field strength and temperature. The use of several different stable radicals, in particular binitroxides, was discussed in these sessions. Another important element is to have the capability to spin the sample (MAS) at the lowest temperature possible (below 77K) in order to maximize the signal enhancement while optimizing the spectral resolution in the sample under investigation. Some new methods were presented. Finally, applications to surface NMR studies and to structural studies of large biomolecules were exposed, demonstrating the wide applicability of the technique.

### **"Biomedical applications I & II" sessions**

These two sessions were dedicated to *in vitro* and *in vivo* biomedical studies. All studies presented were aimed at probing real-time metabolism in particular tissues and organs, which is widely recognized as the most promising application of hyperpolarized techniques. Applications ranging from yeast to humans were presented, with several brain studies in rodents. Most studies were done with  $^{13}\text{C}$ -pyruvate but Mathilde Lerche and Mor Mishkovsky demonstrated that substrates such as  $^{13}\text{C}$ -acetate and  $^{13}\text{C}$ -glucose can also be used and also bring important metabolic information. Daniel Vigneron showed preliminary results of the first preclinical study obtained in patients diagnosed with prostate cancer. The results were spectacular and led to a long debate afterwards.

Note that Alexander Barnes, the last speaker of the session, talked about newly developed high-frequency gyrotrons and their applications (his talk was originally scheduled in the "Instrumentation and design" session)

### **Poster sessions**

A number of 45 posters were presented during two dedicated sessions. The sessions were extremely successful due to the high quality of the research presented on the posters. Many students could present their work to an audience composed of researchers interested in the recent advances in fields that are not directly theirs, an opportunity which is not always given in larger specialized meeting.

## **Assessment of the results and impact of the event on the future direction of the field**

This symposium was a unique opportunity to bring together the researchers from various fields ranging from Physics and Chemistry to Biology and Medicine working in the area of dynamic nuclear polarization. From informal discussions, it was clear that participants were delighted to be able to hear the developments in the different fields which would not be possible outside of such a cross-disciplinary meeting. The Technical University of Denmark, DTU, was selected to organize the 4th International Symposium in 2013 and the 5th International Symposium on DNP will most likely take place at the Radboud University Nijmegen in the Netherlands in 2015. This keen interest in continuing this symposium series demonstrated the success of such an interdisciplinary meeting.

The main conclusion of this symposium was that it is important that physicists, chemists, biologists and medical doctors regularly meet to grasp the challenges needed to be tackled to adapt and improve the DNP technology for the various applications.

Lausanne, November 1<sup>st</sup> 2011

# Final program

## ***Wednesday September 7, 2011***

*10:00 Registration*

*12:30 Lunch available on campus*

*14:00 Introductory remarks*

### **Overview and challenges**

14:15 Jan Henrik Ardenkjaer-Larsen

14:45 Daniella Goldfarb

*15:15 Coffee break*

16:00 Thomas Prisner

16:30 Miquel Pons

16:45 Kevin Brindle

17:15 Huiming Zhang

*17:45 Free evening*

## ***Thursday September 8, 2011***

### **Liquid state DNP techniques**

8:30 Christian Hilty

9:00 Philip Lottmann

9:15 Jan van Bentum

9:30 Sami Jannin

*10:00 Coffee break*

10:45 Walter Koeckenberger

11:15 John Franck

*11:30 Poster session*

*12:30 Lunch served on site*

### **Instrumentation and design**

14:00 Stefano Alberti

14:30 Graham Smith

15:00 Emile de Rijk

15:15 Patrick Hautle

*15:45 Coffee break*

16:30 Melanie Rosay

17:00 Li Wang

17:15 Richard Temkin

*19:30 Conference dinner*

## ***Friday September 9, 2011***

### **Solid state DNP techniques I**

8:30 Anne Lesage

9:00 Olivier Lafon

9:15 Alexey Potapov  
9:30 Mark Smith  
*10:00 Coffee break*  
10:30 Paul Tordo  
11:00 Albert Smith  
11:15 Yoh Matsuki  
*11:45 Poster session*  
*12:45 Lunch served on site*

### **Solid state DNP techniques II**

14:00 Marc Caporini  
14:30 Ümit Akbey  
14:45 Björn Corzilius  
*15:00 Coffee break*

### **Biomedical applications I**

15:45 Mathilde Lerche  
16:15 Thomas Eykyn  
16:30 Daniel Vigneron  
*17:30 Reception*  
*Free evening*

### ***Saturday September 10, 2011***

### **Biomedical applications II**

8:30 Damian Tyler  
9:00 Steven Reynolds  
9:15 Matthew Merritt  
9:45 Mor Mishkovsky  
*10:15 Coffee break*  
11:00 Malgorzata Marjanska  
11:30 Rolf Schulte  
11:45 Alexander Barnes  
*12:15 Closing remarks*

# List of participants

\* Participant/Speaker/Convenor  
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