ST 10: Basic and Applied Medical Physics (Poster Session)

Time: Wednesday 16:00–17:00 Location: H41

ST 10.1 Wed 16:00 H41

MRI Thermometry Based on Encapsulated Hyperpolarized Xenon — •Franz Schilling[1,2,3,5], Leif Schröder[1,2,4], Kanna Palanniappan[1], Sina Zapf[3], David E. Wemmer[1,2], and Alexander Pines[1,2] — [1]University of California, QB3, Berkeley — [2]Lawrence Berkeley National Laboratory — [3]University of Würzburg, Department of Experimental Physics 5 — [4]Leibniz Institute for Molecular Pharmacology (FMP), Berlin — [5]Technical University Munich, Department of Chemistry

Noninvasive, accurate and spatially resolved temperature measurement in the human body is a desired technology for many biomedical applications, including hyperthermic treatment of cancer and detection of vulnerable atherosclerotic plaques. A new MRI thermometry approach using encapsulated hyperpolarized xenon is demonstrated in this work. It is based on the temperature dependent chemical shift of hyperpolarized xenon in a cryptophane-A cage. This shift is linear and was determined to be 0.29 ppm/K with respect to the peak of free xenon in dissolved in water. This value is 30 times higher than the shift of the proton resonance frequency that is currently used for MRI thermometry. Direct MR temperature imaging with caged xenon was shown with a chemical shift imaging (CSI) sequence for the spin 1/2 nucleus ^{129}Xe and homogeneous temperature maps of a phantom could be collected with an accuracy of 0.1 K at a sensor concentration of 150 μM. Another setup allowed visualization of a temperature gradient with a span of only 2 K. MRI thermometry based on hyperpolarized encapsulated xenon improves the accuracy of available MRI thermometry methods.

ST 10.2 Wed 16:00 H41

NMR Spectroscopy and Imaging of blood-dissolved hyperpolarized 129Xe — •Nadia Amor[1], Kathrin Hamilton[2], Markus Küppers[1], Ulrich Steinseifer[2], Thomas Schmitz-Rode[2], Stephan Appelt[3], and Bernhard Blümich[1] — [1]ITMC of RWTH Aachen University, Germany — [2]AME of RWTH Aachen University, Germany — [3]Research Center Jülich, Germany

Hyperpolarization (HP) of noble gases, e.g. 3He and 129Xe, as a means of increasing the signal by several orders of magnitude has been widely employed in NMR over the last decades [1]. The advantages of 129Xe are its solubility and the sensitive chemical shifts. Dissolved HP 129Xe has been of growing importance, especially since the introduction of the so-called "xenonizer" setups [2]. They consist of hollow fiber membranes in oxygenators allowing for efficient and continuous dissolution into carrier agents without formation of foams or bubbling, and have been proven to be feasible for HP 129Xe MRI [3].

The xenon dissolution process has been analyzed for various solvents including porcine blood in home-built xenonizer setups featuring different fibers. The deoxygenating effect of the xenonization on blood with defined oxygen levels could be monitored online spectroscopically. The results presented offer a more comprehensive understanding of the xenonizer and yield valuable information about xenon-blood interactions.

[1] B.M. Goodson, J. Magn. Res. 155, 157 (2002)
[2] D. Baumer et al, Angew. Chem. Int. Ed. 45, 7282 (2006)
[3] N. Amor et al, J. Magn. Res. 201, 93 (2009)

ST 10.3 Wed 16:00 H41

Optimized setup for parahydrogen induced polarization by application of hollow fiber membranes — Meike Roth[1], Petra Kindervater[1], Joachim Bargon[2], Hans W. Spiess[1], and •Kerstin Münnemann[1] — [1]Max-Planck-Institute for Polymer Research, Ackermannweg 10, D-55128 Mainz, Germany — [2]Institute of Physical and Theoretical Chemistry, University of Bonn, Wegelerstrasse 12, D-53115 Bonn, Germany

Enhancing the sensitivity of nuclear magnetic resonance measurements via Parahydrogen Induced Polarization (PHIP) is of high interest for spectroscopic investigations. In order to achieve the highest possible sensitivity gain it is of great importance to optimize the reaction and measurement conditions of the parahydrogenation technique. We optimized the conversion rate and established optimal NMR measurement conditions by utilizing hollow fiber membranes for continuous parahydrogen delivery while performing PASADENA experiments. This new way of dissolving parahydrogen more efficiently into water without the occurrence of foam and bubbles offers the opportunity to implement continuous flow measurements under pressure, leading to higher conversion rates and higher polarization levels. Furthermore, this careful control of the parahydrogenation reaction generates a constant hyperpolarization of 1H and 13C over a certain time (several minutes) which enables us to perform 2D NMR experiments with very high sensitivity.

ST 10.4 Wed 16:00 H41

^{13}C DNP of biomolecules dissolved in water — •Björn C. Dollmann[1], Konstantin Gruss[1], Lasse Jagschies[1], Laura M. Schreiber[2], Hans W. Spiess[1], Dariush Hinderberger[1], and Kerstin Münnemann[1] — [1]Max Planck Institute for Polymer Research, Mainz, Germany — [2]Section of Medical Physics, Mainz University Medical Center, Mainz, Germany

Nuclear magnetic resonance (NMR) and related techniques have become indispensable tools with innumerable applications in physics, chemistry, biology and medicine. One of the main obstacles in NMR is its notorious lack of sensitivity, which is due to the low equilibrium polarization of nuclear spins at ambient temperature. This disadvantage becomes obvious if low γ nuclei are employed for NMR spectroscopy and MR imaging or when small sample volumes should be investigated. However, this obstacle could be overcome by in vitro hyperpolarization of molecules via dynamic nuclear polarization (DNP). One major issue of this approach is the limited lifetime of the hyperpolarized state, which restricts the application and detection of the hyperpolarized molecules to roughly three times T_1. Therefore a lot of effort is put into the hyperpolarization of biomolecules with long spin lattice relaxation times. In this work, we present direct Overhauser-type DNP enhancement of ^{13}C in solution at ambient temperatures. For a 5 μl sample of 10 M ^{13}C-enriched urea with 40 mM TEMPOL dissolved in water we measured a ^{13}C signal enhancement of -335 in a commercial X-band electromagnet.

ST 10.5 Wed 16:00 H41

Einfluss von resonantem US auf H-NMR bei Verwendung magnetischer Nanopartikel — •Felix Repp, Nouri El-Miladi, Christian Höhl, Fahimeh Jahanbakhsh, Peter Wolf und Karl Maier — Helmholtz- Institut für Strahlen und Kernphysik (HISKP), Rheinische Friedrich-Wilhelms-Universität, Bonn

Magnetische Nanopartikel (MNP) bestehen aus ferromagnetischen Partikeln die in eine Polymermatrix eingebettet sind. Sie sind mit einer Vielzahl von chemisch funktionellen Beschichtungen kommerziell erhältlich. Da MNP das kernmagnetische Relaxationsverhalten abhängig von ihrer Konzentration beeinflussen, werden sie z.B. bei Magnetresonanztomographien als Kontrastmittel eingesetzt.

In NMR-Experimenten haben wir gezeigt, dass resonanter Ultraschall (US) das Relaxationsverhalten zusätzlich verändert, sofern die MNP durch eine einseitige Reaktion mit einem Makromolekül in asymmetrischer Form vorliegen. Dieser neue Kopplungsmechanismus zwischen US und dem Kernspinsystem des Lösungsmittels wird diskutiert. Die Verwendung von US lässt Rückschlüsse auf Reaktion und Einbindung der MNP zu und schafft somit neue Anwendungsmöglichkeiten für MNP.

ST 10.6 Wed 16:00 H41

Measurement technique for tracer kinetic studies with stable isotopes of cerium using thermal ionization mass spectrometry — •Teresa Keiser, Vera Höllriegl, Augusto Giussani, and Uwe Oeh — Helmholtz Zentrum München - German Research Center for Environmental Health, Institute of Radiation Protection, Ingolstädter Landstr. 1, 85764 Neuherberg, Germany

The double tracer technique,introduced in the 60s, is a potent method to investigate the biokinetics of elements in humans and was modified and applied over the last years to various elements of interest for radiation protection in order to validate and improve the available biokinetic models of ICRP. One project currently running at Helmholtz Zentrum München aims at studying the biokinetics of cerium in humans using stable tracers. For this purpose a methodology needs to be developed which enables to measure simultaneously different stable cerium isotopes in human body fluids such as blood and urine. The measurement protocol was developed using cerium standard solutions and different combinations of filament materials measured with TIMS.

Best results were achieved adopting the double filament configuration and using tantalum filaments. Under these experimental conditions the measured standard ratios agree within 1% with the IUPAC values. For measuring biological samples with TIMS a chemical treatment is necessary. A chemical method for eliminating all elements except cerium was established. The methodology was applied to biological samples collected during tracerkinetic studies in humans and preliminary results of urine excretion and plasma clearance of cerium will be presented.

ST 10.7 Wed 16:00 H41

Monitoring von Wundheilungsprozessen mit Millimeterwellensensorik — •Helmut Essen[1], Dirk Nüssler[1], Ralf Brauns[1], Christian Krebs[1] und Thorsten Buzug[2] — [1]Fraunhofer FHR, Neuenahrer Str. 20, 53343 Wachtberg — [2]Universität Lübeck, Ratzeburger Allee 160, 23538 Lübeck

Das Monitoring von Wundheilungsprozessen ist aufwändig, wenn sich die Wunde z. B. innerhalb eines Gipsverbandes befindet. Eine regelmäßige Entfernung und Erneuerung des Verbandes ist vielfach notwendig. Mit dem hier vorgestellten Gerätedemonstrator sollen durch Verbände, auch Gipsverbände hindurch Wundheilprozesse beurteilt werden. Grundlage des Verfahrens ist das Vermögen elektromagnetischer Wellen viele Materialien zu durchdringen, jedoch mit dem Körpergewebe so zu interagieren, dass zwar Charakteristika der oberen Hautschichten sehr sensitiv bestimmt werden können, jedoch ein Eindringen in tiefere Schichten nicht möglich ist. Hinzu kommt, dass eine gute Bündelung der Millimeterwellenstrahlung z.B. über dielektrische Messspitzen möglich ist. In Verbindung mit einem X-Y-Scanner ist eine Bildgewinnung eines definierten Bereiches, innerhalb eines Verbandes möglich. Anwendung von Methoden der Bildverbesserung auf die gewonnenen Rohdaten erlauben eine gute Beurteilung des Vernarbungsprozesses.

ST 10.8 Wed 16:00 H41

AreSca: Ein Messsystem zur Klassifizierung und Untersuchung humaner Blutzellen — •Denny Ragusch, Andreas Kummrow und Jörg Neukammer — Physikalisch-Technische Bundesanstalt, Abbestrasse 2-12, 10587 Berlin

Ein Messsystem (AreSca: angular-resolved light-scattering) zur winkelaufgelösten Beobachtung der Streulichtintensität von humanen Blutzellen wird vorgestellt. Die Streulichtverteilungen werden mit geeigneten CCD-Kamerasystemen in Vorwärts- und Seitwärts-Richtung winkelaufgelöst detektiert. Ein in der Arbeitsgruppe aufgebautes Laser-Durchflusszytometer [1] wurde dazu mit CCD-Kamerasystemen und einem neu entwickelten Datenerfassungssystem erweitert. Die Erweiterung ermöglicht eine synchrone Detektion der winkelaufgelösten Streulichtintensität (bei 488 nm) und der integralen Streulichtintensitäten (bei 413 nm und 640 nm). Mit dieser Methode wird eine verbesserte Differenzierung/Klassifizierung verschiedener Zellpopulationen auf physikalischem Wege (mit Hilfe der Lichtstreuung) und die Ableitung der optischen Eigenschaften, der Form und der Größe humaner Blutzellen ermöglicht. Der Versuchsaufbau sowie die ersten Messungen werden vorgestellt.

[1] V. Ost, J. Neukammer, and H. Rinneberg, Cytometry 32, 191-197, 1998

ST 10.9 Wed 16:00 H41

Microfabricated flow cytometers for high throughput analysis of blood cells — •Denny Ragusch[1], Marcin Frankowski[1], Andreas Kummrow[1], Nicole Bock[1], Jörg Neukammer[1], Andrej Tuchscheerer[2], and Martin Schmidt[2] — [1]Physikalisch-Technische Bundesanstalt, Berlin — [2]Technische Universität Berlin, Fachgebiet Mikro- und Feingeräte, Berlin

Microfluidic structures are of particular relevance as a part of simple and robust analytical systems for point-of-care in-vitro diagnostics. In flow cytometric analysis blood cells must be counted at relatively high throughput to assure sufficient statistics. Such systems require implementation of hydrodynamic focusing. Presented disposable measurement platforms allow for analysis and classification of human blood cells detecting scattered light, fluorescence and impedance changes. To overcome limitations of widely used photolithographic manufacturing methods, our approach utilizes mould inserts for hot embossing fabricated by ultra-precision milling [1]. The complex 3D polycarbonate structures featuring two-stage cascade hydrodynamic focusing enables measurements with count rates up to 5 kHz. Differentiation of CD14+ and CD3+/CD4+ cells clearly demonstrate the potential of using such microsystems. Optical excitation and detection was performed either by optical fibres or using external optics. Achieved pulse height distributions are comparable to those of conventional instruments. Measurements of fluorescence signals from calibration particles yield coefficients of variation of less than 2% for optimised settings.

[1] A. Kummrow et al, Lab Chip 9 (2009) 972-981