Physics

Physics-I *Machine Learning in MRI: design, acquisition, and analysis*
(3 speakers, 90 min)

Physics-II ***Chemical Exchange Saturation Transfer: signal origin, animal model, and human applications***
(3 speakers, 90 min)

Physics-III *Diffusion MRI: from basic principles to advanced applications*
(3 speakers, 90 min)

Physics-IV *Quantitative MRI: from parametric mapping to multi-parametric application*
(2 speakers, 60 min)

Physics-V *Novel MRI modalities*
(2 speakers, 60 min)

Gigin Lin, MD, PhD
林吉晉 教授

Time Table

Saturday, May 21, 2022
Room 205

Time	Topics	Speakers	Moderators
13:30-14:00 (30mins)	Cholesterol-weighted imaging based on chemical exchange saturation transfer signal at -1.6ppm	Eugene C. Lin	Gigin Lin Shang-Yueh Tsai
14:00-14:30 (30mins)	Using NMR & MRI to Trace Glucose Metabolism of Brain Tumor in Mice	Dennis W. Hwang	Gigin Lin Shang-Yueh Tsai
14:30-15:00 (30mins) (China time 14:30-15:00)	Downfield rNOE suppressed amide proton CEST imaging from 7T to 3T	Yi-Cheng Hsu	Gigin Lin Shang-Yueh Tsai

Chemical Exchange Saturation Transfer: signal origin, animal model, and human applications

Organizer:Hsiao-Wen Chung

Overview:

Chemical exchange saturation transfer, or CEST MRI, exhibits the attractive characteristics to potentially detect specific biochemical species at low concentrations, making use of indirect changes of the water signals. While fascinating, a lot of technical issues related to CEST remain currently unsolved. Therefore, we have prepared this session by three lectures, one addressing the origin of CEST signal from the theoretical point of view, one demonstrating glucose metabolism depicted by CEST MRI on animal models, and one that shows how CEST could be potentially used in human MR imaging via collaboration by physicists and clinicians.

Cholesterol-weighted imaging based on chemical exchange saturation transfer signal at -1.6ppm

Eugene C. Lin, Ph.D., Taiwan

- Assistant Professor of Chemistry, National Chung Cheng University
- Developing techniques of magnetic resonance spectroscopy and imaging, studying membrane proteins with NMR, disease diagnosis with chemical exchange saturation transfer MRI

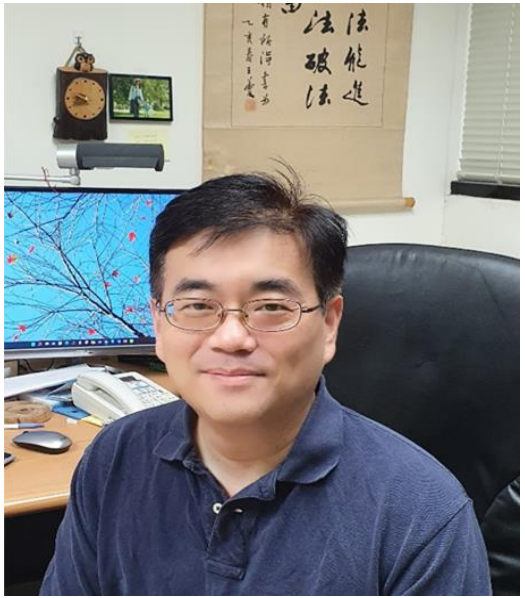
Cholesterol-weighted imaging based on chemical exchange saturation transfer signal at -1.6ppm

- **Synopsis:**
- The bulk water signal can be reduced through chemical exchange saturation transfer (CEST), and it allows us to reveal the change in metabolite concentration and the physiological environment. We have shown that one of the CEST signals at -1.6 ppm, rNOE(-1.6), is from the methyls of phosphatidylcholines when the cholesterol hydroxyls are nearby in liposomes. We further found that the amplitude of rNOE(-1.6) correlates to the cholesterol content in vitro and in vivo, which indicates a potential cholesterol-weighted imaging technique.

- **Key Reference:**

- Chang YC, Liu HQ, Chang JH, Chang YY, Lin EC. Role of the cholesterol hydroxyl group in the chemical exchange saturation transfer signal at − 1.6 ppm. NMR in Biomed. 2020;33:e4356.
- Zu Z, Lin EC, Louie EA, Xu J, Li H, Xie J, Lankford CL, Chekmenev EY, Swanson SD, Does MD, Gore JC, Gochberg DF. Relayed nuclear Overhauser enhancement sensitivity to membrane Cho phospholipids. Magn Reson Med. 2020;84:1961-1976.

Using NMR & MRI to Trace Glucose Metabolism of Brain Tumor in Mice



Dennis W. Hwang, PhD,Taiwan

- Assistant Research Fellow of Biomedical Sciences, Academia Sinica
- New MRI methods for use in biomedical applications, such as real-time glucose MRI by CEST imaging, and machine learning for semiautomated classification of glioblastoma in dynamic glucose-enhanced MRI

Using NMR & MRI to Trace Glucose Metabolism of Brain Tumor in Mice

- **Synopsis:**
- The brain primarily relies on glucose as the metabolism energy source. Chemical ex-change saturation transfer (CEST) using the proton exchange between glucose and water as a contrast mechanism is used to investigate dynamic glucose concentration variation via dynamic contrast enhanced (DGE) imaging. Here, we used DGE magnetic resonance imaging (MRI) to investigate the real-time glucose metabolism in tumor cells under longer duration times and more com-prehensile analyzing methods. In addition, self-organized mapping (SOM), an artificial neural network, was used to classify the time evolution of DGE MRI and form a 2D image with dynamic information. Results indicated that after glucose injection, glucose consumption conditions in different tumor regions can distinguish the changes in tumor microenvironment. Furthermore, in the same region of the tumor area on the contralateral side and WT group, glucose level accumulates after glucose injection. SOM displayed a functional image to reflect the different glucose metabolism conditions in the tumor cells. To validate the DGE result, NMR metabolome and fluxomics were also be applied to analysis the consequent metabolism.

- **Key Reference:**
- Svyatova A, Kozinenko VP, Chukanov NV, Burueva DB, Chekmenev EY, Chen YW, Hwang DW, Kovtunov KV, Koptyug IV. PHIP hyperpolarized [1-13C]pyruvate and [1-13C]acetate esters via PH-INEPT polarization transfer monitored by 13C NMR and MRI. Sci Rpt. 2021;11:5646.

Downfield rNOE suppressed amide proton CEST imaging from 7T to 3T

Yi-Cheng Hsu, Ph.D., China

- Lead research scientist, MR collaboration, Siemens Healthineers Ltd., Shanghai, China
- Development of sequence and reconstruction for collaborative research including quantifying microstructure and water exchange properties using diffusion imaging and novel CEST methods

Downfield rNOE suppressed amide proton CEST imaging from 7T to 3T

- ## Synopsis:

Chemical exchange saturation transfer (CEST) is a molecular imaging method that detects biomolecules in vivo via proton exchange between solute and water. Amide proton transfer (APT) imaging is a type of CEST imaging that has been used to grade tumors[1], estimate ischemic penumbra[2], and identify characteristics of tumors[3]. The most widespread APT imaging method quantifies the presence of amide by magnetization transfer ratio asymmetry (MTRasym). However, this method is sensitive to fluid signals and captures the contribution from the relayed nuclear Overhauser effect (rNOE) and asymmetric semi-solid magnetization transfer (ssMT).

Snap-shot CEST can densely sample the Z-spectrum for improved separation of CEST effects at ultra-high field[4]. To reduce the blurring and varying point spread function problem at different Z-spectrum, we proposed compressed sensing (CS) sampled SPACE CEST imaging method that simultaneously acquired B0-corrected APT, rNOE, and ssMT images within 7 minutes at 3T.

- ## Key Reference:

[1]Zaric, Olgica, et al. "7T CEST MRI: A potential imaging tool for the assessment of tumor grade and cell proliferation in breast cancer." Magnetic resonance imaging 59 (2019): 77-87.
[2]Msayib, Y., et al. "Quantitative CEST imaging of amide proton transfer in acute ischaemic stroke." NeuroImage: Clinical 23 (2019): 101833.
[3]Paech, Daniel, et al. "Assessing the predictability of IDH mutation and MGMT methylation status in glioma patients using relaxation-compensated multipool CEST MRI at 7.0 T." Neuro-oncology 20.12 (2018): 1661-1671.
[4]Zaiss, M., et al. "Snapshot-CEST: optimizing spiral-centric-reordered gradient echo acquisition for fast and robust 3D CEST MRI at 9.4 T." NMR in Biomedicine 31, e3879 (2018).