WEEKDAY EDUCATIONAL COURSE: Off-Mainstream Techniques

Imaging with Hyperpolarized Silicon Nanoparticles

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Hyperpolarization is a rapidly growing area of research with applications that span fundamental physics, materials science, biochemistry and clinical medicine. Most research on hyperpolarized materials for *in-vivo* applications has focused on optically pumped noble gases such as ^{3}He and ^{129}Xe, or ^{13}C labeled metabolites hyperpolarized by low-temperature DNP. Although an impressive range of *in-vivo* applications have been demonstrated, these materials all suffer from short spin lattice relaxation (T_1) times that degrade even further in the *in-vivo* environment.

Silicon-based micro and nanoparticles are an emerging platform in nanomedicine that have gained popularity in a wide range of applications due to their biocompatibility and biodegradability *in-vivo*, as well as a flexible surface chemistry which allows drug loading, functionalization and targeting. To date, *in-vivo* imaging and tracking of silicon particles has been realized via confinement-enhanced optical activation or by the incorporation of imaging agents such as fluorescent markers, paramagnetic compounds for conventional ^{1}H MRI, or radionuclides for PET.

We have recently demonstrated direct *in-vivo* imaging of hyperpolarized ^{29}Si nuclei in silicon particles by MRI. Natural physical properties of silicon provide surface electronic states that are used for low temperature DNP, and so no additional radicals are required for hyperpolarization. These particles have extremely long depolarization times (> 40 min) which are insensitive to surface functionalization, the *in-vivo* environment, particle tumbling or the external magnetic field. This is a new positive contrast, background-free imaging modality that is applicable to a range of inexpensive (~$1/g), readily available, and biocompatible silicon particles.

In this presentation I will discuss the basics of silicon nanoparticle DNP with a focus on sharing information that would allow new researchers to enter the field. In particular I will answer:

- What are the physical properties of these materials that give them such long T_1 times? Why are the NMR and DNP properties of solids so different to liquids and gases? What other nanoparticles may be suitable for hyperpolarized MRI?
- What is the experimental setup we have used for silicon DNP? How can you build your own polarizer? Are commercial DNP polarizers also suitable?
- What are the considerations for imaging silicon nanoparticles? How can the long coherence times be accessed and exploited?
- What areas for improvement do we foresee in T_1, ^{29}Si nuclear hyperpolarization and detection sensitivity? What are the limitations of this technique?
- What clinical applications for hyperpolarized silicon particles are currently being explored?

Also see oral presentation #4982 in Novel Contrast Agents & Reporters (Monday 22 April, 16:30)