TIFR Centre for Interdisciplinary Sciences
21, Brundavan Colony, Narsingi, Hyderabad 500 075

Seminar

Nuclear Spins Far From Equilibrium

Malcolm H Levitt

University of Southampton, UK

It is possible to generate materials with strongly perturbed nuclear spin distributions. There are two different types of non-equilibrium nuclear spin states.

In the first type, the nuclei are strongly lined up in one direction, to a degree which is much greater than that which is available without intervention. Such materials are said to be hyperpolarized. Materials in hyperpolarized states can generate NMR signals which are 100000 stronger than normal. This phenomenon has already been used in clinical trials for the detection of cancer in human patients. In my talk I will discuss some methods for generating such hyperpolarized materials, and how they are exploited in real-world experiments.

In the second type of non-equilibrium spin state, neighbouring nuclei in the same molecule are strongly aligned with other, as opposed to being aligned along an external direction. In sufficiently symmetrical molecules, this leads to the phenomenon of spin isomerism, in which compounds with different nuclear spin configurations behave as separate physical substances, which can be stable for a long time. The seminal case is hydrogen gas (H_2) where the spin isomers are called ortho and parahydrogen. These spin isomers were predicted to exist by Heisenberg (for which he was awarded a Nobel Prize) and their existence is one of the triumphs of quantum mechanics. Recently our group showed that ordinary water may also exhibit ortho and para spin isomers, providing the water molecules are trapped inside carbon cages (fullerenes) so that they are free to rotate at low temperature. We also showed that the type of water spin isomer has an influence on the electrical properties of the material.

In my talk I will discuss how these different types of non-equilibrium nuclear spin states are generated, and how they relate to each other. I will also discuss the topic of long-lived states, in which certain types of non-equiilibrium spin order persist for a long time even when no spin isomers exist.

Monday, Jan 9th 2017

4:00 PM (Tea/Coffee at 3:45 PM)

Seminar Hall, TCIS