Hyperpolarized Magnetic Resonance: Enhancing MRI Signals by >10,000-fold for Metabolic Assessment of Cancer

In vivo or in vitro nuclear magnetic resonance (NMR) spectroscopy and imaging (MRI) of nuclei other than proton is hampered by the low signal sensitivity due to the minute differences in spin populations between the nuclear Zeeman energy levels. Dynamic nuclear polarization (DNP) or hyperpolarization, an offshoot of a particle physics technology, has recently solved this insensitivity problem by amplifying the magnetic resonance signals of insensitive nuclei such as carbon-13 by 10,000-fold or higher. The trick is to transfer the high electron thermal polarization to the nuclear spins via microwave irradiation at low temperature (close to 1 K) and high magnetic field (> 1 T), then rapidly dissolve the frozen polarized samples into hyperpolarized liquids at physiologically tolerable temperature. In this talk, I will delve into the discussion of the physics, instrumentation and engineering aspects, optimization methods, and biomedical applications of the DNP technology. This cutting-edge physics technology is currently improving cancer diagnostics by providing biochemical and metabolic information at the molecular level with superb sensitivity and specificity a quantitative analysis of the Raman and PL data, supported by numerical simulations, we point out the main limiting factors of the SERRS efficiency. The presented studies contribute to the understanding of the near-field interaction between strongly localized surface plasmons and excitons, and paves the way to the development of new applications in the field of hybrid plasmonics.