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Hyperpolarized Magnetic Resonance: Enhancing MRI Signals by >10,000-fold for Non-Invasive Metabolic Assessment of Cancer[1]

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In vivo or in vitro nuclear magnetic resonance (NMR) spectroscopy and imaging (MRI) of nuclei other than proton is hampered by inherently low signal sensitivity. This insensitivity problem emanates from the minute differences in spin populations between the nuclear Zeeman energy levels. Dynamic nuclear polarization (DNP) or hyperpolarization, an offshoot of a particle physics/nuclear scattering technology, has recently solved this insensitivity problem by amplifying the NMR 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 present the physics, instrumentation and engineering aspects, optimization methods, and biomedical applications of the DNP technology. This cutting-edge physics technology is currently revolutionizing cancer diagnostics by providing biochemical and metabolic information at the molecular level with superb sensitivity and excellent specificity.

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