Startup Project for Nuclear Spin Imaging (NSI)

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From the last year on, the development has been placed on production of a highly polarized ^{3}He gas for the hyperpolarized ^{3}He MRI (Magnetic Resonance Imaging) by means of the brute force method, in which an extremely low temperature and a high magnetic field are used [1].

The imaging technology in either microscopic or macroscopic scale is nowadays well established in a variety of scientific fields including the medical diagnosis. The imaging probed by the nuclear spins is called the MRI, and regarded sometimes as a more powerful candidate for the X-ray CT (Computer Tomography) and PET (Positron Emission Tomography). We christened the imaging probed by the hyperpolarized nuclear spin "NSI", i.e., Nuclear Spin Imaging. One of the most important advantages of the NSI is radiation-free, i.e., no use of radioactive beam or isotope. This is of particular importance in the medical diagnosis because the radiation exposure can be avoided for not only patients but also doctors, nurses and clinical engineers. As a matter of fact, the danger of the exposure to low-dose ionizing radiation from the imaging procedures has been pointed out in U.S.A.[2]. In addition, because of the good position resolution and short measurement time the NSI will hopefully open a new frontier. In this context, our project has been revised, and aims at the study on the space/time structure of living body by means of the NSI. The brute force method can create the hyperpolarized nuclei irrespectively of nuclear species. This is another merit of the NSI. In fact, at least a few tens % polarization could be obtained for ^{13}C, ^{15}N, ^{19}F, and ^{31}P which have spin $\frac{1}{2}\hbar$ with T=10 mK and B=17 T. Since these nuclear species are important constituents in living body, these nuclear species will be employed as the probes of the NSI for the study on the molecular biology and medical diagnosis.

Meanwhile, we are developing a ^{3}He polarizer to be dedicated to the hyperpolarized ^{3}He MRI as the first step of our project. The idea of the ^{3}He polarization was proposed more than 30 years ago by Castaing and Nozières [3]. In Fig. 1, a schematic view of the polarizer is shown. The polarizer will be used in combination with the ^{3}He/^{4}He dilution refrigerator (DRS2500, Leiden) under the high magnetic field (∼17T). This system consists of thermal switches mechanically controlled from the outside. For quick melting of the polarized solid ^{3}He , an internal part of the polarizer including the Pomeranchuk cell and the thermal switches are designed to be lifted up. For enabling a convenient test of the Pomeranchuk cell itself including gas handling and NMR, a liquid helium-free ^{3}He/^{4}He dilution refrigerator (Suzuki Shokan Co. LTD.) with a 1 T superconducting Helmholtz coil installed was introduced, and optimization of the refrigerator gets started soon.

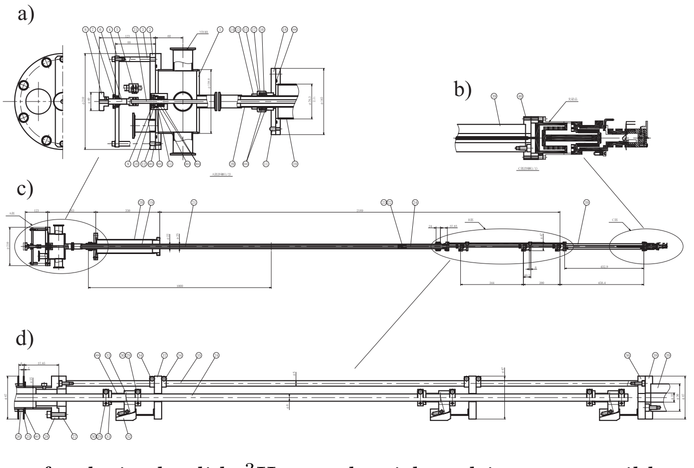

Fig. 1 Polarizer. Creation of polarized solid ^{3}He , and quick melting are possible. a) Head part. Extraction signals, mechanical operation of the thermal switches, and quick melting of ^{3}He can be done. b) Bottom part. Pomeranchuk cell is attached. c) Whole layout of the polarizer. d) Middle part. Thermal switches are adapted.

References

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