Developing advanced NMR technique and device material toward a solid-state quantum computer

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A 12 qubits Quantum Computer by Isotope Superlattice of CdTe

We propose a solid-state device for a quantum computer composed of the compound semiconductor CdTe. Isotope superlattice is made of all spin 1/2 nuclei, ^{111}Cd (A), ^{113}Cd (C), ^{123}Te (B) and ^{125}Te (D), and no magnetic field gradient is needed. The unit cell contains 14 layers in a specific layer order on the [111] direction of the magic angle to reduce nuclear dipole fields. We show that the device provides a 12 qubits quantum computer with a DNP initialization using optical pumping technique and controlling the spins by RF. MRFM would be better for the readout than NMR detection. We assume in this proposal that J couplings in CdTe would be moderate as can be expected, so that the 12 line splittings appropriately occur and also provide the T_1's long enough for the computing time.

An NMR Quantum Computer by Quantum Many Body Spintronics

We propose a method of switching on and off nuclear interactions caused by the longitudinal ($I_i^z I_j^z$) component of the Suhl-Nakamura interaction using singlet-triplet ESR transitions in an 1D antiferromagnet opening spin gaps by the quantum many body effect in the ground state. This provides us with a new method of controlling the logic gates XOR in the solid state NMR quantum computers. The new feature is the localized creation and annihilation of nuclear interaction, which would be an advantage over the method using nuclear dipole interaction.

NMR study of rare-earth phosphides as promising materials for 2 qubits quantum computer

In order to explore the promising materials with 2 qubiuts for solid-state NMR quantum computers, we have synthesized rare-earth monopnictide YP and rare-earth orthophosphate YPO_4 with ^{31}P and ^{89}Y. The NMR line width and the spin-lattice relaxation time T_1 for ^{31}P nuclei were measured at room temperature by a FT-NMR spectrometer. The nuclear dipolar contribution to the line width at half maximum (FWHM) of the spectrum was estimated from the theoretical second moment and compared with the experimental data. Experimentally obtained FWHM of 5.7 kHz and 2.9 kHz for the ^{31}P nuclei in YP and YPO_4 , respectively, are larger than expected one of 1.6 kHz and 1.2 kHz due to magnetic impurities and/or defects. It is necessary to improve the sample quality for the 2-qubit quantum computing.