FUNDING PROGRAM FOR NEXT GENERATION WORLD-LEADING RESEARCHERS

Project Title: Implementation of a scalable two dimensional quantum computer with an optical potential controlled by the holographic method	
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1. Background of research

It is advantageous from view points of time, cost, and also energy to clarify the property of the new material without the process of the synthesis. It is however quite difficult to perform the computer simulation of the physicality, since the property of the material obeys the quantum mechanics. While the quantum computer has been proposed to perform such calculations, its implementation has poor visibility.

2. Research objectives

Implementation of the quantum computer requires qubit which works as a memory obeying the quantum mechanics. While quantum computation using several qubits has already been demonstrated, here we try not a demonstration but a quantum computation with 100 of qubits which is of practical use.

3. Research characteristics (incl. originality and creativity)

The electron has a spin which works as a qubit and the spin behaves like a small magnet. Residual magnetic field caused by e.g., the geomagnetic field thus randomizes the direction of the magnet and the quantum computation can not be performed. The nucleus also has the spin, but the corresponding magnet is much smaller than that of the electronic spin. We control the position of individual nucleus of neutral atoms by using the laser force, make an array of the nuclei and implement the quantum computer.

4. Anticipated effects and future applications of research

The property of the material is characterized by its structure and also concerned force. The system which freely controls such parameters can clarify physicality of the material without the process of the synthesis. Such a system can also be a powerful tool to figure out various types of magnetic phenomena and also physics concerned with the superconductivity.

Background of research

Calculation speed	Notebook	10^9/s
	Super computer	10^{14}/s

There are several problems which can not be calculated by the classical computer.

① Factorization in prime numbers

200 of digits : Super computer 10 years → Q.C. : minutes

10,000 of digits : 10^{11} years → Q.C.: hours

② Quantum simulation : Condensed matter physics, material design・・・

Hubbard model calculation 20~30 cites → Q.C. : seconds

Quantum calculation dramatically reduces the calculation time.

However, current research is limited to calculation with several qubits.

The purpose of the research

① Introducing a novel calculation method

Combination of quantum gates → Cluster computing

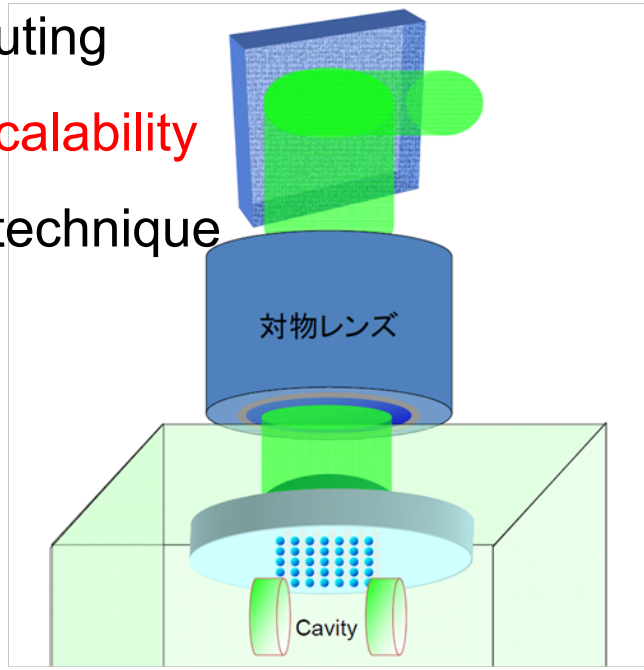
② New system having a long coherence time and scalability

2D array of nuclear spin qubits with laser cooling technique

③ Original technique developed by our labolatory

Projective measurement of single nuclear spin

with Cavity QED



Implementation of quantum computation

with 100 of qubits.

Change the status from ‘Impossible’ to ‘possible’.