



## Diamond Quantum Computer for Education

# Product Introduction

Diamond Quantum Computer for Education is based on the principle of NV color center and spin magnetic resonance in diamond. By controlling laser, microwave, magnetic field, etc, to perform quantum manipulation and readout of the spin of the NV color center to realize the quantum computing functions. The instrument operates at room temperature conditions, and without low-temperature vacuum environment, which makes the equipment have almost zero operating costs. The desktop design allows it to adapt to a variety of teaching environments, whether in the classroom or laboratory, it's easy to carry out the experimental teaching of quantum mechanics and quantum computing.

Besides, it allows students to build and debug the experiment equipment by hand, and write custom pulse sequence with the multi-functional software. Also it can provide complete teaching and experimental content of quantum computing based on the diamond NV system. From basic quantum mechanics experiments to quantum computing algorithm experiments, it helps and universities and research institutions to open and optimize university physics experiment courses and modern physics experiments courses in quantum information science, promotes the construction of the discipline of quantum mechanics, innovates the teaching content of the discipline, and improves related disciplines and teaching quality.



## Product Parameters

Qubit: NV color center in diamond	Microwave channel: 2
Laser power: 10mW	Time accuracy : 2 ns
Magnetic field: 10-50 Gauss	Pulse control module channel: 8

# Product Functions

## 1/ Quantum computing

- qubit
- quantum logic gate
- quantum decoherence
- quantum algorithm

## 2/ Quantum mechanics

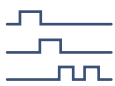
- quantum state
- quantum state evolution
- Zeeman effect
- electron spin

## 3/ More functions

- magnetic resonance
- optically detected magnetic resonance
- quantum control technology
- quantum precision measurement

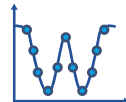
# Experiments

Diamond quantum computer for education is composed of microwave module, light module, control acquisition module and power module. The hardware supports a variety of basic experiments related to quantum computing, as well as quantum precision measurement, light detection magnetic resonance and more expand development.



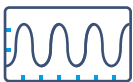
### Instrument Calibration

Set up and adjust the instrument, get familiar with the principle of optically detected magnetic resonance, NV center, microwave generation and pulse control.



### Continuous Wave

Understand NV center qubit by measuring the optically detected magnetic resonance spectrum and get the resonance frequency for spin control.



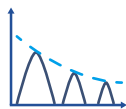
### Rabi Oscillation

The Rabi oscillation of NV center is measured, and get the microwave pulse length corresponding to the quantum logic gate.



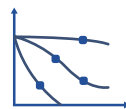
### Spin Echo

Spin echo is an effective technique used to suppress the coupling between the qubit and the environment, so as to prolong the coherence time.



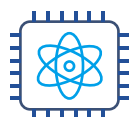
### T2 Measurement

T2 experiment shows the evolution of quantum superposition state and measures the decoherence time of NV center spin.



### Dynamic Decoupling

The decoherence time is extended by designing the dynamic decoupling sequence to average out the coupling between the qubit and the environment.

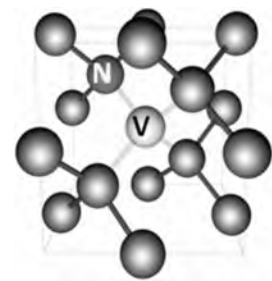


### D.J. Algorithm

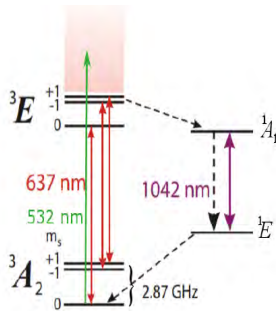
A truly qubit Deutsch-Jozsa quantum algorithm is realized on the NV center quantum processor.

# Experimental principle

NV color center is a point defect in diamond crystal, which is an excellent quantum system. What we call NV color center refers to the negatively charged NV<sup>-</sup> paramagnetic center. NV<sup>-</sup> color center has six electrons, so its spin angular momentum is  $0, \pm 1$ .

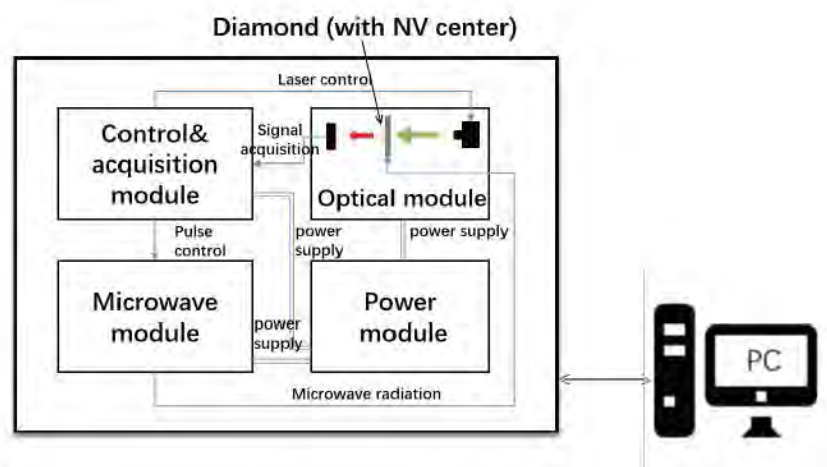


NV color center



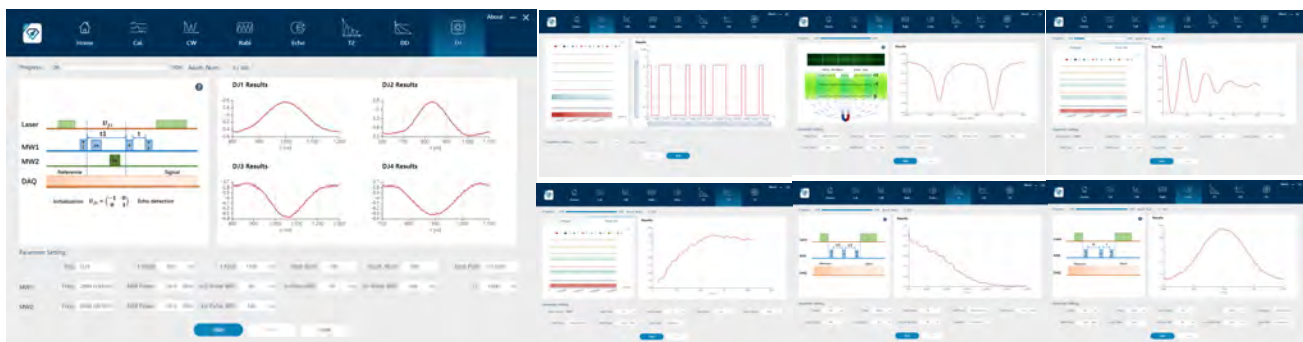
Energy level structure of NV center

NV color center energy level structure as shown in the left, it can be seen that, part of  $|+1\rangle$  quantum state can be transferred into  $|0\rangle$  quantum state after a green light excitation, and not emit red light, so we can use the green laser to realize polarized light and read-out of NV color center.



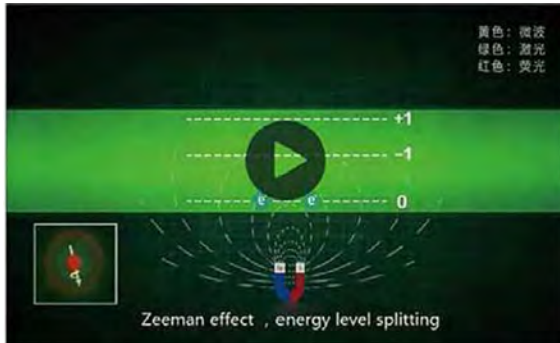
Module function topology of diamond quantum computer for education

# Experiment Interface



# Curriculum Solutions

Based on the diamond quantum computer for education, we can provide a complete set of solutions related to quantum computing curriculum , including laboratory construction, course handout, lecture video, courseware, demonstration and training, etc.

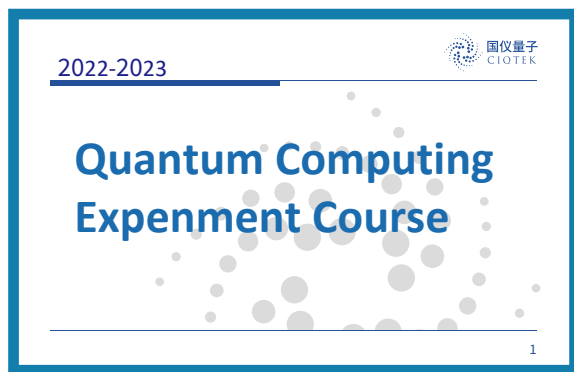


Lecture Video



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Course Handout



Lecture Slides



Demonstration and Training

## Cooperation Universities

100+ customers delivered

