SpinQ Gemini: a desktop quantum computer for education and research

Shi-Yao Hou ,Guanru Feng , Zipeng Wu , Hongyang Zou , Wei Shi , Jinfeng Zeng, Chenfeng Cao, Sheng Yu, Zikai Sheng, Xin Rao, Bing Ren, Dawei Lu, Junting Zou, Guoxing Miao, Jingen Xiang, and Bei Zeng

***Contact:* jzou@spinq.cn**

FEATURES

- Designed and manufactured by SpinQ Technology, hardware based on NMR spectrometer, permanent magnet providing 1T magnetic field.
- Operating under room temperature(0-30 °C), lightweight (55 kg with a volume of 70*40*80 cm^3), cost-effective (under 50k USD), maintenance-free.
- Featuring quantum control design capabilities that benefit the researchers studying quantum control and quantum noise.

METHODS & RESULTS

The schematic diagram of Gemini system ▼

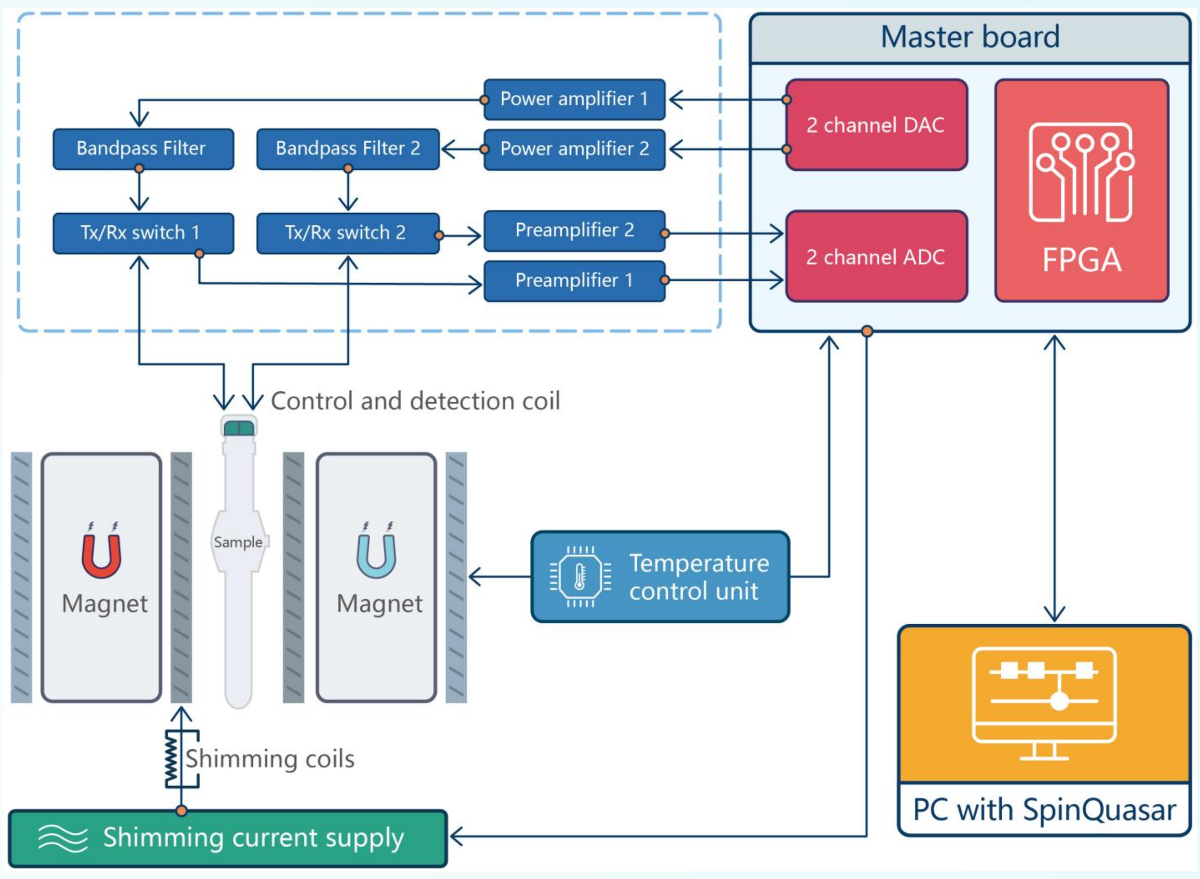
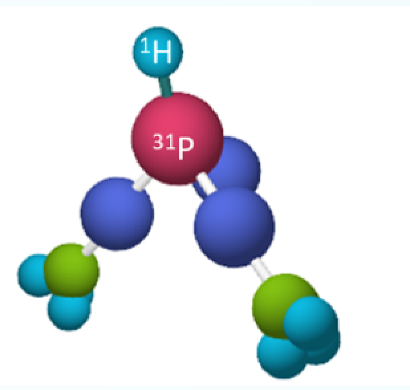


Figure 1: The master board equipped with an FPGA, provides the control logic of Gemini. SPINQUASAR communicates with FPGA through USB so that the user can access Gemini. The magnets, together with the temperature control unit and the field shimming system provide a stable static homogeneous magnetic. The RF module provides the function required to control and measure the qubits.

The molecule structure and its parameter table ▼

Figure 2: The sample we used is Dimethylphosphite ($(CH_3O)_2PH$) molecules . The ^{31}P and ^{1}H atom are connected directly and provide a two-qubit quantum processor.



	^{1}H	^{31}P
^{1}H	0	697.4
^{31}P	697.4	0
T2 (s)	0.3	0.5
T1 (s)	4	7.2

The gate set ▼

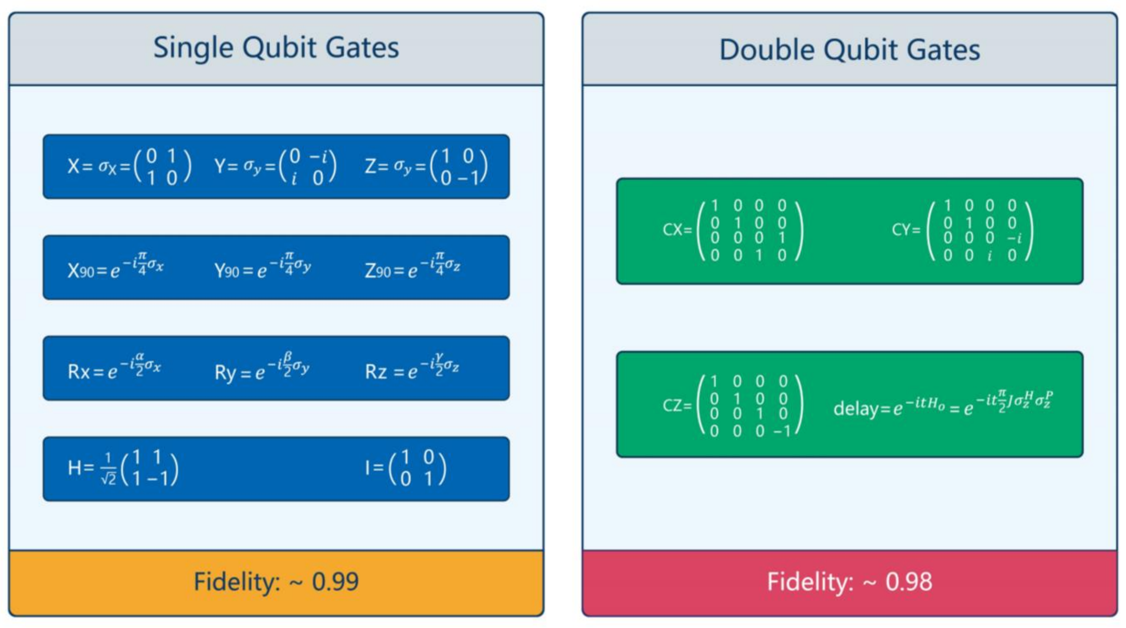


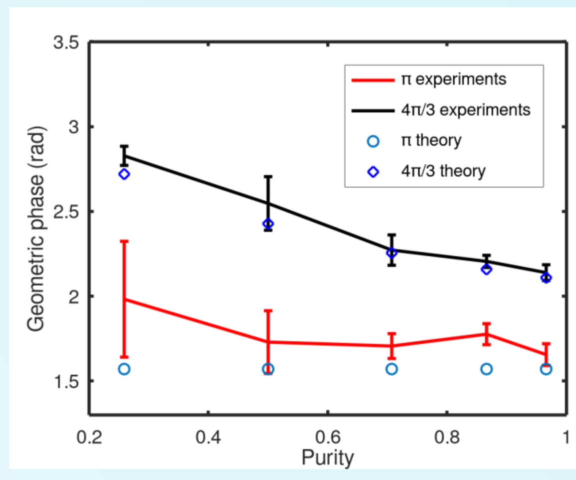
Figure 3: all quantum gates are realized using square pulses which are resonant with ^{1}H or ^{31}P and combined with free evolution. The available quantum gates contain single-qubit and two-qubit gates.

The SPINQUASAR interface for quantum computing ▼

Figure 4: There is a quantum circuit composer where users can drag and drop the supported quantum gates to construct a desired circuit, corresponding pulse sequence is shown below the quantum circuit.

The theoretical and experimental results of the mixed state ▼

Figure 5: The main error sources are the non-ideal initial mixed state and rf pulse inhomogeneity. The large fluctuations in the experimental results come from the uncertainty in fitting the NMR spectra. The change trend of the geometric phase as a function of the purity and the solid angle of the path can be observed from the results.



Results of VQE (variational quantum eigensolver) ▼

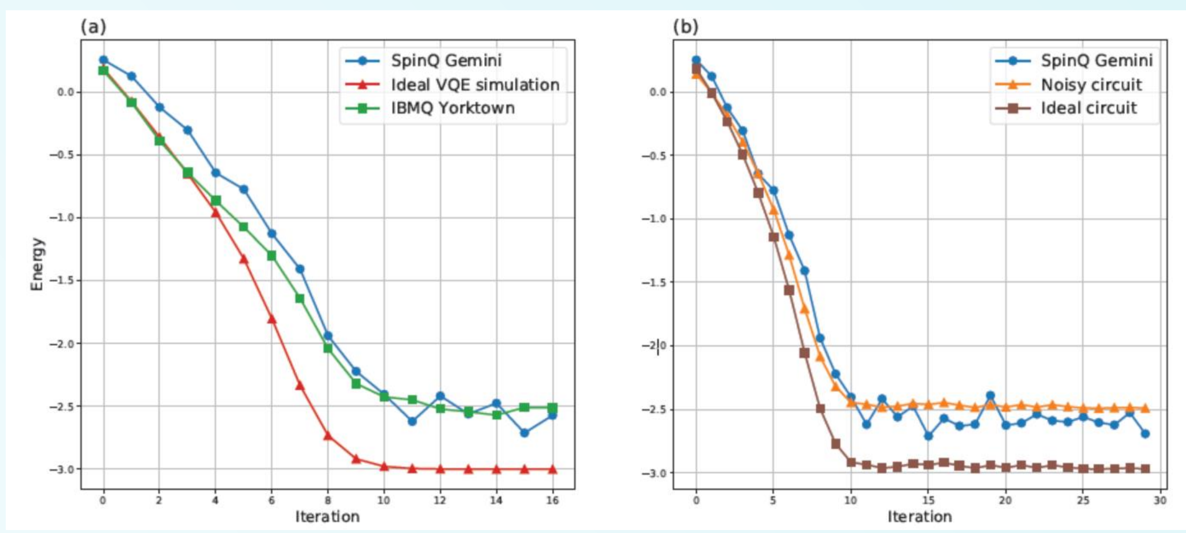


Figure 6: SpinQ Gemini and IBM Q Yorktown perform similar, both converge to $E(\theta) \approx -2.6$ after enough iterations. The gaps to the ground state energy result from gate errors and readout errors. The noisy circuit result shows great consistancy to the experiment data. The paramaters θ found by SpinQ Gemini is close to the parameters for ground state. These results indicate our desktop quantum computer can run VQE algorithm well.

COMING SOON

- Design of a 3-qubit machine is underway and the product is expected to be released in the second quarter of 2021, with a comparable price as SpinQ Gemini (i.e. under 50k USD).
- A simplified version of the current model, which is more portable and of much lower cost (under 5k USD), is expected to be released in the fourth quarter of 2021.

Reference: arXiv:2101.10017 [quant-ph] http://arxiv.org/abs/2101.10017