

Composite Pulses for Quantum Engineering

Results in Brief

Composite pulses make for error-free quantum computing

Stable qubits resilient to the detrimental effects of environmental noise are critical for commercialising quantum computing applications. EU-funded researchers demonstrated efficient error correction for qubits, marking a significant step towards fault-tolerant quantum information processing.



© plotplot, Shutterstock

To develop their full potential, quantum computers will need to meet specific criteria: They need to have a considerably high number of qubits and be capable of processing errors. Qubits are particularly prone to errors: a passing radio wave or a flash of light is enough to disrupt its quantum state and cause havoc with a quantum computer's calculations.

More accuracy in quantum computations

Undertaken with the support of the EU-funded Marie Skłodowska-Curie fellowship, the COPQE project conducted breakthrough research on reducing environmental noise and optimising control over qubits. The project's novelty lies in the development of composite pulses, a quantum engineering technique capable of correcting any errors present in quantum information processing. This fault tolerance was achieved using quantum error correction, where information is encoded redundantly, enabling error detection without destroying quantum data.

“Composite pulses boast several advantages: They give qubits – independently of their initial state – an incredible level of control, precision and insensitivity to the presence of errors. They also help create high-fidelity quantum states of qubits sent down in defect integrated photonic waveguides,” notes project coordinator Dr Elica Kyoseva. Composite pulses demonstrated a negligible loss of fidelity – the precision rate was above the limit of 99.99 % for quantum information processing – with minimal pulse overhead (the smallest sequence contained only two pulses).

‘Lighting’ the way to quantum computing

The research conducted by COPQE strengthens the power of integrated quantum photonics on quantum computing. Integrated quantum photonics – the science of generating, manipulating and detecting light in regimes where it is possible to coherently control photons – is a fundamental field in exploring quantum phenomena. Due to photons being particularly attractive carriers of quantum information, quantum photonics is also expected to play a central role in advancing quantum information processing.

“Project results will form the cornerstone platform to experiment with various protocols for quantum information processing. They also bring high-fidelity quantum computing in integrated photonic circuits closer to practical reality,” Dr Kyoseva points out. As she further describes, composite pulses were initially developed to mitigate fluctuations in the strength of the driving oscillating field in nuclear magnetic resonance. Since then, they have attracted considerable interest in quantum engineering due to their robustness against errors. So far, no composite pulses have been realised in integrated photonics systems.

Quantum computing impact

Being able to run processes in parallel compared to classical computers, which perform tasks sequentially, quantum computers will analyse big data and solve complex optimisation problems significantly faster. “Quantum computers have a huge potential to redefine existing industries including quantum computing security, financial services, drug development, material science, pharmaceuticals and other data heavy industries. To this end, a lot of effort is dedicated to pushing the technology beyond the realms of laboratory to emerge into reality. The most significant roadblock is the extreme sensitivity of quantum systems to their surrounding environment which significantly reduces the accuracy of quantum operations and destroys quantum computations,” notes Dr Kyoseva.

A lot of science and engineering is still required to improve qubit stability. Reducing noise and optimising the error control over the qubits is a significant step towards this direction. Project methods for qubit control based on composite pulses are highly relevant to error-free quantum information processing.

Keywords

COPQE

qubits

quantum information processing

composite pulses

quantum computing

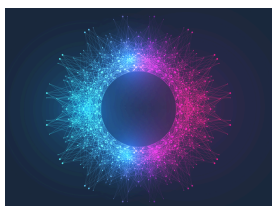
fidelity

integrated photonic

environmental noise

error correction

Discover other articles in the same domain of application



Working to make the quantum phase device a reality

29 September 2020



Metal-organic structures for electrolyzers improve the efficiency of their chemical reactions

27 May 2021



EU project pioneers new wave material analysis

22 March 2018





EU project pushes boundaries of nanostructure knowledge

22 March 2018



Project Information

COPQE

Grant agreement ID: 705256

[Project website](#)

DOI

[10.3030/705256](https://doi.org/10.3030/705256)

Project closed

EC signature date

15 April 2016

Start date

7 October 2016

End date

6 November 2018

Funded under

EXCELLENT SCIENCE - Marie Skłodowska-Curie Actions

Total cost

€ 140 994,00

EU contribution

€ 140 994,00

Coordinated by

INSTITUTE OF SOLID STATE
PHYSICS BULGARIAN ACADEMY
OF SCIENCES



Bulgaria

This project is featured in...



Related articles

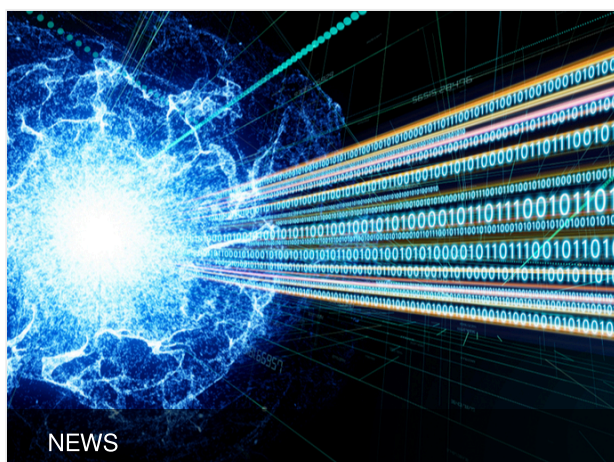


SCIENTIFIC ADVANCES

Mission impossible? Stopping light for tiny fractions of a second



24 July 2020



SCIENTIFIC ADVANCES

Everyday transistors point the way to large-scale manufacture of quantum computers



28 January 2021

Last update: 17 May 2019

Permalink: <https://cordis.europa.eu/article/id/300390-composite-pulses-make-for-errorfree-quantum-computing>

European Union, 2025