HORIZON 2020

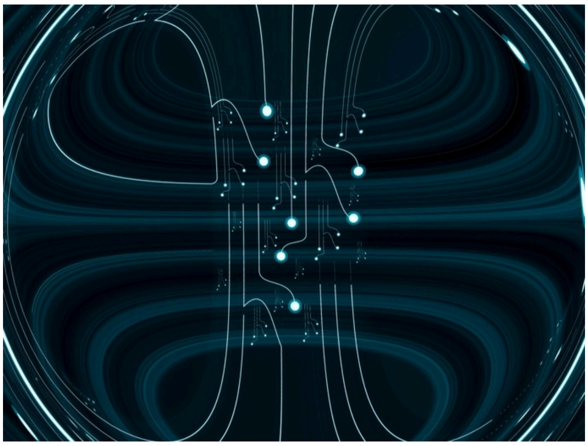
Development and Control of Flexible Mode-locked Integrated Laser

Results in Brief

On-chip light sources and qudits: Is this the new face of quantum computing?

Controlling and harnessing the properties of classical and non-classical light is key to the development of ultraprecise metrology and quantum computer applications. An EU-funded project has developed sophisticated laser systems and flexible on-chip light sources, a step forward in this direction.

DIGITAL ECONOMY



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Small, practical and highly efficient photonic on-chip systems are central to both producing and controlling optical pulses in the classical and quantum regimes, a topic that lay at the heart of the EU-funded project DC FlexMIL. This research was undertaken with the support of the Marie Curie programme.

"We worked to enable a new class of integrated pulsed light sources in the classical and non-classical regimes with stable and flexible emission properties," notes Michael Kues, holder of the Marie Curie Fellowship and recently appointed professor at the Leibniz University of Hannover. To do so, researchers utilised optical microring resonators. Resonant frequencies create constructive interference within a ring waveguide, enabling access to many discrete colours. Benefiting from a nonlinear phenomenon called four-wave mixing within these microring resonators, researchers exploited these systems for realising controllable light sources with novel and unique properties.

Record optical bandwidth of pulsed lasers

The project team successfully created a miniaturised yet efficient laser with a microring resonator as its cavity.

This is the first pulsed passively Kerr mode-locked nanosecond laser with a record-low and transform-limited spectral width of 105 MHz. Its mode-locking mechanism is attributed to four-wave mixing. “Our new laser architecture capitalised on the latest advances in nonlinear micro-cavity optics. Specifically, we exploited the narrow passband characteristic of the high-quality integrated microring resonator, which in addition to enabling high nonlinear phase shifts, makes it possible to generate nanosecond pulses though mode locking,” explains Kues.

The generated pulsed laser output had a spectral bandwidth so narrow that it was inaccessible with state-of-the-art optical spectrum analysers. To characterise the laser bandwidth, researchers instead used a coherent optical beating technique.

The record-low laser bandwidth made it possible, for the first time, to measure the full spectral characteristics of a mode-locked laser in the radio-frequency (RF) domain using widely available RF electronics. This helped verify the laser's strong temporal coherence.

Passively mode-locked laser systems are the optimal choice for generating low-noise optical pulse trains. Such systems make it possible to create stable optical frequency references for metrology (for example optical clocks) and high-intensity light-matter interactions.

Quantum computing – When less is more

Most attempts at building practical quantum computers have so far relied on qubits that unlike classical bits can simultaneously hold two values (0 and 1).

Instead of increasing the number of qubits to reach the processing capabilities required for meaningful quantum information science, it would be easier to maintain a smaller number of qudits, each able to hold a greater range of values.

“We have generated for the first time on an integrated chip two entangled qudits each with 10 levels, for 100 dimensions in total. This is more than what six entangled qubits could generate,” notes Kues. The team used on-chip devices and standard telecommunications components to create and manipulate the quantum states.

Through a frequency to time mapping, the project team transformed these highly entangled quantum states into high-dimensional cluster states. “This novel kind of quantum systems is an optimal tool for performing quantum computing operations," concludes Kues.

Keywords

DC FlexMIL | qudit | on-chip | microring resonator | qubit | quantum computer | radio-frequency (RF) | metrology | mode-locked laser | four-wave mixing

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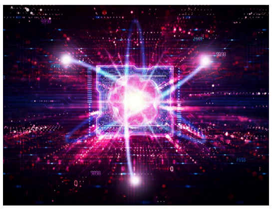

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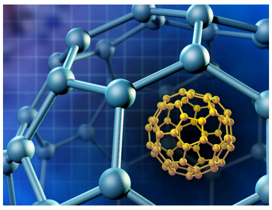

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Project Information

DC FlexMIL

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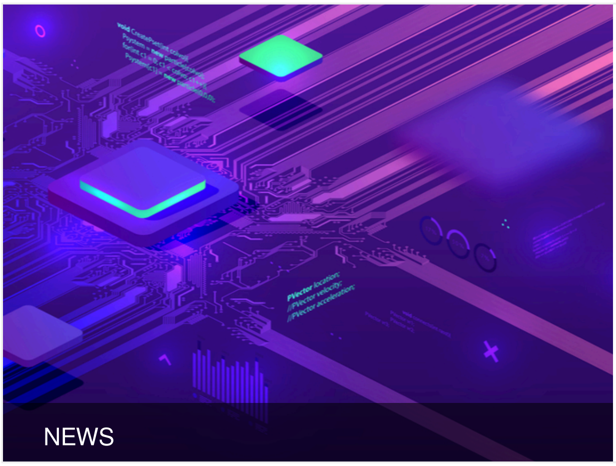

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