QUANTUM BERNOULLI FACTORY PHOTONIC CIRCUIT INDEPENDENT OF INPUT STATE BIAS

KEYWORDS

❑Quantum information processing

❑Quantum technologies

❑Integrated quantum photonics

❑Quantum randomness manipulation

❑Modular design

AREA

❑Elettrical Electronic & ICT Engineering

CONTACTS

➢ PHONE NUMBERS
+39.06.49910888
+39.06.49910855

➢ EMAIL
u_brevetti@uniroma1.it

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Patent Type
Patent for invention.

Ownership
Sapienza 70%, International Iberian Nanotechnology Laboratory INL, 20%, Centro Nazionale delle Ricerche CNR-IFN, 10%

Inventors
Ernesto Fagundes Galvão, Fabio Sciarrino, Gonzalo Alfredo Carvacho Vera, Francesco Hoch, Nicolò Spagnolo, Roberto Osellame, Taira Giordani, Luca Castello

Industrial & Commercial Reference
The industry of quantum computing, cryptography and communication in the multi-client scenario.

Time to Market
The current state of development has reached a TRL 4 level with a scientific publication under peer-review.

Availability
Assignment, exclusive or non-exclusive license, research, development, experimentation and collaboration

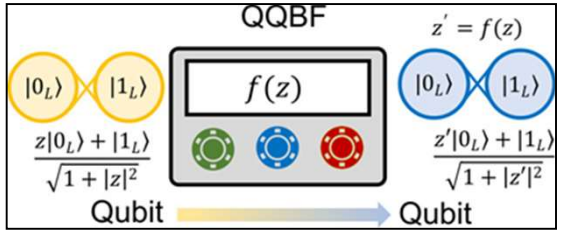


Fig. 1 Conceptual scheme of a Quantum-to-Quantum Bernoulli factory performing a selected operation on an input qubit.

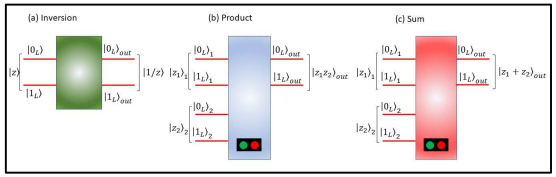
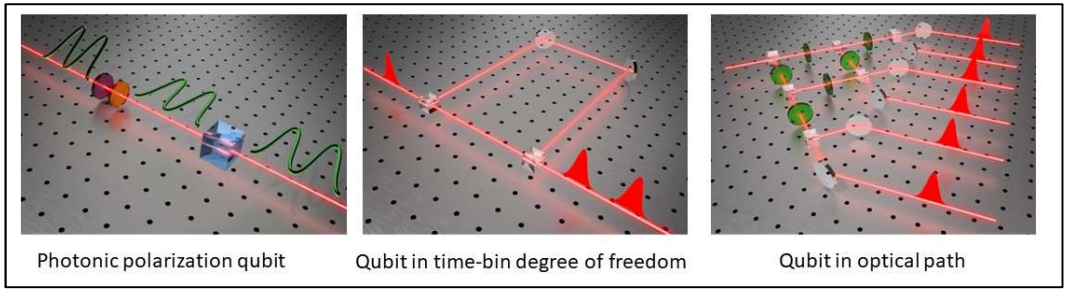


Fig. 2 Conceptual diagram of the blocks that carry out the fundamental operations of inversion, product and addition.

Fig. 3 Possible encodings of information on single qubits for the implementation of a Quantum-to-Quantum Bernoulli factory according to the present invention.



Abstract
The present invention concerns a scheme that allows to create a Quantum-to-Quantum Bernoulli Factory, wherein random bits and qubits can be generated given input qubits, by employing a quantum photonic system that can take advantage of the different quantum information encoding approaches using states of single photons.
The approach of the invention is modular and does not employ any information on the input state to implement the desired operation.
According to the invention, inversion, multiplication and sum operations can be realized with photon qubits and can be concatenated without generating noise.

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Technical Description

We introduce a scheme that allows to create on the one hand the more general Quantum Bernoulli Factory, i.e. the one in which random bits and qubits can be generated given an input qubit, and on the other hand to reproduce all the properties and advantages of the protocol. The validity of the proposed scheme has already been experimentally verified in an integrated and fully reconfigurable photonics platform.

The space of functions that can be constructed using a Quantum Bernoulli Factory are constituted by:

- The realization of 3 building blocks corresponding to the fundamental operations of the field (addition/sum, product and inverse operations);
- The possibility of combining the operations in order to realize an arbitrary function.

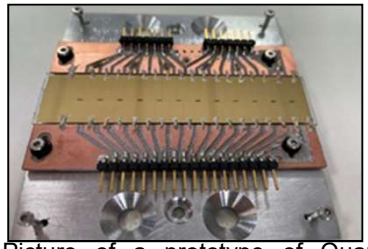

Fig. 4 Picture of a prototype of Quantum-to-Quantum Bernoulli factory for 3 qubits implemented by integrated photonic circuit, in the path degree of freedom.

Technologies & Advantages

The advantages of the invention are the possibility of obtaining a computational advantage, the modularity, the scalability and the intrinsic accuracy of the protocol. These characteristics make the invention a perfect candidate as a subroutine of more complex quantum algorithms. This approach has advantages for inclusion within a quantum network. Current technological developments are progressively allowing the creation of intermediate quantum processors of increasing size. These systems are based on high cost platforms that must be used locally and are unsuitable for a distributed type approach via quantum communication. The use of a photonic apparatus to create algorithm subroutines would allow its natural integration into a long-distance quantum communication network, thus being able to exploit photonic communication technologies, which are at a high level of technological maturity and commercialization. Other advantages are given by the "Blind" nature of the approach which does not require any information on the input and is therefore particularly suitable for cryptography and distributed quantum computing applications.

Applications

The applications of the patent concern various areas of computing and communication. The patent offers benefits in the following scenarios. Subroutine of sampling algorithms, having the purpose of sampling from an unknown distribution. Subroutine of quantum algorithms, given the quantum nature of the method in both input and output. Cryptography, as the distinctive property of not requiring knowledge of the input probability distribution, makes the patent compatible with the spirit of cryptographic protocols. Distributed Quantum Computing among multiple clients, leveraging patent generalization with more than one input probability distribution. The applicability of the method extends to variants of traditional quantum computing, known as blind-quantum computing.

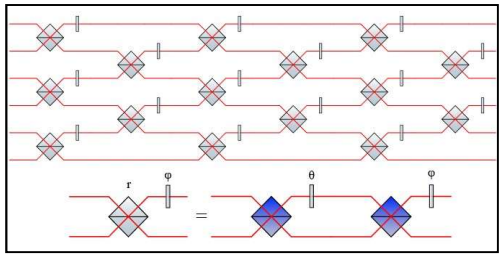

Fig. 5 Internal scheme of the elements of the Quantum-to-Quantum Bernoulli factory prototype for 3 qubits, in the path degree of freedom.

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