DIPARTIMENTO DI SCIENZE MATEMATICHE E INFORMATICHE, SCIENZE FISICHE E SCIENZE DELLA TERRA
Dottorato di Ricerca in Fisica

SEMINARI SPECIALISTICI
A.A. 2020/2021

From artificial atoms to quantum computers

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Quantum computers are machines that could perform specific calculations that our existing classical computer cannot. Among several proposed platforms to build a quantum computer, only one has reached an important level of maturity, superconducting qubits [1]. In this talk I will show how a quantum bit is made, and how a quantum computer is built using superconducting circuits. Furthermore, I will discuss the main problems that affect quantum computers and that, till now, prevent the possibility to have a practical advantage respect the classical ones.

[1] Arute, F., et al. "Quantum supremacy using a programmable superconducting processor." Nature 574.7779 (2019): 505-510.

Hide and unhide a Schrödinger cat state in the vacuum

One of the most fascinating feature of quantum mechanics is that the vacuum is filled of virtual particles. In extreme physical conditions these particles can be promoted to real at the expense of a high energy field. For example, Hawking radiation is predicted to be emitted from outside the event horizon of a black hole. Another interesting case, that is possible to investigate in laboratory, is the one that concerns a superconducting qubit interacting deep in the ultrastrong coupling regime with a cavity resonator. Here the vacuum is predicted to be a virtual photonic Schrödinger cat state entangled with the atom [1]. In this seminar, first I will give a brief introduction to Hawking radiation and relative paradox. After I will show the connection between this radiation and the photonic Schrödinger cat state in the ultrastrong light-matter coupling regime. To finish I will show a method to convert in laboratory the Schrödinger cat state from virtual to real and back driving the atom with optimally chosen pulses.

[1] Yoshihara, F. et al. Superconducting qubit–oscillator circuit beyond the ultrastrong-coupling regime. Nat Phys 13, 44 47 (2016).