Colloqui di Fisica

The quantum vacuum in cavity QED

In this talk I review the recent and less recent debate about the role of quantum vacuum in modifying materials and chemical properties in cavity quantum electrodynamics. One crucial element of this story is the possibility to reach the regime of ultrastrong coupling between the cavity quantized field and the enclosed material.
While the experiments are reporting results validating this picture, the theoretical community is still fragmented, without a clear agreement, due to the enormous complexity of the considered systems.
As an attempt, I will introduce a simple 'quantum optical' toy model, and I will show how matter's thermalization is drastically altered in the deep-strong coupling regime. However, these modifications are relavant only when the light-matter coupling is far beyond the real experimental regime, posing doubts on the realistic applicability of this theory.
In the last part I will show an alternative theory, without quantum vacuum, and only based on correctly including all the electrostatic contributions. In particular I will show that, without the need of quantum vacuum effects, this theory can recover very recent and important experimental results in integer quantum Hall systems in a THz cavity. Here is observed a breakdown of the topological protection, which was attributed to the presence of the quantum vacuum of the THz cavity. I will show that a consistent inclusion of standard electrostatic effect leads to predictions completely comparable with the experiment.

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