How two-component Bose-Einstein condensates can 'bypass' the no-cloning theorem?

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The no-cloning theorem in quantum cryptography prevents any eavesdropper from perfectly duplicating an arbitrary quantum superposition state of a single photon. Here [1] we argue that an experimental scheme to produce a quantum superposition of interacting, two-component Bose-Einstein condensates can generate N bosonic clones of any such arbitrary single photon wave packet at large N limit of thermodynamic equilibrium with high fidelity. Initially one can isolate the orthogonal polarizations using polarizing beam splitters and then amplify the corresponding single photon wave packets separately. This is to ensure that the amplified beams can further be used to generate proportionate numbers of bosons (say excitons) respectively to produce the required interacting condensates with additional light-matter interactions. The overall process can operationally 'bypass' the restrictions imposed by the above-mentioned theorem. It is possible because quantum statistical nature of this 'cloning operation' does not require strict unitary evolution of standard quantum mechanics within a single Hilbert space. Such interacting, two component multi-particle quantum superposition states as tensor product of single particle states are well documented for condensates of atoms and Helium-3 in particular.

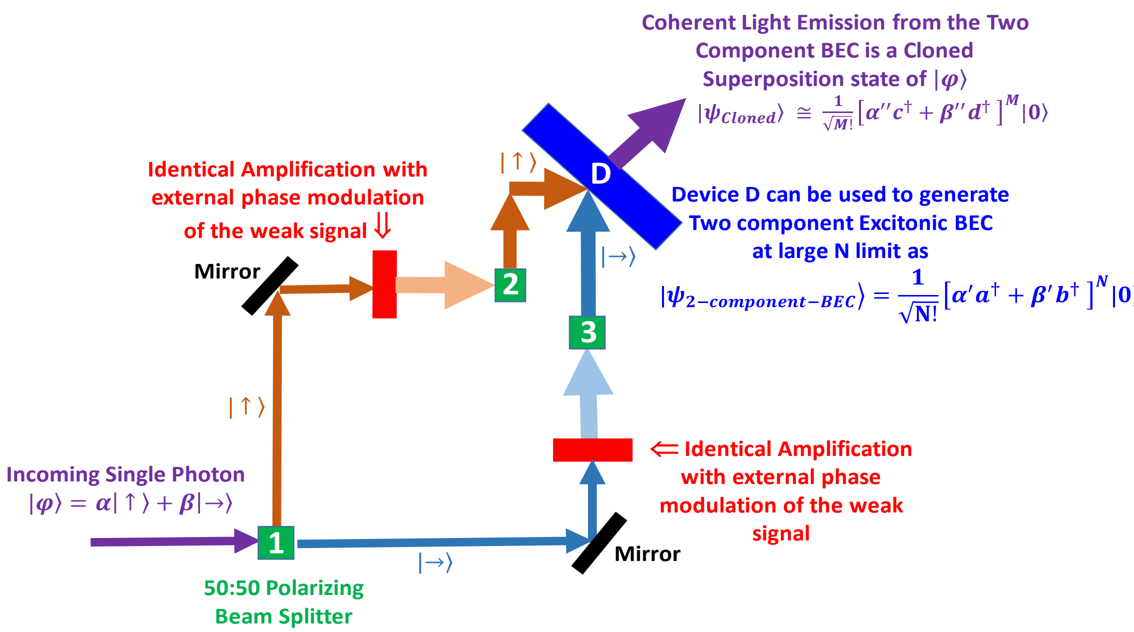

Figure 1. Schematic of the quantum cloning process using the 'bosonic clones' in the quantum ground state of a two-component, interacting Bose-Einstein condensates of excitons. The only requirement is large and identical amplification of both polarization channels using periodically pooled non-linear crystals and phase modulations of single photon wave packets. Green squares are 50:50 polarizing beam splitters. Polarizing beam splitters # 2,3 are used to filter out any unwanted polarization states due to the presence of spontaneous emissions during amplification processes. These last two 'classical' beam splitters can ignore negligible quantum fluctuations entering through their unused ports while filtering these highly amplified beams in respective polarization channels. Thicker arrows indicate the amplified beams.

References

[1] https://doi.org/10.48550/arXiv.2206.07523.