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Quantum Coherent Absorption of Squeezed Light

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Abstract: Two identical squeezed coherent states at the input ports of a 50% absorbing beam splitter do not show coherent perfect absorption (CPA). All coherence is lost, though, since at the output ports entangled squeezed vacuum states emerge. Remarkably, this output state is a pure state, although produced by a lossy device. Therefore this CPA gate could become a new tool for continuous-variable quantum state preparation. Moreover, for graphene multilayers engineered for CPA, we discuss the effects of interlayer separation.

We study coherent absorption of squeezed light by a 50% absorbing beam splitter [1]. Identical coherent states at the input ports of such a beam splitter lead to coherent perfect absorption (CPA): the output state is the vacuum state. Not so for identical pairs of squeezed coherent states, we find. We make a distinction between the loss of coherence and the loss of intensity, and show that corresponding absorption coefficients for quantum coherence and for intensity are different. This CPA gate has further intriguing properties: two identical but otherwise arbitrary incoming squeezed coherent states leave all of their coherence and half of their squeezing behind in the beam splitter, producing a pure entangled squeezed vacuum state as the output. This output state of light is not entangled with the lossy beam splitter by which it was produced. This surprising result may make the CPA gate a new tool for continuous-variable quantum state preparation.

Next we analyze absorbing beam splitters made by layers of graphene [2]. To achieve the 50% absorption needed for the CPA gate described above, we are in the “difficult” regime where we need more than a few layers of graphene on the one hand, but we are not necessarily in the bulk graphite limit either. To understand the absorption of a few layers of graphene, one typically uses the transfer matrix approach and neglects their subnanometer interlayer separation. Continuing to neglect this separation results in upper bounds to the absorption by graphene multilayers of 50%, exactly the value needed for coherent perfect absorption (CPA). This upper limit is only reached for real-valued sheet conductivities, and for pristine graphene the finite number of layers that would be required to attain this maximum is fixed by the fine structure constant. We show however that for the thicker multilayers needed to engineer 50% absorption, realistic interlayer separations need to be taken into account, in which case the upper bounds to the absorption at a finite number of layers no longer exist. More generally, more reliable predictions of the absorption by multilayer Van der Waals crystals suitable for CPA can be obtained if their subnanometer interlayer separations are carefully accounted for.

References

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2. Pandey, D., S. Xiao and M. Wubs, “Graphene multilayers for coherent perfect absorption: effects of interlayer separation”, Opt. Express, Vol. 30, No. 25, 44504–44517, 2022.