Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **3034** Type: **Oral (Non-Student) / Orale (non-étudiant(e))**

Coherence, nonclassicality and entanglement of continuous-variable states

Wednesday 8 June 2022 15:45 (15 minutes)

The quantum nature of a state of a bosonic quantum field can manifest itself in its bipartite entanglement, in its coherence and in its optical nonclassicality. Each of these distinct properties have been viewed as a resource, notably for quantum computing and quantum metrology, and can be measured with a variety of witnesses, measures and monotones. The question then naturally arises what the quantitative relations are between them. In this work, we first introduce, for each state of a bosonic quantum field, its quadrature coherence scale (QCS), a measure of the range of its quadrature coherences. We then link the QCS to optical nonclassicality: optical classical states have a small QCS and a large QCS implies strong optical nonclassicality. In addition, we try to clarify the relation between optical nonclassicality and bipartite entanglement, for multi-mode fields, by providing quantitative and computable bounds relating those quantities. We show in particular that strongly entangled states are strongly optically nonclassical.

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Session Classification: W3-9 Laser Development (DAMOPC) | Progrès dans les lasers (DPAMPC)

Track Classification: Technical Sessions / Sessions techniques: Atomic, Molecular and Optical Physics, Canada / Physique atomique, moléculaire et photonique, Canada (DAMOPC-DPAMPC)