World Academy of Science, Engineering and Technology
International Journal of Physical and Mathematical Sciences
Vol:19, No:09, 2025

A Study of Cavity Quantum States Induced by Cavity-Matter Coupling Using Negativity in the Wigner Distribution

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Abstract : Interaction between light and matter is the primary tool to probe matter at the microscopic level. In recent years, light-matter interaction in optical cavity has found interesting applications in manipulating chemical reactions and material properties by modifying matter states in the cavity. However, not much attention has been given to study modifications in the cavity-field states, which is the focus of study in this work. The classical to non-classical transition in the field state due to interaction with the matter inside the cavity is discussed. The effect of the initial state of the matter on the cavity states as well as the role of photon-fluctuations are explored by considering different initial states of the matter and the field. The results demonstrate that the initial states of the field and the matter play a significant role in generating non-classicality in the cavity-field state as quantified in terms of negativity in the (Wigner) phase-space distribution of the cavity. It is found that the coherences induced between different photon-number states due to the interaction always contribute to enhance the non-classicality, while populations may suppress or enhance it depending on the relative weight of the vacuum state over other states. An increased weight of the vacuum state diminishes the non-classicality. It is shown that the energy exchange takes place between different photon-number states in the cavity field while matter acts as the facilitating agent.

Keywords : cavity QED, light-matter interaction, phase space methods, quantum optics
Conference Title : ICAMOP 2025 : International Conference on Atomic, Molecular and Optical Physics
Conference Location : Paris, France
Conference Dates : September 20-21, 2025