Phase Structures in the Micromaser Photon Statistics*

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In the photon number distribution $p(\theta, k)$ of the micromaser, distinct structures are formed by the ridges connecting the peaks in the $\theta - k$ space. We refer to these structures as phases. By a simple condition we can distinguish between "semiclassical" and "quantum" regimes of operation near and far above threshold, respectively. In the semiclassical regime, the equations of state of the phases $\theta = \theta(k)$ are monotonous and coincide with the steady state solutions of the semiclassical theory. They reflect typical features of the micromaser dynamics. The transition jumps, e. g., between the phases decrease with increasing pumping parameter θ, signifying the onset of the Jaynes-Cummings collapse. On increasing θ further, the phases first disintegrate and then restructure into new kinds of phases in the quantum regime. The equations of state are no longer monotonous. Large single peaks, the quantum island states (QIS), develop in the neighborhoods of minima. The system undergoes oscillations between two kinds of quantum island states, QIS^- and QIS^+, as a function of θ. The disintegration and transformation of phases recur periodically as θ is varied, and the phases in the semiclassical region are followed by consecutive phase structures in the quantum regime. The subsequent collapses and revivals of phases are directly connected to the Jaynes-Cummings collapse and revival. The observation of these phase structures and the accompanying QIS is experimentally feasible.

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