Superradiance in Transport through Ensemble of Double Quantum Dots

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When an ensemble of two-level systems is coupled to a common bosonic field, the Dicke's superradiance takes place:[1] The emission of a boson creates an entangled state, which results in an enhancement of the subsequent radiation. We theoretically study the superradiance of optical phonons in the transport through an ensemble of double quantum dots (DQDs). We propose an experimental setup to observe the dynamical generation of entanglement, which should be important in the application to charge qubits for the quantum information processing. We consider a set of DQDs, $(\mathrm{L}_j, \mathrm{R}_j)$ $(j = 1, 2, \ldots, N)$. The current flows through the DQDs in parallel: from the source lead to L_j, and from R_j to the drain lead. The level spacing, $\epsilon_{\mathrm{L}_j} - \epsilon_{\mathrm{R}_j}$, is tuned to the energy of optical phonons. Using the pulse experiment,[2] N electrons are confined in L_j $(j = 1, 2, \ldots, N)$ in the initial state: $|\mathrm{L}_1\mathrm{L}_2 \cdots \mathrm{L}_N\rangle$. The tunneling from L_j to R_j is accompanied by the emission of a phonon, which makes an entangled state of $\big(|\mathrm{R}_1\mathrm{L}_2 \cdots \mathrm{L}_N\rangle + |\mathrm{L}_1\mathrm{R}_2 \cdots \mathrm{L}_N\rangle + \ldots\big)/\sqrt{N}$. This state enhances the ratio of the next tunneling event with phonon emission. Using the density matrix, we show the enhanced current due to this superradiance. If a specific DQD is connected to the drain strongly, the measurement of the current breaks the entangled state. The superradiance is hardly observed in such a situation.

[1] R. H. Dicke, Phys. Rev. **93**, 99 (1954); T. Brandes, Phys. Rep. **408**, 315 (2005).
[2] T. Hayashi *et al.*, Phys. Rev. Lett. **91**, 226804 (2003).