Origins of linear polarization of intersubband transitions in InAs/GaAs self-assembled quantum dots: a new picture

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Abstract—**Contrary to common knowledge that the transition to the state localized along the long axis of the structure shall have a larger dipole moment, we show that the transition from the ground electronic state in elongated InAs/GaAs quantum dots to the second excited state exhibits larger oscillator strength than that to the first excited state. A microscopic theory is proposed to explain the anomalous inversion of intensity ratio, which also presents a new picture to understand the origins of linear polarization of intraband transitions in self-assembled quantum dots. Our theory agrees well with a recent experiment.**

***Index Terms*—Quantum dot, intersubband transition, linear polarization**

Figure 1 schematically plots two intersubband transitions in an elongated self-assembled InAs/GaAs quantum dot. In the single-band picture, it is generally believed that the transition $\Psi_S \rightarrow \Psi_X$ has a larger dipole moment than $\Psi_S \rightarrow \Psi_Y$, and hence higher absorption intensity because Ψ_X is more spatially extended than Ψ_Y. However, just opposite to our common knowledge, it is shown in a recent experiment that the transition with higher energy, i.e., $\Psi_S \rightarrow \Psi_Y$, exhibits larger oscillator strength. The breakdown of the simple picture requires not only a new explanation to the inverted ratio of intensity but also a revisit to the origins of linear polarization of intraband transitions. Presented here is a microscopic theory beyond the effective-mass approximation to explain the inversion of intensity ratio and understand the origins of anisotropic spectrum of intraband transitions.

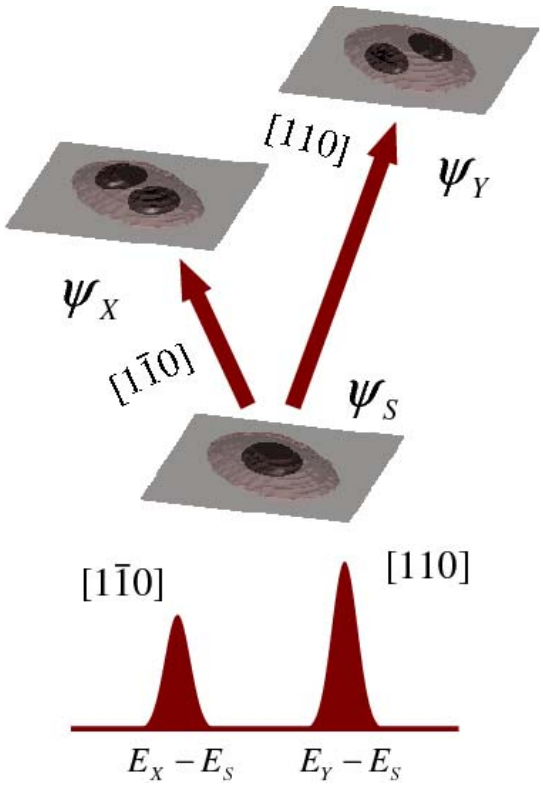

Figure 1. Schematic view of intersubband transitions from the ground electronic state Ψ_S to the first two excited states Ψ_X and Ψ_Y in an elongated self-assembled InAs/GaAs quantum dot. These transitions are respectively polarized along the long and short axes of the structure.

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