Modulation Instability in Semiconductor Quantum Dots

Y-type Excitation Scheme: Interpretation of Plots and Experimental Implications

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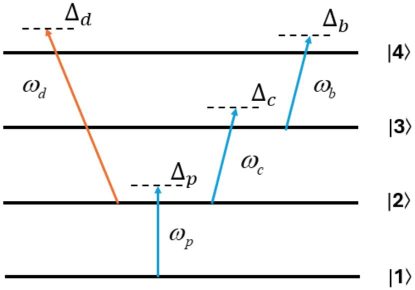
Overview

- Motivation: Understanding Modulation Instability (MI) in SQDs.
- Tools: Density matrix formalism, Maxwell-Bloch, NLSE.
- Focus: Interpretation of numerical plots & physical insights.

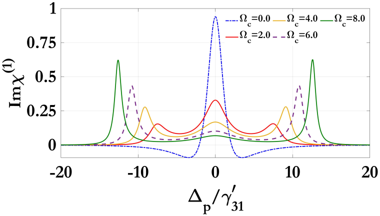
Light Matter Interaction

Y-type Excitation Scheme in SQDs

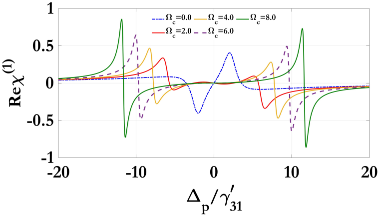


- We take Y-type 4-level excitation scheme.

Absorption Spectra: Ω_c & Ω_d

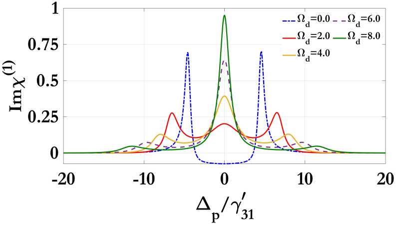


(a)

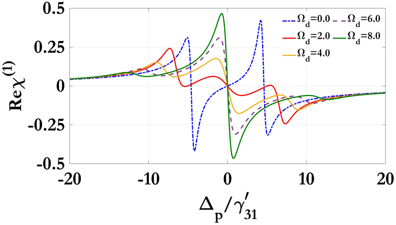


(b)

Dispersion Spectra: Ω_c & Ω_d



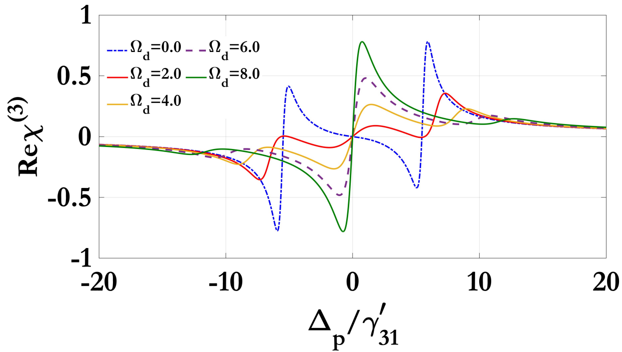
(a)



(b)

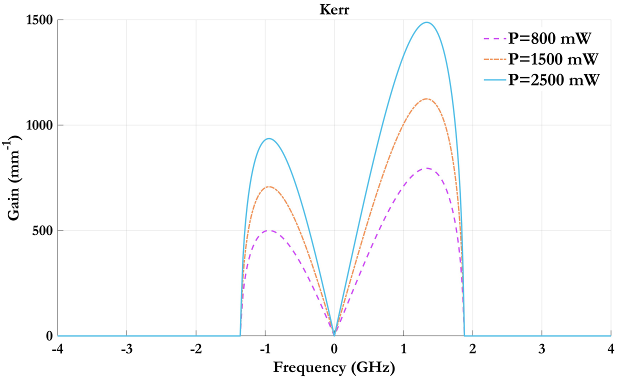
- Ω_c controls slope & zero-crossings.
- Enables slow/fast light applications.

Kerr Nonlinearity: Re $\chi^{(3)}$



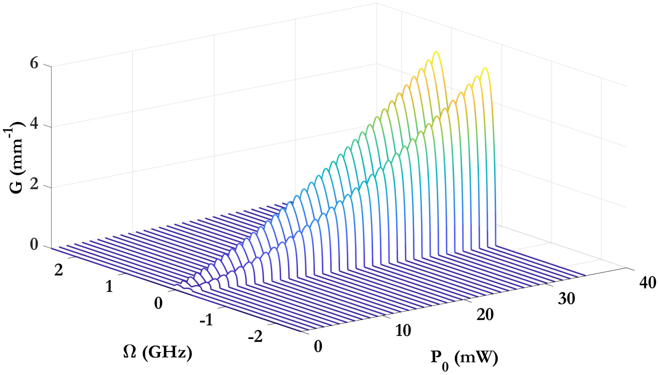
- Strong Ω_c & Ω_d amplify Kerr response.
- Enhanced four-wave mixing & optical switching.

Modulation Instability Gain



- Peak gain shifts & increases with CW power.
- Symmetric sidebands from four-wave mixing.

MI Gain



- MI threshold: $P_0 \gtrsim 5\ mW$.
- Fourth-order dispersion broadens bandwidth.

Conclusion & Applications

- Strong nonlinearities allow tunable MI gain.
- Control via Rabi frequencies & detunings.
- Applications: quantum communication, slow light, optical logic.