Quantum steering of a two-mode Gaussian state using a quantum beat laser

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Introduction to Questions

- How the quantum steering of a two-mode Gaussian state evolved by a quantum beat laser?
- What are the influences of various system parameters on the steering, for example, non-classicality and purity of the initial cavity modes, the Rabi frequency of classical driving field, and the cavity damping rates?

Model System

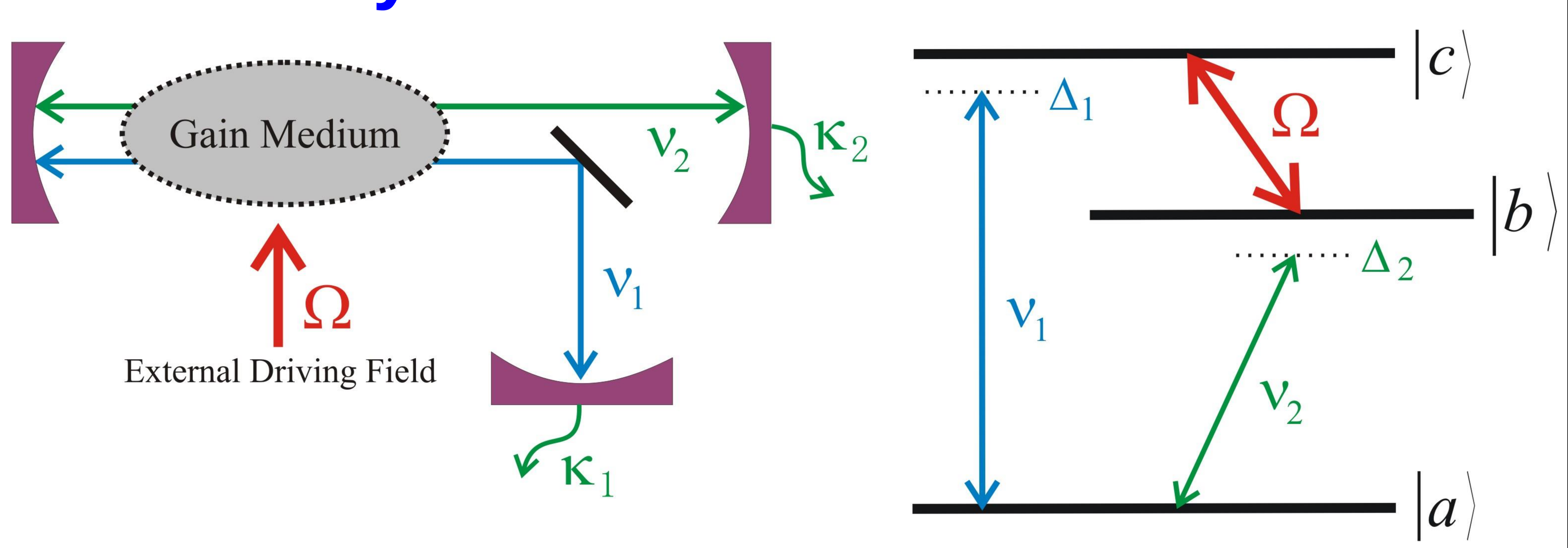

Fig. 1. Schematic of the quantum beat laser.

$$H = H_0 + V,$$

$$H_0 = \hbar(\omega_a + \upsilon_2 + \Delta_2)|b\rangle\langle b| + \hbar(\omega_a + \upsilon_1 + \Delta_1)|c\rangle\langle c| + \hbar\omega_a|a\rangle\langle a| + \hbar\upsilon_1 a_1^\dagger a_1 + \hbar\upsilon_2 a_2^\dagger a_2,$$

$$V = \hbar\left[g_1 a_1|c\rangle\langle a| + g_2 a_2|b\rangle\langle a| - \frac{\Omega}{2}|c\rangle\langle b|e^{-i\varphi - i\upsilon_3}\right] + \text{H.c.}$$

Covariance Matrices of Input and Output Modes:

$$V_{\text{in}} = \begin{pmatrix} V_1 & 0 \\ 0 & V_2 \end{pmatrix} \qquad V_{\text{out}} = \begin{pmatrix} \mathbb{V}_1 & \mathbb{V}_3 \\ \mathbb{V}_3^T & \mathbb{V}_2 \end{pmatrix}$$

Quantum Steering [1]:

$$S^{V_1 \to V_2} = \max\left\{0, \frac{1}{2}\log_2 \frac{\det \mathbb{V}_1}{4 \det V_{\text{out}}}\right\}.$$

Results and Conclusions

- The quantum steering effect is observed oscillatory in nature with respect to time in the resulting modes of the cavity field in the system.
- These results show that by adjusting the atomic coherence, one can easily control the steerability of the two modes of the cavity field.

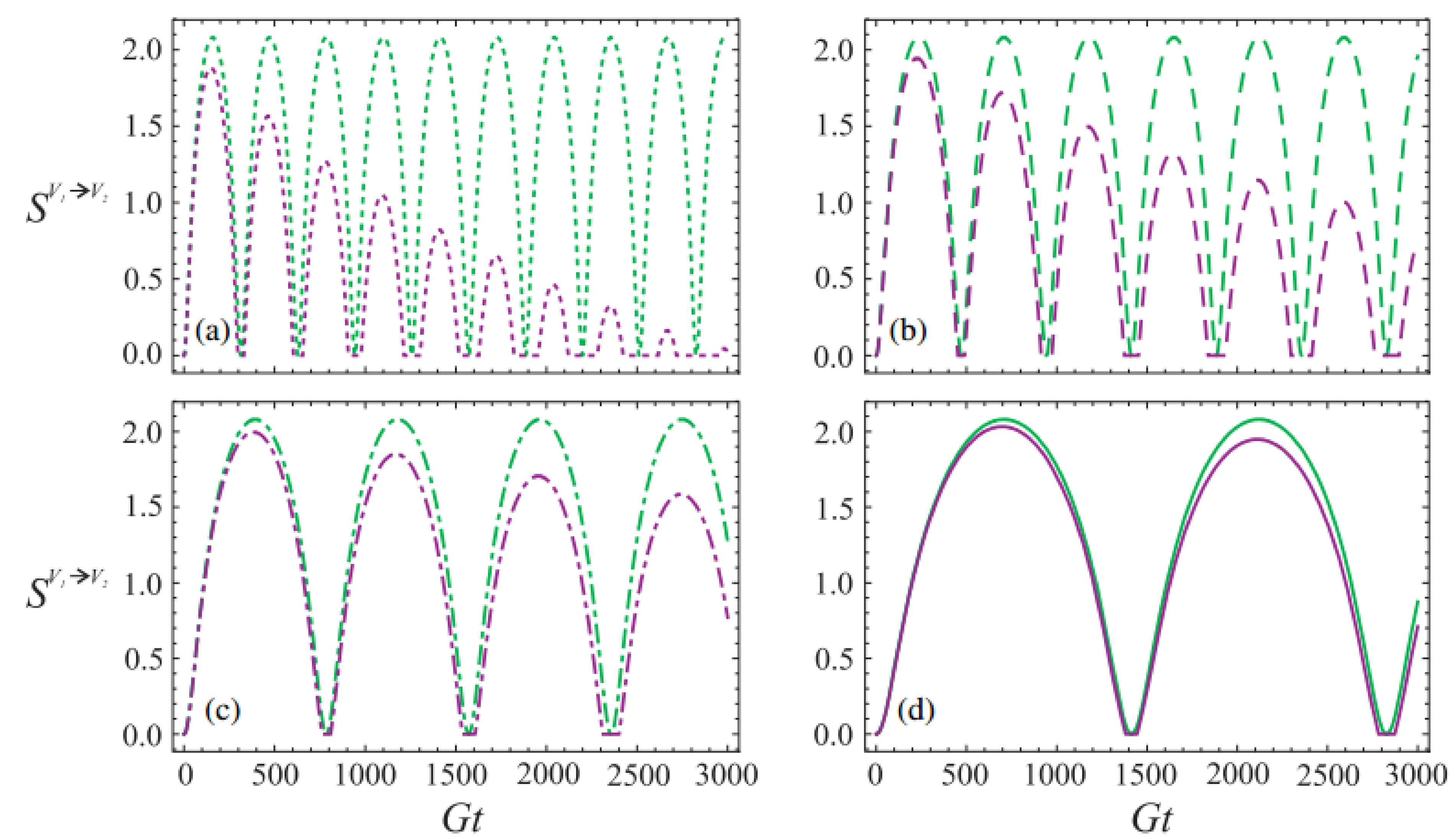

Fig. 2. Gaussian quantum steering $S^{V_1\to V_2}$ versus Gt (a) 200γ, (b) 300γ, (c) 500γ, and (d) 900γ. The green and purple curves show the results for the strongly driven limit ($\Omega \gg \gamma$) and arbitrary limit, respectively. Other parameters are kept fixed.

Experimental Feasibility [2]

- Oscillations are diminished in the profile of quantum steering of the two-mode Gaussian state in the output cavity field.
- We speculate that our proposed scheme of QBL, under the experimental parameterization [2], seems to be a good choice for generation of quantum steerable states in a laboratory.

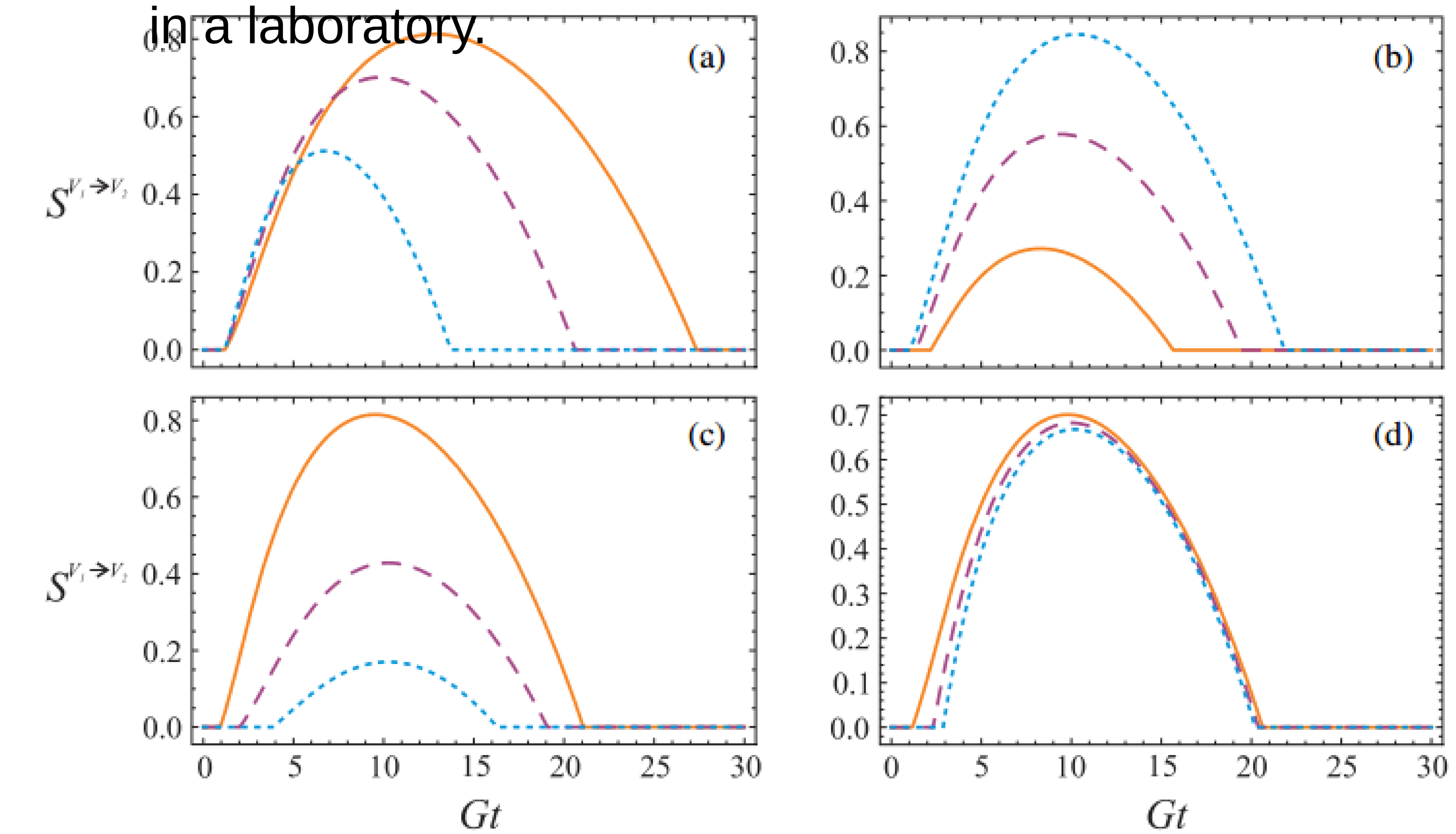

Fig. 3. Gaussian quantum steering $S^{V_1\to V_2}$ versus Gt. The dotted-blue, dashed-purple, and solid-orange curves, respectively, represent the results for (a) $\Omega = 250, 300,$ and 400 kHz, (b) $\kappa = 0, 0.3,$ and 0.8 kHz, (c) $\tau = 0.37, 0.43,$ and 0.45, and (d) $\mu = 0.6, 0.8,$ and 1. Other parameters are kept fixed.

Literature cited

1. I. Kogias, *et al.*, Phys. Rev. Lett. **114**, 060403 (2015).
2. D. Meschede, *et al.*, Phys. Rev. Lett. **54**, 551 (1985).

Acknowledgments

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Further information

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