Simulación de sistemas cuánticos abiertos y preparación de estados enredados por medio de procesos de disipación virtual

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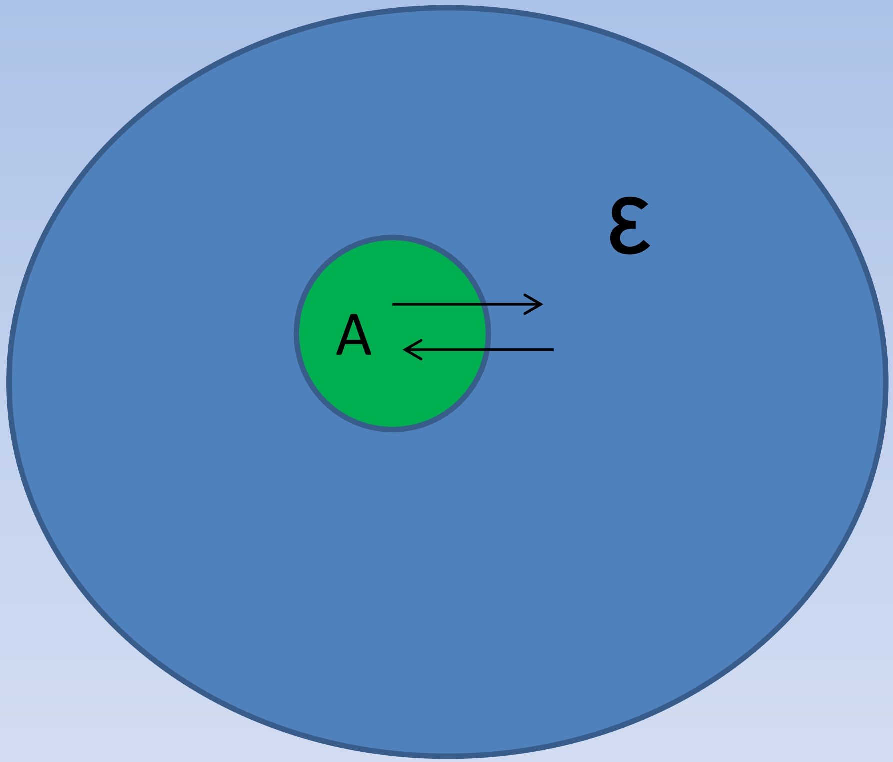
Introducción

Decoherencia



Cuanticidad: Coherencia

Coherencia: relación de fase, fase constante, capacidad de interferir.

Ejemplo: 1 qubit:

$$|\Psi\rangle = c_0|0\rangle + c_1|1\rangle$$

$$c_0 = |c_0|e^{i\phi_0}, \;\; c_1 = |c_1|e^{i\phi_1}$$

$$\Delta\phi = \phi_1 - \phi_0 = cte$$

También hay coherencia a escala macroscópica: Laser, Superconductividad, BEC…

Mecanismo de la decoherencia

$$|i\rangle|\epsilon\rangle \longrightarrow |i\rangle|\epsilon_i\rangle$$

$$|\Psi\rangle = \sum_i c_i|i\rangle \otimes |\epsilon\rangle \longrightarrow |\Psi\rangle = \sum_i c_i|i\rangle|\epsilon_i\rangle$$

Formalismo de la matriz densidad

$$\rho = \sum_{i,j} c_i c_j^* |i, \epsilon_i\rangle\langle j, \epsilon_j|$$

$$\rho_{\mathrm{s}} = Tr_{\epsilon}(\rho)$$
$$= \sum_{i,j,k} c_i c_j^* |i\rangle\langle j| \langle\epsilon_k|\epsilon_i\rangle\langle\epsilon_j|\epsilon_k\rangle$$
$$\approx \sum_{i,j} c_i c_j^* |i\rangle\langle j| \delta_{ki}\delta_{jk} = \sum_i |c_i|^2 |i\rangle\langle i|$$

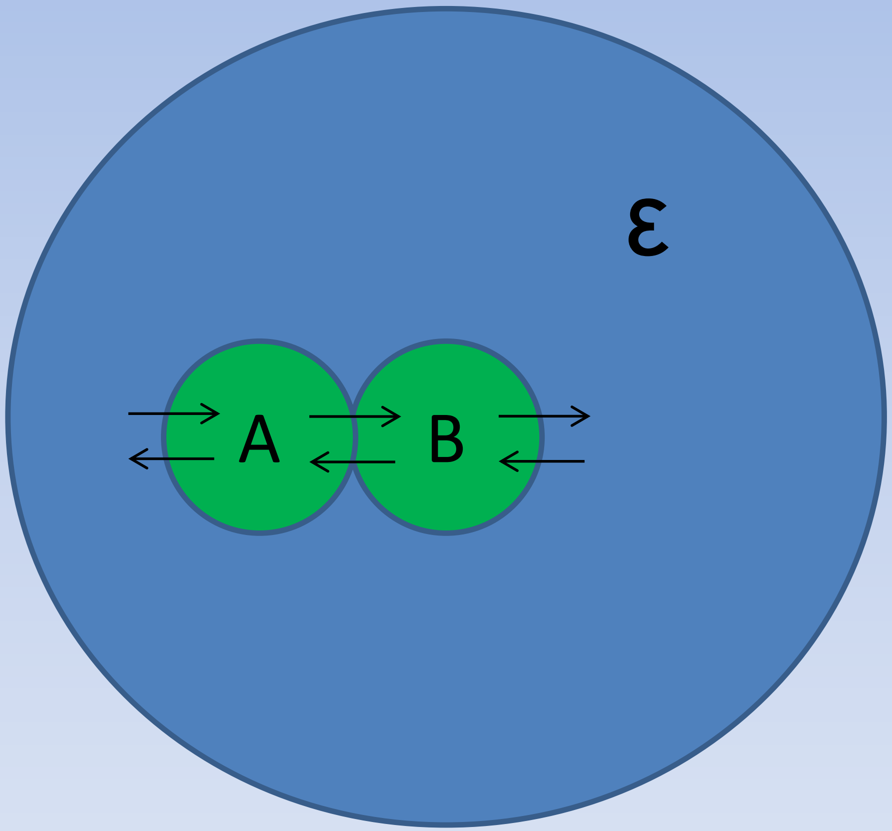
$|c_i|^2$: Probabilidad clásica

Clasicidad: Pérdida de coherencia

Einselection:

$$\langle\epsilon_i|\epsilon_j\rangle \approx \delta_{ij}$$

Sistemas Multipartitos



Cuanticidad: Enredamiento, No-localidad

$$|\Psi\rangle = \sum_{ij} c_{ij} |i\rangle_A \otimes |j\rangle_B$$

Clasicidad: Separabilidad

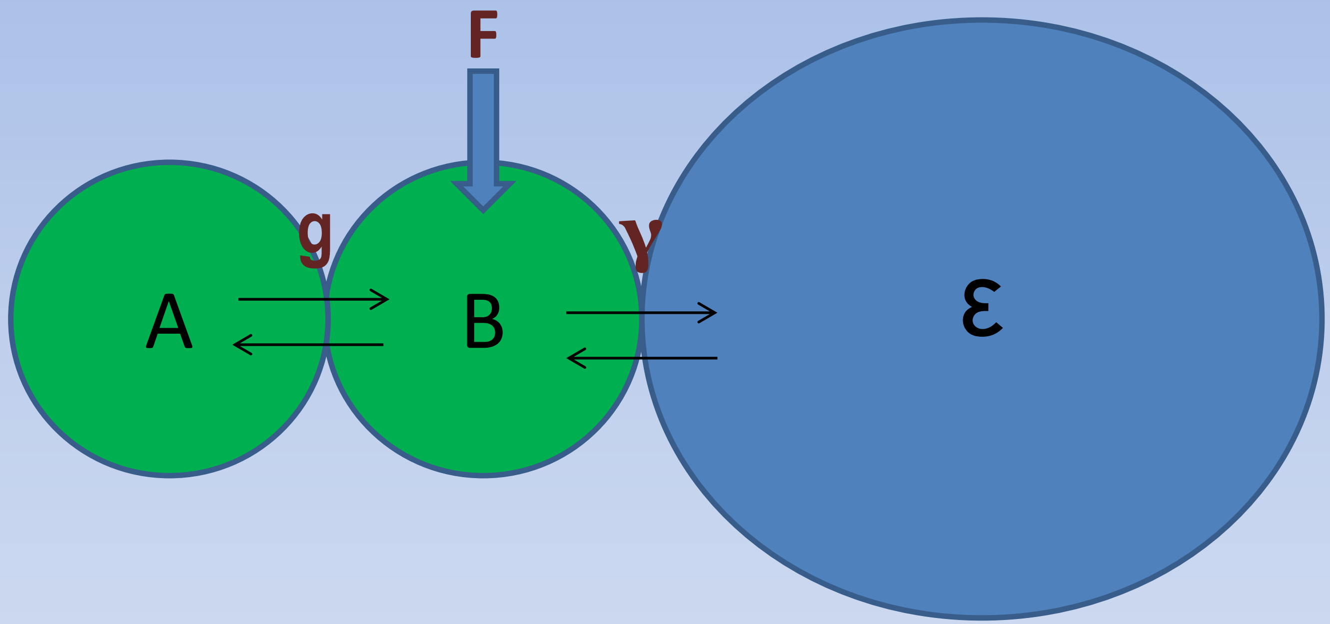
$$|\Psi\rangle = |\psi\rangle_A \otimes |\psi\rangle_B, \quad \rho = \sum_i w_i \rho_i^A \otimes \rho_i^B$$

¿Como medir la separabilidad?: Pureza parcial

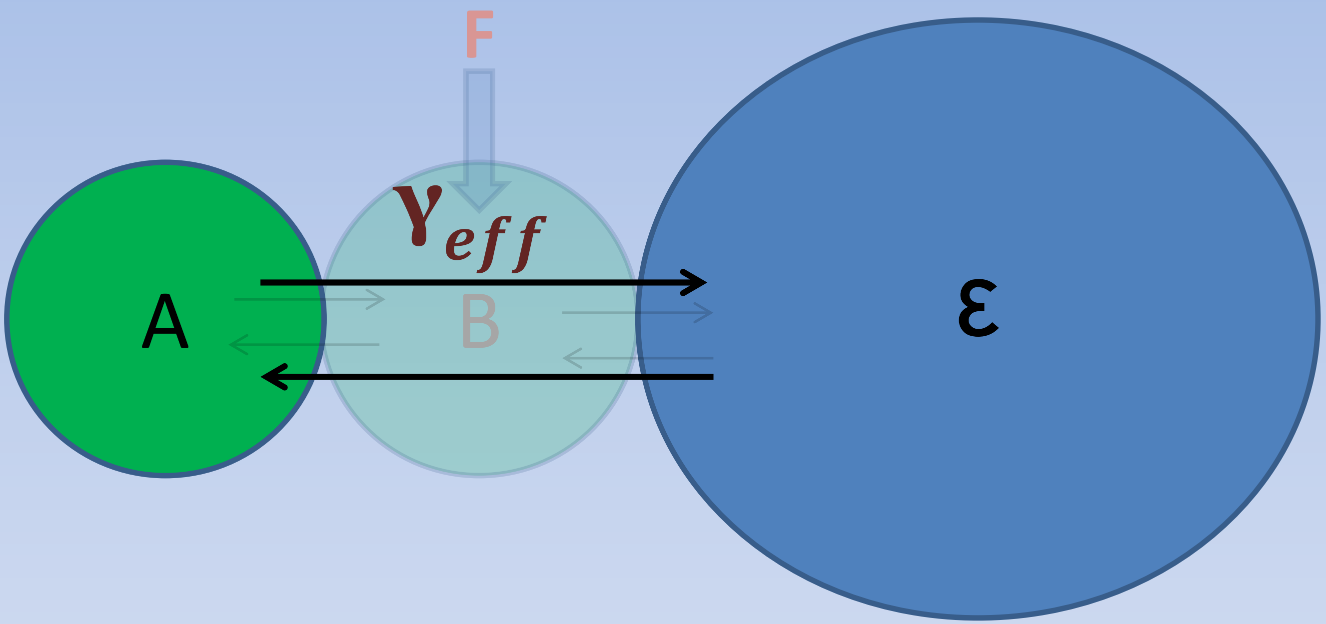
$$\rho_A = Tr_B(\rho), \quad \delta_A = Tr(\rho_A^2)$$

Otras: Negatividad, Entropía, Concurrencia

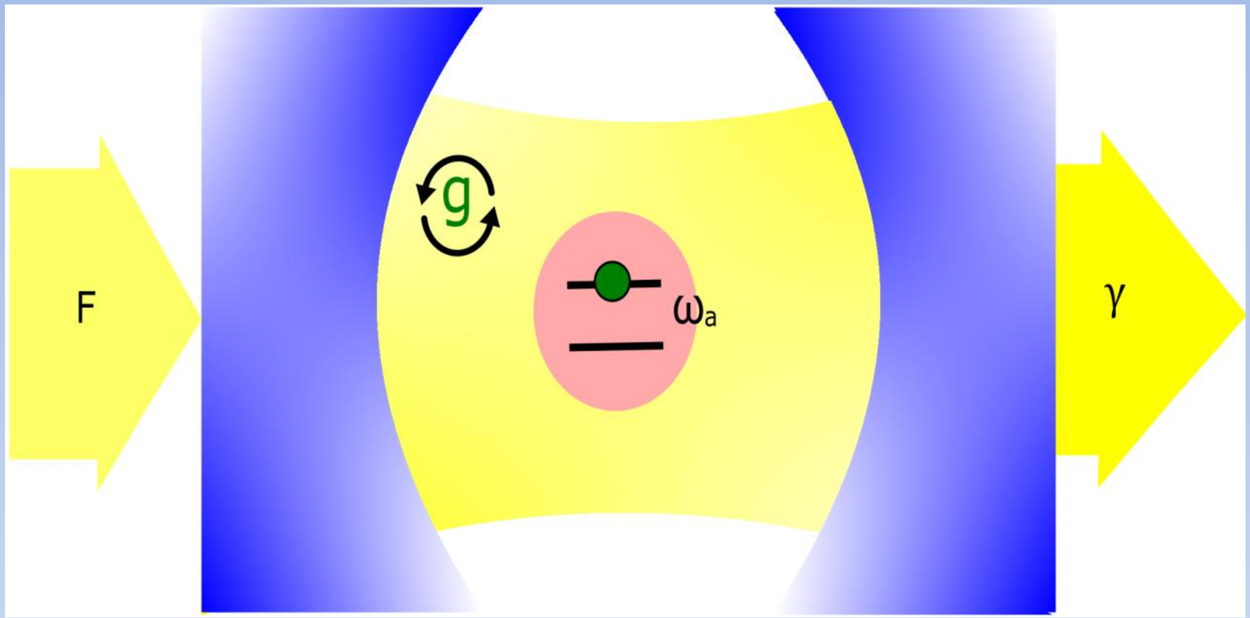
Disipación Virtual



Disipación Virtual



Sistema: Cavidad-Átomo



$$\langle n \rangle \approx 1$$

$$F \approx \frac{\gamma}{2}$$

$$g \ll \gamma, F$$

$$\hat{H}_I = \hbar g(a\sigma^\dagger + a^\dagger\sigma) - \hbar F(a + a^\dagger)$$

$$\frac{d\rho}{dt} = -\frac{i}{\hbar}[H, \rho] + \frac{\gamma}{2}\left(2a\rho a^\dagger - \{a^\dagger a, \rho\}\right)$$

Estado inicial:

$$|\Psi(0)\rangle = |g\rangle \otimes |\alpha\rangle$$

$$|\alpha|^2 \approx 1 \quad \longrightarrow \quad \alpha \approx \frac{iF}{\gamma}$$

$$\begin{aligned} \bar{H}_I &= D^\dagger(\alpha) H_I D(\alpha) \\ &= g(\alpha\sigma^\dagger + \alpha^*\sigma) + g(a\sigma^\dagger + a^\dagger\sigma) \end{aligned}$$

$$\dot{\rho} = -i[H_{cl} + H_Q, \rho] + \mathcal{L}(\gamma a)$$

Aproximación adiabática

$$P_i \dot{\rho} P_j = -i P_i [H, \rho] P_j + P_i \mathcal{L}(a) P_j$$

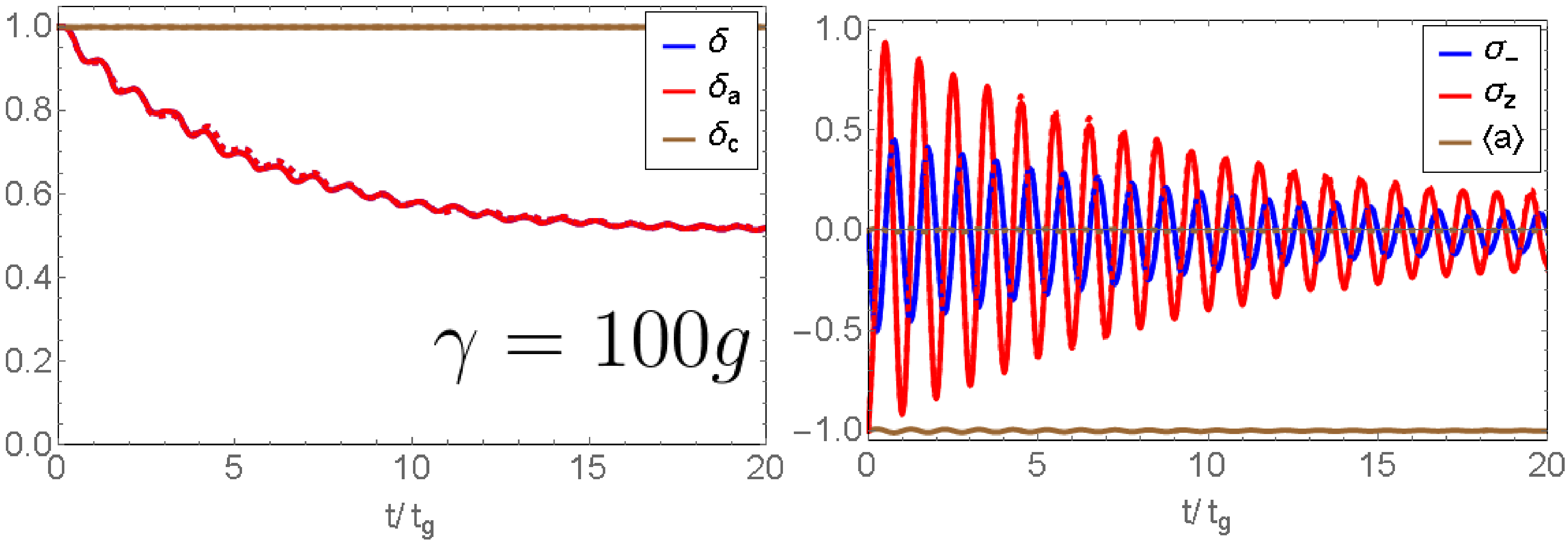
$$P_i = |i\rangle\langle i|, \;\; \sum_i P_i = \mathbf{1}, \;\; P_i P_i = Pi$$

$$\begin{pmatrix} \dot{\rho}_{00} & \dot{\rho}_{01} \\ \dot{\rho}_{10} & \dot{\rho}_{11} \end{pmatrix} \approx \begin{pmatrix} \dot{\rho}_{00} & 0 \\ 0 & 0 \end{pmatrix}$$

$$\dot{\rho}_{00} \approx -i[H_{cl}, \rho_{00}] + \gamma_{eff} \left(2\sigma\rho_{00}\sigma^\dagger - \{\sigma^\dagger\sigma, \rho_{00}\} \right)$$

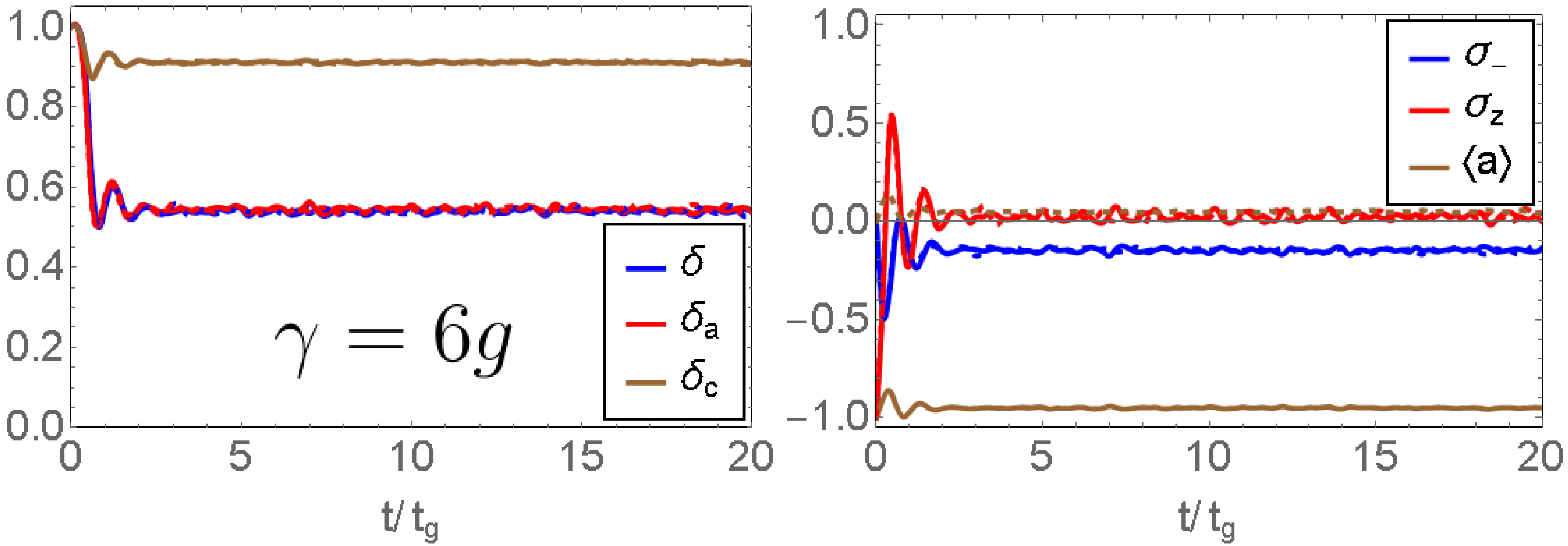
$$\dot{\rho}_{00} \approx -i[H_{cl}, \rho_{00}] + \mathcal{L}(\gamma_{eff}\sigma)$$

$$\gamma_{eff} = \frac{2g^2}{\gamma} \qquad \tau = \frac{\gamma}{2g^2}$$



$$\dot{S}_z = 2ig(\alpha_f^* S_- - \alpha_f S_+) - \frac{8g^2}{\gamma} S_- S_+$$

$$\dot{S}_- = -ig\,\alpha_f S_z - \frac{4g^2}{\gamma} S_-$$


1.0
0.8
0.6
0.4
0.2
0.0
0
5
10
15
20
t/ t_g
δ
δ_a
δ_c
γ = 6g
1.0
0.5
0.0
−0.5
−1.0
0
5
10
15
20
t/ t_g
σ_−
σ_z
⟨a⟩

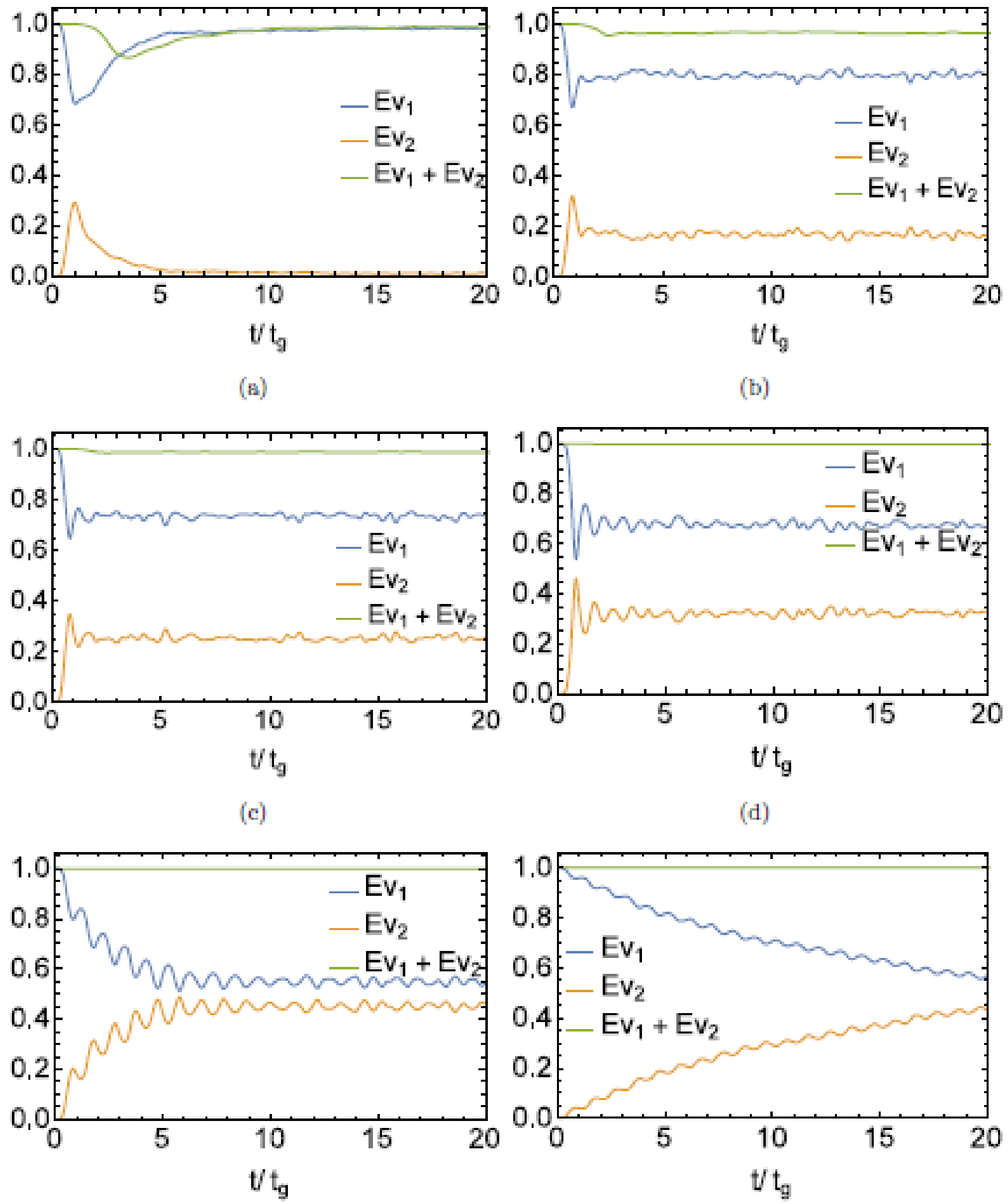
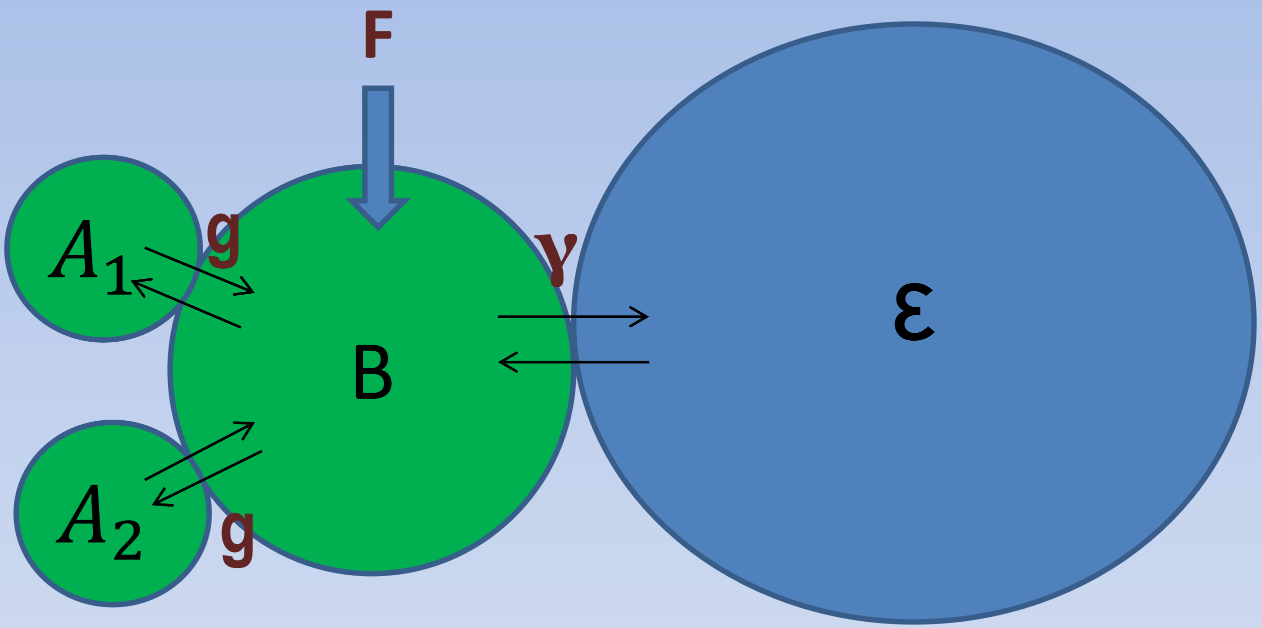
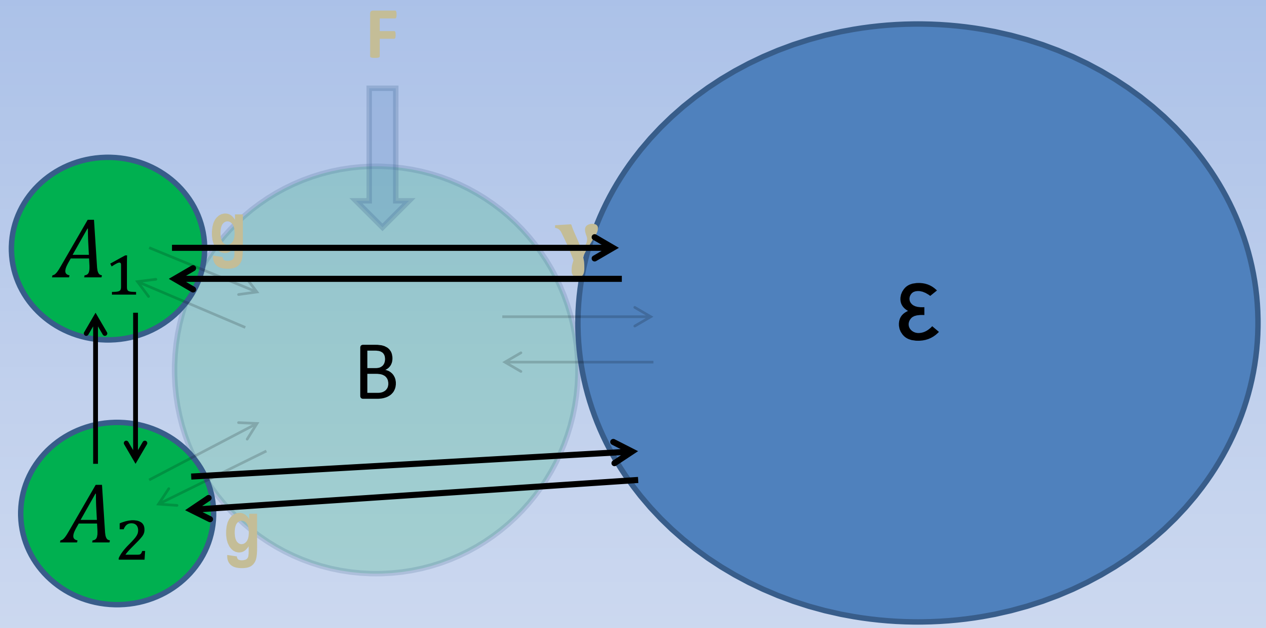


Figura 4-2.: Los 2 primeros eigenvalores de ρ global y su suma. Para $\gamma = 0{,}6g$ (a), $\gamma = 1{,}5g$ (b), $\gamma = 2{,}4g$ (c), $\gamma = 4g$ (d), $\gamma = 20g$ (e), $\gamma = 100g$ (f).

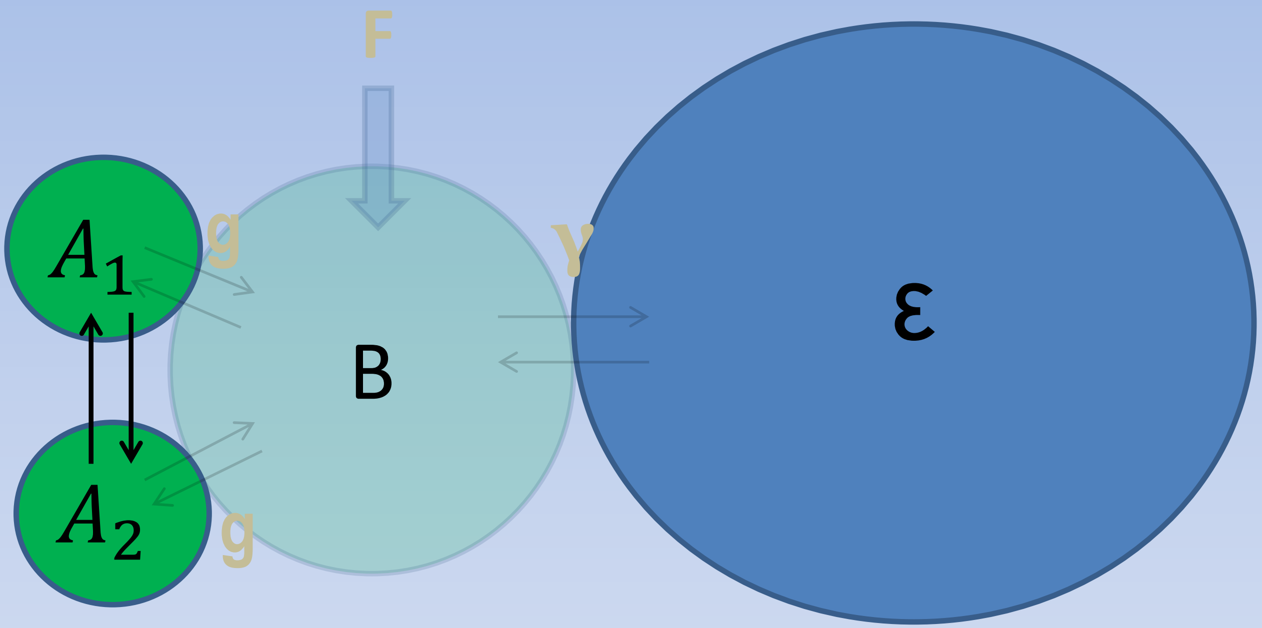
Dos átomos o mas



Dos átomos o mas



Dos átomos o mas



PHYSICAL REVIEW A **88**, 042324 (2013)

Method for preparing two-atom entangled states in circuit QED and probing it via quantum nondemolition measurements

D. Z. Rossatto* and C. J. Villas-Boas

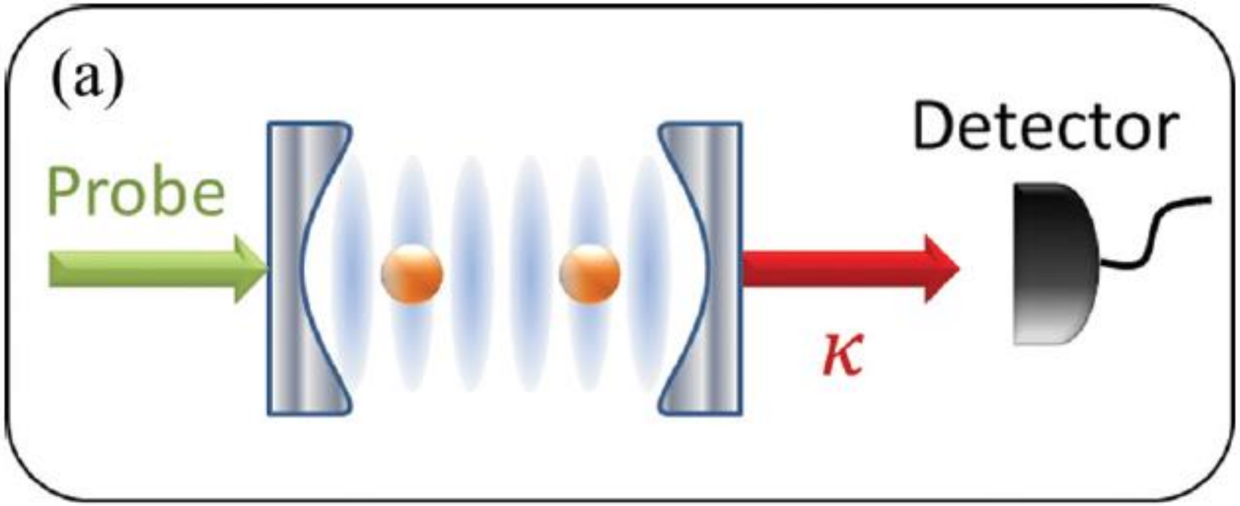


FIG. 1. (Color online) (a) Pictorial experimental setup. A pair of two-level atoms coupled to a leaking cavity mode. Once the system reaches the steady state, the weak probe field is switched on and the cavity transmission is monitored.

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Dissipative universal Lindbladian simulation

Paolo Zanardi, Jeffrey Marshall, and Lorenzo Campos Venuti

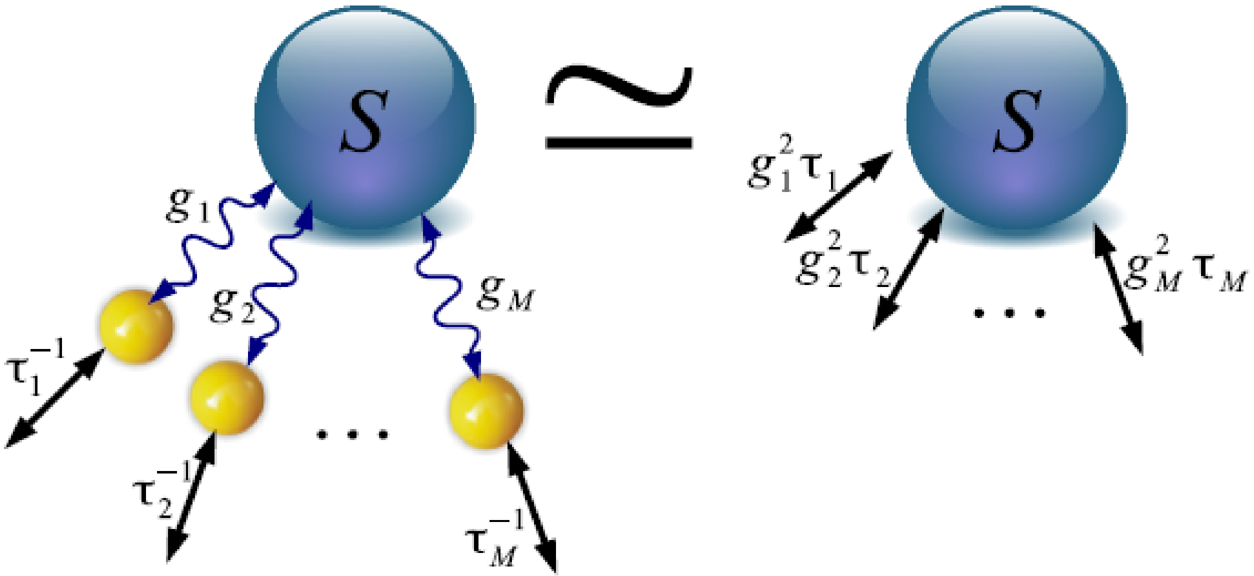

FIG. 1. A quantum system S (blue ball) is coupled with coupling strengths g_i to M qubits (yellow balls). Each of these qubits is subject to amplitude damping with rates τ_i^{-1}.

References

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[3] P.Zanardi, J. Marshall, and L. Campos Venuti. PHYSICAL REVIEW A 93, 022312 (2016).

[4] Mikel Sanz, Enrique Solano, and Inigo L. Egusquiza. arXiv:1503.01369v2. 2015.