Evolution of squeezed states under the Fock-Darwin Hamiltonian

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The Hamiltonian

The Fock-Darwin Hamiltonian describes a quantum particle of mass m and charge $-e$ in $2d$ bounded to an harmonic potential of frequency ω_0 and placed in a homogeneous magnetic field B along the z axis:

$$\hat{H}_0 = \frac{1}{2m}\left[\left(\hat{p}_x - \frac{eB}{2}\hat{y}\right)^2 + \left(\hat{p}_y + \frac{eB}{2}\hat{x}\right)^2\right] + \frac{1}{2}m\omega_0^2(\hat{x}^2 + \hat{y}^2)\,, \qquad (1)$$

This Hamiltonian qualitatively describes the behaviour of electrons in InAs/GaAs QD for magnetic fields up to 15 T (many-body effects and assymetry of potential also play a role). It also describes the dynamics of single ions in traps, subjected to magnetic and electric fields.

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Response functions and evolution of squeezed states

One takes as the system Hamiltonian $\hat{H}(t) = \hat{H}_0 + \hat{H}_1(t)$, where $\hat{H}_1(t) = e(E_x(t)\hat{x} + E_y(t)\hat{y})$.

- We have computed the response functions of the system, defined as $P_i(t) = \int_0^t du\, \chi_{ij}(t-u)\, E_j(u)$, $j_i(t) = \int_0^t du\, \sigma_{ij}(t-u)\, E_j(u)$.
- Furthermore, we have related the evolution of an initial squeezed state $| \overline{\psi}_0 \rangle$ under $\hat{H}(t)$, to the known evolution of a state $| \psi_0 \rangle$ under the isotropic harmonic oscillator, in the absence of magnetic or electric fields.

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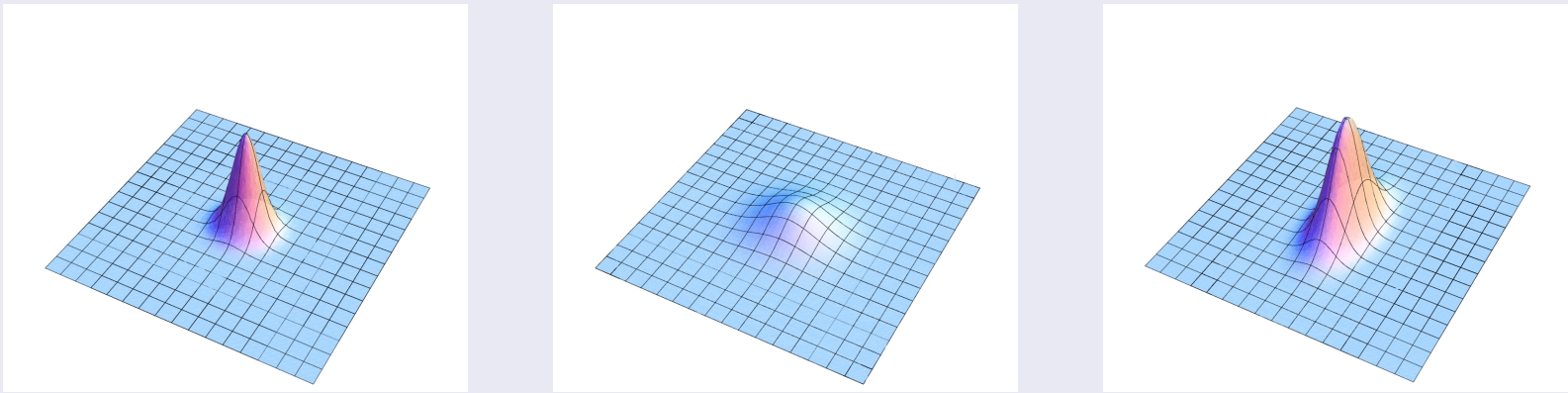
Square-modulus and Wigner function of a squeezed-coherent state



From left to right: Square-modulus of wave-function in ***r*** and ***p*** spaces. The system is subjected to RH circular polarized field of strength $E_0 = 10^2\, Vm^{-1}$ and frequency $\Omega = 1,4x10^9 Hz$. Projection of Wigner function along x, p_x. Squeezing parameter $r = 0,35$. The central peak follows the classical trajectory of motion.

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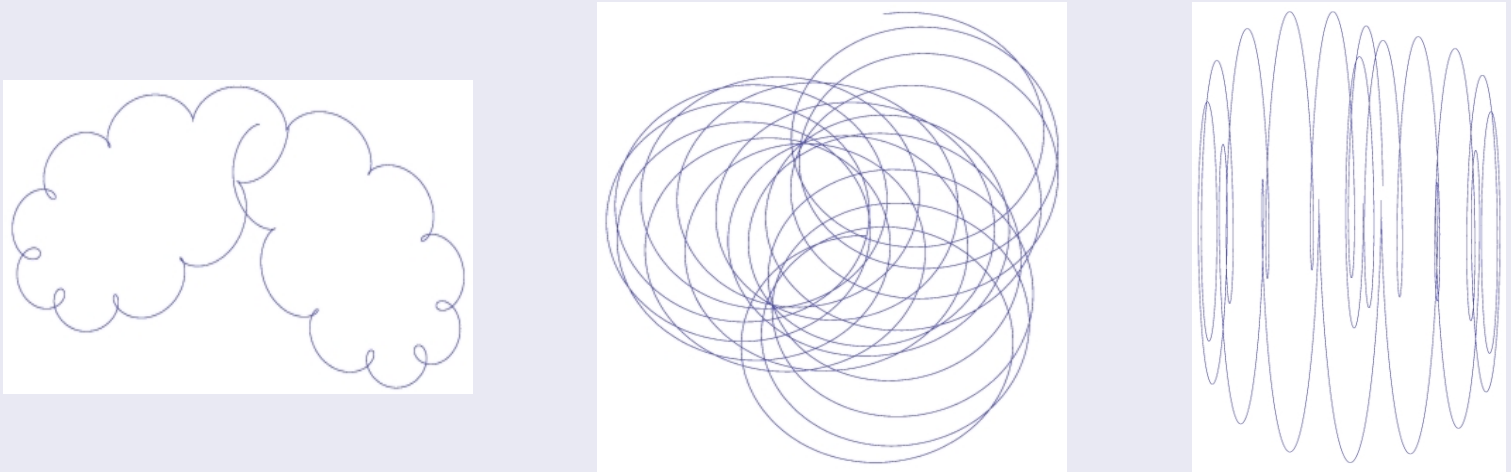
Classical trajectories for previous slide



From left to right: Trajectories during a period of motion in coordinate space, momentum space and phase space (x, p_x projection). Length scales of figures: $10^{-8} m, 10^{-26} kg\, m\, s^{-1}$.