ELECTRODYNAMICS

https://doi.org/10.46813/2026-163-113

INFLUENCE OF THE WHITE NOISE ON QUANTUM DYNAMICS OF THE WAVE FUNCTION IN THE TIME-PERIODIC HARMONIC POTENTIAL

A.S. Mazmanishvili[1], V.I. Dubinko[1], Klee Irwin[2]
[1]National Science Center "Kharkiv Institute of Physics and Technology", Kharkiv, Ukraine;
[2]Quantum Gravity Research, Los Angeles, USA
E-mail: vdubinko@hotmail.com

We investigate the quantum dynamics of a particle in a one-dimensional parabolic potential subject to both time-periodic driving and stochastic perturbations modeled as white noise. Using the non-stationary Schrödinger equation and the Green's function formalism, we derive analytical expressions for the time evolution of the wave function and its statistical moments. It is shown that, due to the quadratic nature of the potential, the wave function retains a Gaussian form, allowing a reduced description in terms of its first and second moments. Under resonant periodic driving, the mean energy exhibits quadratic growth in time. In the presence of white noise, the wave packet undergoes diffusive spreading and loss of coherence. For combined deterministic and stochastic driving, we identify a characteristic decoherence (delocalization) time, which scales inversely with the noise intensity. The results are relevant to quantum transport, driven systems, and tunneling processes in fluctuating environments.

PACS: 29.17.+w

INTRODUCTION

Quantum dynamics in time-dependent potentials is a fundamental problem with applications in condensed matter physics, quantum transport, and non-equilibrium systems. Of particular interest are systems where the confining potential is subject to external driving and environmental fluctuations.

Quadratic (harmonic) potentials occupy a special place, as they admit exact analytical solutions and preserve Gaussian wave packet structure during evolution. Time-periodic modulation of such systems has been extensively studied and is known to lead to parametric resonance and energy growth. Separately, the influence of stochastic perturbations (e.g., white noise) has been analyzed in the context of decoherence and diffusion.

However, realistic systems often involve both deterministic driving and stochastic fluctuations. Examples include:

- lattice vibrations with thermal fluctuations;
- channeling of charged particles in crystals;
- driven tunneling processes in noisy environments.

In this work, we consider a quantum particle in a time-dependent parabolic potential subject to:

1. periodic modulation, and
2. additive stochastic perturbations modeled as white noise.

We derive analytical expressions for the wave function and its momentums and analyze the interplay between coherent driving and noise-induced decoherence.

Applications of these results are associated with the excitation of localized anharmonic vibrations in a crystal [1–3]. Their distinctive feature is the periodicity in time and the large amplitude of atomic oscillations, which may affect the rate of chemical (and possibly nuclear [3]) reactions near them. Due to the large amplitude of oscillations, the position of the potential well in which the particle is located can no longer be considered motionless. In [2, 3], the problem of particle motion in a quadratic potential subject to time-periodic driving was considered. Analytical expressions for the wave function and its momentums of motion were obtained. However, such consideration presupposes strict periodicity in time of localized anharmonic vibrations. In reality, they are subject to the action of fluctuations from neighboring atoms, which can be represented as "white" noise.

A similar situation is also realized when an electron moves along the crystal axis [4–7]. In this case, the role of time in the problem is played by the depth of particle penetration, and the perturbation function describes the forced oscillations of the crystal lattice.

The influence of white noise on quantum systems has been the subject of numerous studies, see e.g. [8–12].

We consider the quantum-mechanical problem of particle motion in a quadratic potential, which is subject to time-periodic driving, as well as to stochastic perturbation such as "white" noise.

STATIONARY POTENTIAL

Below we will consider the time evolution of a particle in a stationary quadratic potential.

The initial wave function is given by

$$\psi(x_0,0)=\left(\frac{m\omega}{\pi\hbar}\right)^{1/4}\exp\left(-\frac{m\omega}{2\hbar}x_0^2\right), \quad (1)$$

where m is the particle mass, w is the natural frequency, h is the Plank constant.

In the absence of perturbation, the time evolution of the probability density function $p(x,t)=|\psi(x,t)|^2$ on the interval $0\le t\le 60$ stationary (Fig. 1).

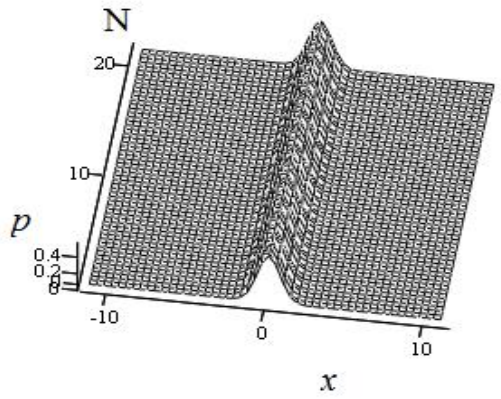


Fig. 1. Probability distribution density $p(x,t)$ *in the stationary case on the interval* -14≤x≤14, $\omega = 1$

TIME PERIODIC DRIVING

We begin the analysis by considering the time evolution of a particle with the initial wave function in the potential

$$V(x,t) = \frac{1}{2} m\omega^2 [x - U(t)]^2 , \qquad (2)$$

where $U(t)$ is some square-integrable function. This type of potential is a generalization of parabolic potential with $U(t) = 0$ and $V(x,t) = \frac{1}{2} m\omega^2 x^2$ [6, 7].

In this case, for the wave function $\Psi = \Psi(x,t;x_0,t_0)$. The Schrödinger equation has the form [2]

$$\frac{\hbar}{i}\frac{\partial \Psi}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2 \Psi}{\partial x^2} + \frac{1}{2} m\omega^2 [x - U(t)]^2 \Psi . \qquad (3)$$

Physical meaning of the wave function Ψ is that it describes the amplitude of the probability of transition from a state to a moment $t_0 = 0$, characterized by the coordinate x_0, to the state at the moment t, characterized by the coordinate x.

Based on the parabolic of potential (2), we will seek a solution to equation (3) in the form

$$\Psi(x,t;x_0,t_0) = \exp\left(C_0(t) + C_1(t)x + C_2(t)x^2\right)$$

with functions $C_0(t)$, $C_1(t)$, $C_2(t)$, which can be found from a system of three ordinary differential equations with initial conditions. As a result, we find that the solution to the Schrödinger equation (3) is as follows [13]

$$\Psi(x,t;x_0,t_0) = \left(\frac{me^{i\omega t}}{\pi\hbar(e^{2i\omega t} - 1)}\right)^{1/2} \times$$

$$\exp\left(-\frac{m\omega}{2\hbar}(x^2 - x_0^2) - i\frac{m\omega^2}{2\hbar}\int_0^t U^2(\tau)\,d\tau\right) \times$$

$$\exp\left(i\frac{\hbar}{2m}\int_0^t Y^2(\tau)\,d\tau + xY(t) - \right.$$

$$\left. - \frac{m\omega}{\hbar(e^{2i\omega t} - 1)}\left[x - e^{i\omega t}x_0 - R(t)\right]^2\right), \qquad (4)$$

where

$$Y(\tau) = i\frac{m\omega^2}{\hbar}\int_0^\tau U(\tau')\exp(-i\omega\tau + i\omega\tau')\,d\tau',$$

$$R(t) = \frac{\hbar e^{i\omega t}}{m}\int_0^t Y(\tau)\exp(-i\omega\tau)\,d\tau.$$

Gaussian form of expression (4) for the function $\Psi(x,t;x_0,t_0)$ (Green's function) is a consequence of the parabolic of the potential (2). The function $\Psi(x,t;x_0,t_0)$ (4) satisfies the same equation as the wave function $\psi(x_0,0)$, but with an initial condition $\Psi(x,t;x_0,0) = \delta(x - x_0)$.

Type of the wave function $\psi(x,t)$ at the moment $t > t_0$ can be determined by its given value $\psi(x_0,0)$ at the moment $t_0 = 0$:

$$\psi(x,t) = \int_{-\infty}^{\infty}\psi(x_0,0)\,\Psi(x,t;x_0,0)\,dx_0 . \qquad (5)$$

After calculating the integral (5) with the kernel $\Psi(x,t;x_0,0)$ (4) and the initial wave function $\psi(x_0,0)$ (1) we obtain

$$\psi(x,t) = \left(\frac{m\omega}{\pi\hbar}\right)^{1/4}\exp\left(-i\frac{m\omega^2}{2\hbar}J - \frac{m\omega}{2\hbar}\left[x - X(t)\right]^2\right), \qquad (6)$$

$$X(t) = \omega\int_0^t U(\tau)\sin(\omega t - \omega\tau)\,d\tau,$$

where J the phase shift of the resulting wave function

$$J = \int_0^t U^2(\tau)d\tau + \frac{t\hbar}{m\omega} + 2x\int_0^t U(\tau)\cos\left(\omega(t-\tau)\right)d\tau +$$

$$+\int_0^t d\tau\int_0^t d\tau' U(\tau)U(\tau')\sin\left(\omega(\tau - t)\right)\cos\left(\omega(\tau' - t)\right). \qquad (7)$$

If at $t = 0$ the particle was in the ground state with wave function (1), then at the moment of time t for probability density $p(x,t)$ we will find

$$p(x,t) = |\psi(x,t)|^2 = \left(\frac{m\omega}{\pi\hbar}\right)^{1/2}\exp\left(-\frac{m\omega}{\hbar}\left[x - X(t)\right]^2\right). \qquad (8)$$

Thus, if a particle undergoes a time evolution in potential (2) with $U(\tau) = 0$, then by the moment of time t the probability distribution $p(x,t)$ remains the same as at the moment $t_0 = 0$. The behavior of the wave function changes significantly if $U(\tau) \neq 0$, which can be seen from the characteristics of the wave function.

From (8) we obtain that the quantum-mechanical averages are the first and second moments of the probability distribution density $p(x,t)$ are the following:

$$< x(t) >= \omega\int_0^t U(\tau)\sin(\omega t - \omega\tau)\,d\tau , \qquad (9)$$

$$\left\langle x^2(t)\right\rangle = \frac{\hbar}{2m\omega} + \omega^2 \times$$

$$\left\langle\int_0^t\int_0^t U(\tau)U(\tau')\sin(\omega t - \omega\tau)\sin(\omega t - \omega\tau')\,d\tau\,d\tau'\right\rangle \qquad (10)$$

and experience a swing. If the modulation function $U(t)$ contains a stochastic component, then $< x(t) >$ and $< x^2(t) >$ are also time-dependent random variables.

Next, we will consider the case of resonance, when $\omega = 1$ and $U(t)$ is given by

$$U(t) = g\sin(\omega t), \quad (11)$$

where $g << 1$ – modulation index. In this case we get

$$< x(t) >= \frac{1}{2} g\omega t\left(\cos(\omega t) - \frac{\sin(\omega t)}{\omega t}\right), \quad (12)$$

$$< x^2(t) >= \frac{\hbar}{2m\omega} + \frac{1}{4} g^2\omega^2 t^2\left(\cos(\omega t) - \frac{\sin(\omega t)}{\omega t}\right)^2, \quad (13)$$

$$< p(t) >= \frac{1}{2} g\omega^2 t\sin(\omega t), \quad (14)$$

$$< p^2(t) >= \frac{\hbar\omega}{2m} + \frac{1}{4}\left[gm\omega^2\sin(\omega t)\right]^2. \quad (15)$$

As a result, we obtain for the average energy

$$E = \frac{1}{2m} < p^2 > + \frac{m}{2}\omega^2 < x^2 >= \\ = \frac{\hbar\omega}{2} + \frac{g^2\hbar\omega}{2}\left(\omega^2 t^2 + \omega t\sin(2\omega t) + \sin^2(\omega t)\right). \quad (16)$$

The coefficient of increase of the average energy of a particle over time is

$$r_t = \frac{E}{E_0} = 1 + g^2\left(\omega^2 t^2 + \omega t\sin(2\omega t) + \sin^2(\omega t)\right). \quad (17)$$

Potential $V(x,t)$ with a swing of type (11) on the interval $0 \le t \le 50$ shown in Fig. 2.

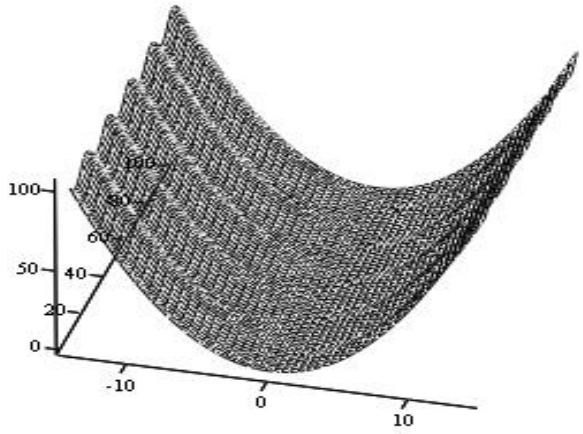


Fig. 2. Potential $U(x,t)$, $g = 0.1$

Temporal evolution of the probability density function on the interval $0 \le t \le 60$ shown in Fig. 3.

Fig. 4 shows the dependences of the Pr_L and Pr_R shares of probability density $p(x,t)$, located in the positive and negative parts of the axis $0x$ respectively. It is evident that, in accordance with Fig. 3, the wave packet as a whole oscillates around the axis $0x$ with assign amplitude, while as a result of resonant buildup the average energy of the particle increases over time according to (16) according to a parabolic law.

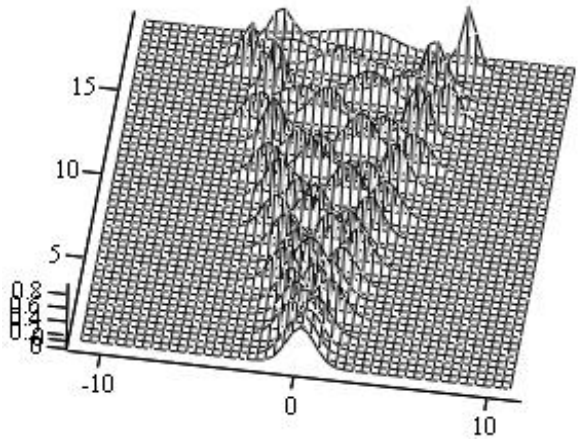


Fig. 3. The probability density distribution of a wave function $p(x,t)$ *on the interval* $-14 \le x \le 14$, $g = 0.1$

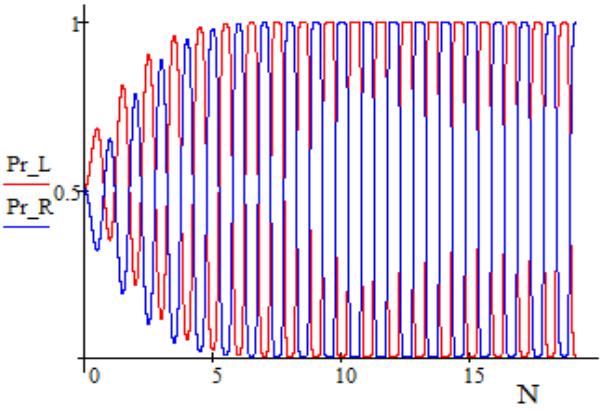


Fig. 4. Shares Pr_L and Pr_R of the probability distribution density $p(x,t)$ *for on the interval* $x \ge 0$ *(red) and* $x \le 0$ *(blue); the number of periods N is shown;* $g = 0.1$

EVOLUTION OF THE WAVE FUNCTION IN A PARABOLIC POTENTIAL DISTURBED BY WHITE NOISE

Next, we will consider the case when $U(t)$ is stochastic process of "white" noise $n(t)$ with zero mathematical expectation and variance σ_W^2:

$$U(t) = \sigma_W n(t). \quad (18)$$

Fig. 5 shows an example of the evolution of the density profile $p(x,t)$, obtained on the basis of the solution of equation (3). If the modulation function $U(t)$ contains a stochastic component, then $< x(t) >_W$ and $< x^2(t) >_W$ are also time-dependent random variables. Here and below, in angle brackets $< ... >_W$ the operation of finding the mathematical expectation relative to the realizations of the stochastic process of "white" noise is designated $U(t)$.

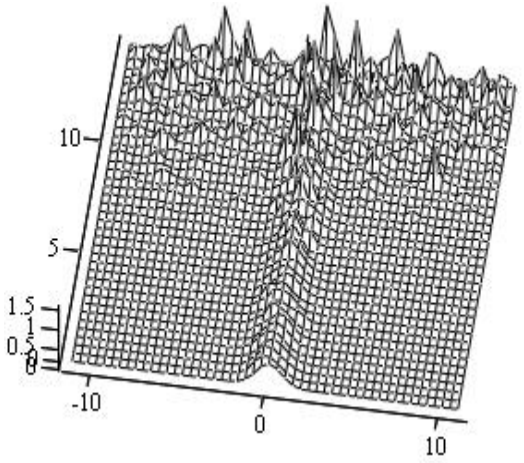


Fig. 5. Example of the probability distribution density $p(x,t)$ disturbed by stochastic process of "white" noise; $g=0$, $\sigma_{\mathrm{W}}=1$; the number of periods N is shown along the coordinate axis

Over time t density $p(x,t)$ undergoes transformations that reflect the influence of the function $U(t)$ (18). In Fig. 6 these oscillations are shown in red for the positive part ($x \ge 0$) density and blue color – for the negative part ($x \le 0$).

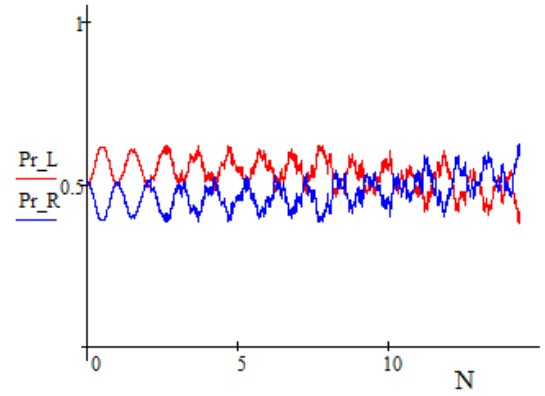


Fig. 6. Evolution of parts Pr_L and Pr_R of the probability distribution density $p(x,t)$ on the interval $x \ge 0$ (red), $x \le 0$ (blue); $g=0$, $\sigma_{\mathrm{W}}=1$

Quantum-mechanical averages – the first and second moments of the probability distribution density are:

$$\langle x(t)\rangle_{\mathrm{W}} = \left\langle \omega\int_0^t U(\tau)\sin(\omega t-\omega\tau)\,d\tau \right\rangle = 0\,. \quad (19)$$

For the second moment we write

$$\langle x^2(t)\rangle_{\mathrm{W}} = \frac{\hbar}{2m\omega} + \omega^2 \times \quad (20)$$

$$\left\langle \int_0^t\int_0^t U(\tau)U(\tau')\sin(\omega t-\omega\tau)\sin(\omega t-\omega\tau')\,d\tau\,d\tau' \right\rangle.$$

Due to the properties of "white" noise $\langle U(\tau)U(\tau')\rangle = \sigma_{\mathrm{W}}^2\delta(\tau-\tau')$, that's why one has

$$\langle x^2(t)\rangle_{\mathrm{W}} = \frac{\hbar}{2m\omega} + \omega^2\sigma_{\mathrm{U}}^2\int_0^t \sin^2(\omega t-\omega\tau)\,d\tau\,. \quad (21)$$

For sufficiently long times, $t >> \omega^{-1}$, we have for the dispersion

$$\langle x^2(t)\rangle_{\mathrm{W}} = \frac{1}{2}\omega^2\sigma_{\mathrm{W}}^2 t\,. \quad (22)$$

Consider evolution of the wave function under the combined influence of both dipole pumping and white noise.

EVOLUTION OF THE WAVE FUNCTION IN A PARABOLIC POTENTIAL UNDER TIME PERIODIC DRIVING DISTURBED BY WHITE NOISE

In this case $U(t)$ is given by a sum of time periodic driving and stochastic part $n(t)$ with zero mathematical expectation and variance σ_{W}^2:

$$U(t) = g\sin(\omega t) + \sigma_{\mathrm{W}} n(t)\,. \quad (23)$$

According to (6) the wave function as a function of the coordinate x retains its Gaussian form under arbitrary perturbation. Therefore, for its description it is sufficient to give expressions for its first two moments. Further, we assume that for the times under consideration the contribution of the ground state can be neglected.

Because $< x(t) >_{\mathrm{w}} = 0$, for the first moment μ_1 according to (12) and (17) we have

$$\mu_1 = \frac{1}{2}g\omega t\left(\cos(\omega t) - \frac{\sin(\omega t)}{\omega t}\right). \quad (24)$$

Dispersion μ_2 of the wave function will be equal to the sum of the dispersions caused by the disturbances, namely

$$\mu_2 = \langle x^2(t)\rangle + \langle x^2(t)\rangle_{\mathrm{W}} = \\ = \frac{1}{4}g^2\omega^2 t^2\left(\cos(\omega t) - \frac{\sin(\omega t)}{\omega t}\right)^2 + \\ + \omega^2\sigma_{\mathrm{W}}^2\int_0^t \sin^2(\omega t-\omega\tau)\,d\tau. \quad (25)$$

Next, the first term in (25) grows over time as t^2, while the integral in the second term can be replaced by $t/2$. At large t the second term in (24) can be neglected. The first term can be replaced by ½ due to the rapidly oscillating dependence. Therefore, one has

$$\mu_2 = \frac{1}{8}g^2\omega^2 t^2 + \frac{1}{2}\omega^2\sigma_{\mathrm{W}}^2 t\,. \quad (26)$$

Then the distribution density is $p(x)$ can be written as

$$p(x) = \frac{1}{\sqrt{2\pi\mu_2}}\exp\left(-\frac{(x-\mu_1)^2}{2\mu_2}\right). \quad (27)$$

Figs. 7–9 show the evolution of wave function excited by dipole swing and disturbed stochastic process of "white" noise.

In Fig. 7 you can see the oscillations of the function as a whole at $\sigma_{\mathrm{W}} = 0.8$, which corresponds to expressions (24) and (27), however, starting from N=5, they gradually leave the stationary mode. For large N on the

periphery $|x| \cong 10$ one can see fluctuation bursts of the wave function.

Fig. 8 illustrates the process of transition of the wave function from an increase in its size μ_2 to decrease at N=4, which occurs with increasing noise intensity $\sigma_W = 1.0$.

Fig. 9 shows that on average the function is concentrated in the region Xsr= $\langle x(t) \rangle = 0$, which occurs starting from N=3. The moment N=3 of transition from a regular state to an incoherent one can be called the collapse time $N_{collapse} = 3$.

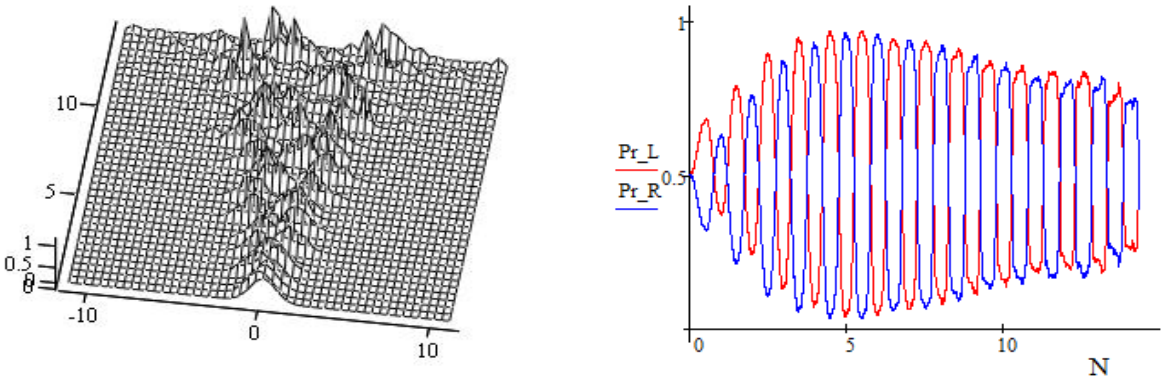


Fig. 7. Left – example of the probability density distribution $p(x,t)$ under time periodic driving disturbed by stochastic process of "white" noise; g= 0.1, $\sigma_W = 1$; the number of periods N is shown along the coordinate axis. Right – evolution of parts Pr_L and Pr_R of the probability distribution density $p(x,t)$ on the interval $x \geq 0$ (red), $x \leq 0$ (blue); $g = 0.1$

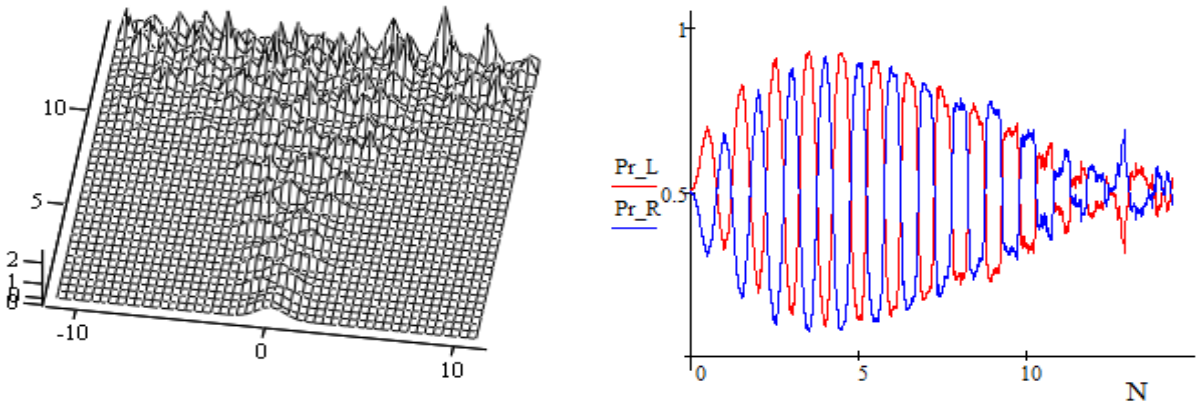


Fig. 8. Left – example of the probability density distribution $p(x,t)$ under time periodic driving disturbed by stochastic process of "white" noise; g= 0.1, $\sigma_W = 1$; the number of periods N is shown along the coordinate axis. Right – evolution of parts Pr_L and Pr_R of the probability distribution density $p(x,t)$ on the interval $x \geq 0$ (red), $x \leq 0$ (blue); $g = 0.1$, $\sigma_W = 0.8$.

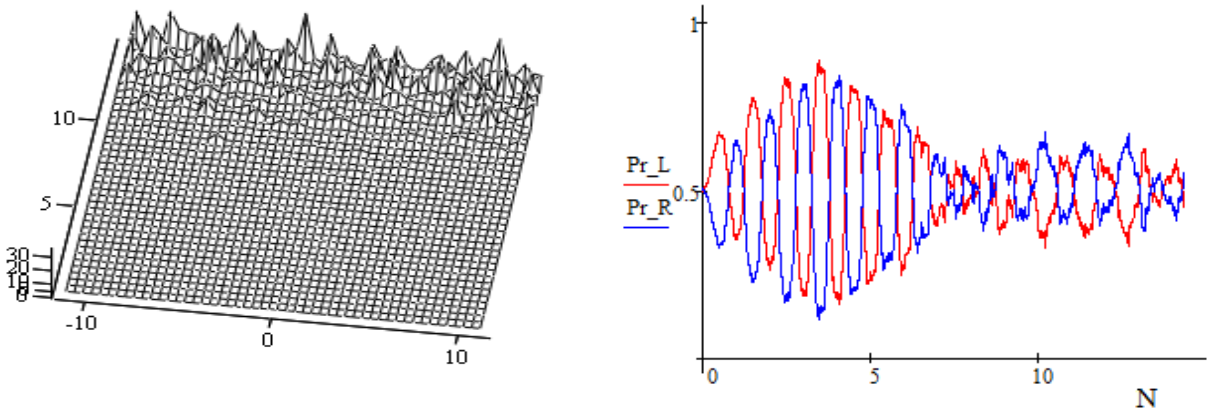


Fig. 9. Left – example of the probability density distribution $p(x,t)$ under time periodic driving disturbed by stochastic process of "white" noise; g= 0.1 $\sigma_W = 1.2$; the number of periods N is shown along the coordinate axis. Right – evolution of parts Pr_L and Pr_R of the probability distribution density $p(x,t)$ on the interval $x \geq 0$ (red), $x \leq 0$ (blue); $g = 0.1$, $\sigma_W = 1.2$

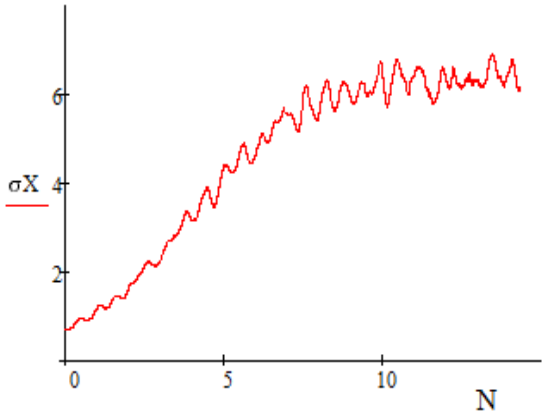


Fig. 10. Time dependences of the beam center Xsr and the root-mean-square beam size σX *;* $g = 0.1$, $\sigma_W = 1.2$

From Fig. 10 it can be seen that when $\sigma_W = 1.1$ the oscillations of the beam as a whole become less and less coherent and regular. In this case, the shares of Pr_L (for $x \geq 0$) and Pr_R (for $x \leq 0$) probability distribution density $p(x,t)$ become more and more equalized over time. This indicates a complete breakdown of the oscillations in the function. The root mean square size of the beam σX while continuing to increase. The observed process can be called the collapse of the wave function.

PHYSICAL INTERPRETATION

To build a hypothesis about the relationship between σ_U and $T_{collapse}$ the calculation was carried out at intensity $\sigma_W = 0.50$ (Fig. 11).

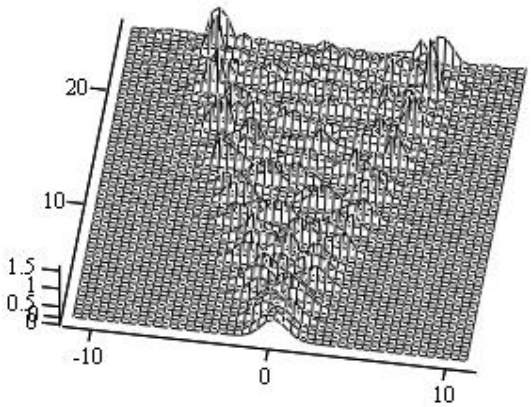


Fig. 11. Probability density evolution $p(x,t)$ *under time periodic driving disturbed by stochastic process of "white" noise;* $g = 0.1$, $\sigma_W = 1.2$*; the number of periods N is shown along the coordinate axis*

From Fig. 12 the duration of the transition from a regular state to an incoherent one is approximately $N_{collapse} \approx 8$. Comparison of the data in Figs. 9 and 12 allows us to call it the time to collapse $N_{collapse}$ which is inversely proportional to the noise intensity σ_W:

$$N_{collapse} \approx C_1 + C_2 \sigma_W^{-1}, \qquad (28)$$

where C_1 and C_2 are the coefficients.

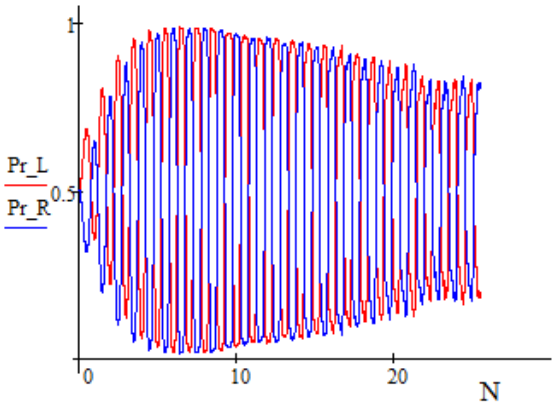


Fig. 12. Evolution of parts Pr_L and Pr_R of the probability distribution density $p(x,t)$ *on the interval* $x \geq 0$ *(red),* $x \leq 0$ *(blue);* $g = 0.1$, $\sigma_W = 0.50$

SUMMARY

We considered dynamics of the wave function in a parabolic potential, which is subject to time-periodic driving, as well as to the stochastic effect of the "white" noise. Based on the solution of the non-stationary Schrödinger equation, algorithms for calculating the dynamics of the wave function were constructed. Asymptotic solutions of the equation of motion were given. The main characteristics of the wave function were obtained for the selected types of perturbation of the potential. Cases of destruction (collapse) of the wave function due to the noise were considered. It was shown that the time before the collapse was inversely proportional to the noise intensity.

REFERENCES

1. V.I. Dubinko, P.A. Selyshchev, J.F.R. Archilla. Reaction-rate theory with an account of the crystal anharmonicity // *Phys. Rev. E.* 2011, v. 83, p. 041124-1-13.

2. V.I. Dubinko, D.V. Laptev, A.S. Mazmanishvili, J.F.R. Archilla. Quantum dynamics of wave functions in a nonstationary parabolic potential and the Kramers escape rate theory // *Journal of Micromechanics and Molecular Physics.* 2016, v. 01, N 2, p. 1650010-1-12.

3. V.I. Dubinko, D.V. Laptev, A.S. Mazmanishvili. Quantum tunneling in a time-periodic double-well potential as a driver of LENR // *J. Condensed Matter Nucl. Sci.* 2023, v. 37, p. 124-138.

4. A.S. Mazmanishvili, I.A. Knyaz. Dynamics of quantum particles in perturbed parabolic 2d potential // *Journal of Nano- and Electronic Physics*. 2016, v. 8, N 4, p. 04014.

5. A.A. Sokolov, Yu.I. Loskutov, I.M. Ternov. *Quantum Mechanics*. M.: "Nauka", 1962, 591 p.

6. A.I. Akhiezer, N.F. Shulga. *Electrodynamics of high energies in matter*. M.: "Nauka", 1993, 344 p.

7. V.G. Baryshevsky. *Channeling, radiation and reactions in crystals at high energies.* Minsk: "Publishing house of BSU", 1982, 256 p.

8. K. Funo, A. Ishizaki. Dynamics of a quantum system interacting with white non-Gaussian baths: Poisson noise master equation // *Phys. Rev. Lett*. 2024, v. 132, p. 170402.

9. F. Werner et al. On the averaged quantum dynamics by white noise Hamiltonians with and without dissipation // *Annalen Phys.* 1998, v. 7, p. 59-100.

10. V.C. Convicto, S.A. Somerado. On the solution of perturbed quantum harmonic oscillator: a white noise analysis *// International Journal of Modelling, Simulation and Applications.* 2020, v. 4, N 1.

11. B.M. Butanas. Dynamics of coupled harmonic oscillators in an environment using white noise analysis // *AIP Conf Proc*. 2020, v. 2286, N 1, p. 040002.

12. F. Werner, H. Lesckhe, P. Mulle. On the averaged quantum dynamics by white-noise hamiltonians with and without dissipation // *Annalen der Physik*. 1998, v. 510, issue 2, p. 59-100.

13. A.S. Mazmanishvili. *Path integration as a method for solving physical problems.* K.: "Naukova Dumka Press", 1987, 224 p

Article received 22.04.2026

ВПЛИВ БІЛОГО ШУМУ НА КВАНТОВУ ДИНАМІКУ ХВИЛЬОВОЇ ФУНКЦІЇ У ПЕРІОДИЧНОМУ ЗА ЧАСОМ ГАРМОНІЧНОМУ ПОТЕНЦІАЛІ

О.С. Мазманішвілі, В.І. Дубінко, Klee Irwin

Ми досліджували квантову динаміку частинки в одновимірному параболічному потенціалі, що піддається як періодичному збудженню з часом, так і стохастичним збуренням, змодельованим як білий шум. Використовуючи нестаціонарне рівняння Шредінгера та формалізм функції Гріна, ми виводимо аналітичні вирази для часової еволюції хвильової функції та її статистичних моментів. Показано, що завдяки квадратичній природі потенціалу хвильова функція зберігає гауссову форму, що дозволяє скорочений опис через її перший та другий моменти. При резонансному періодичному збудженні середня енергія демонструє квадратичне зростання в часі. За наявності білого шуму хвильовий пакет зазнає дифузійного розтікання та втрати когерентності. Для комбінованого детерміністичного та стохастичного збудження ми визначаємо характерний час декогеренції (делокалізації), який масштабується обернено пропорційно до інтенсивності шуму. Результати стосуються квантового транспорту, збуджених систем та тунельних процесів у флуктуючих середовищах.