# Classical Simulation of Double Slit Interference


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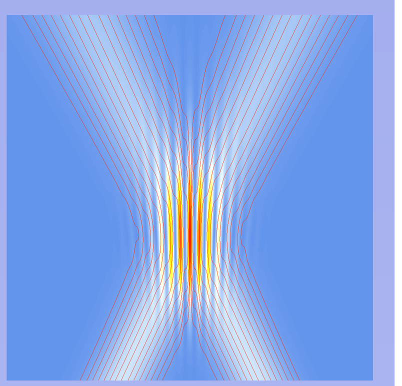
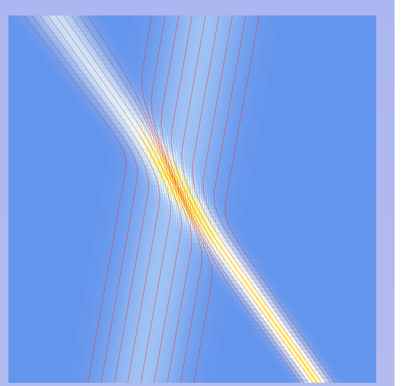
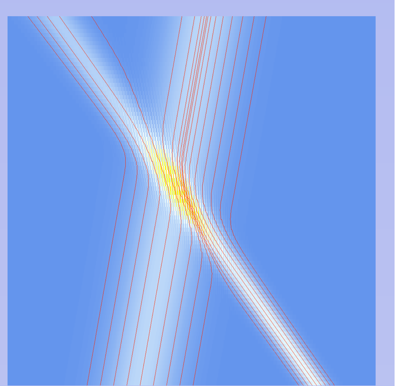


$v_{x,2} = -v_{x,1}$

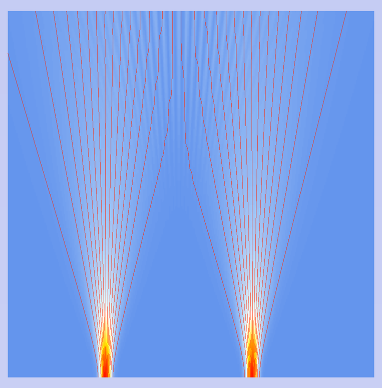


$v_{x,2} = -4v_{x,1}$
$\sigma_1 = 3\sigma_2$

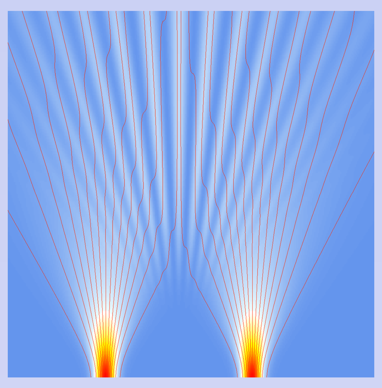


$v_{x,2} = -4v_{x,1}$
$\sigma_1 = 3\sigma_2$
$P_1 = 2P_2$

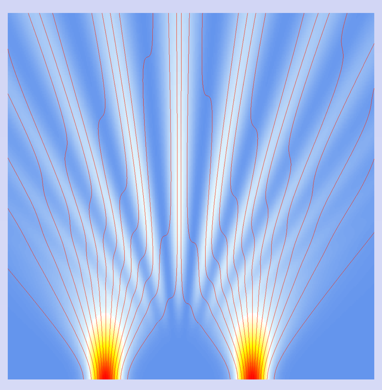
Series for:
$v_{x,1} = v_{x,2} = 0$
$\sigma_1 = \sigma_2$



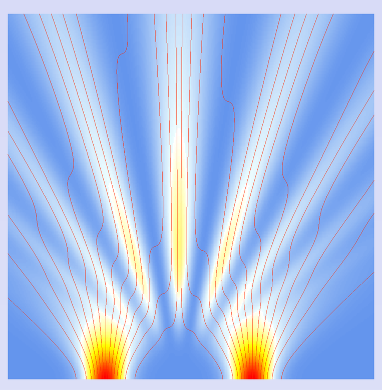
$0.5\sigma_0$



$1.0\sigma_0$



$1.5\sigma_0$



$2.0\sigma_0$


Based on a proposed classical explanation of interference effects, we claim that for every single "particle" a thermal context can be defined, which reflects its embedding within boundary conditions as given by the totality of arrangements in an experimental apparatus. The intensity distribution of two colliding Gaussian wave packets is computed, as well as the corresponding trajectories. For the case of the double slit, the emerging trajectories are shown to obey a "no crossing" rule with respect to the central line, i.e., between the two slits and orthogonal to their connecting line. For other cases of the interference of two Gaussian wave packets, more complicated behaviors emerge. Despite using the classically derived (!) quantity $\hbar$ in the relations $m\mathbf{v} = \hbar\mathbf{k}$ and $D = \hbar/2m$, respectively, we utilize no quantum mechanics, but only familiar simulation techniques for diffusion, i.e., coupled map lattices (CML). The essential ingredient of our model is that the diffusivity $D(t)$ is time dependent, which is due to a changing thermal environment as one moves away from the immediate regime of the slits.


**Ballistic diffusion equation:**

$$\frac{\partial}{\partial t}P(x,t) = D(t)\frac{\partial^2}{\partial x^2}P(x,t), \qquad D(t) = \frac{D^2}{\sigma_0^2}t =: u_0^2\, t,$$

$$P(x,t) = \frac{1}{\sqrt{2\pi\sigma^2}}e^{-[x \pm (X+v_x t)]^2/2\sigma^2}, \qquad D = \frac{\hbar}{2m} \text{ ... diffusion constant,} \qquad u_0 \text{ ... diffusive velocity}$$

**Classically derived phase relation:**

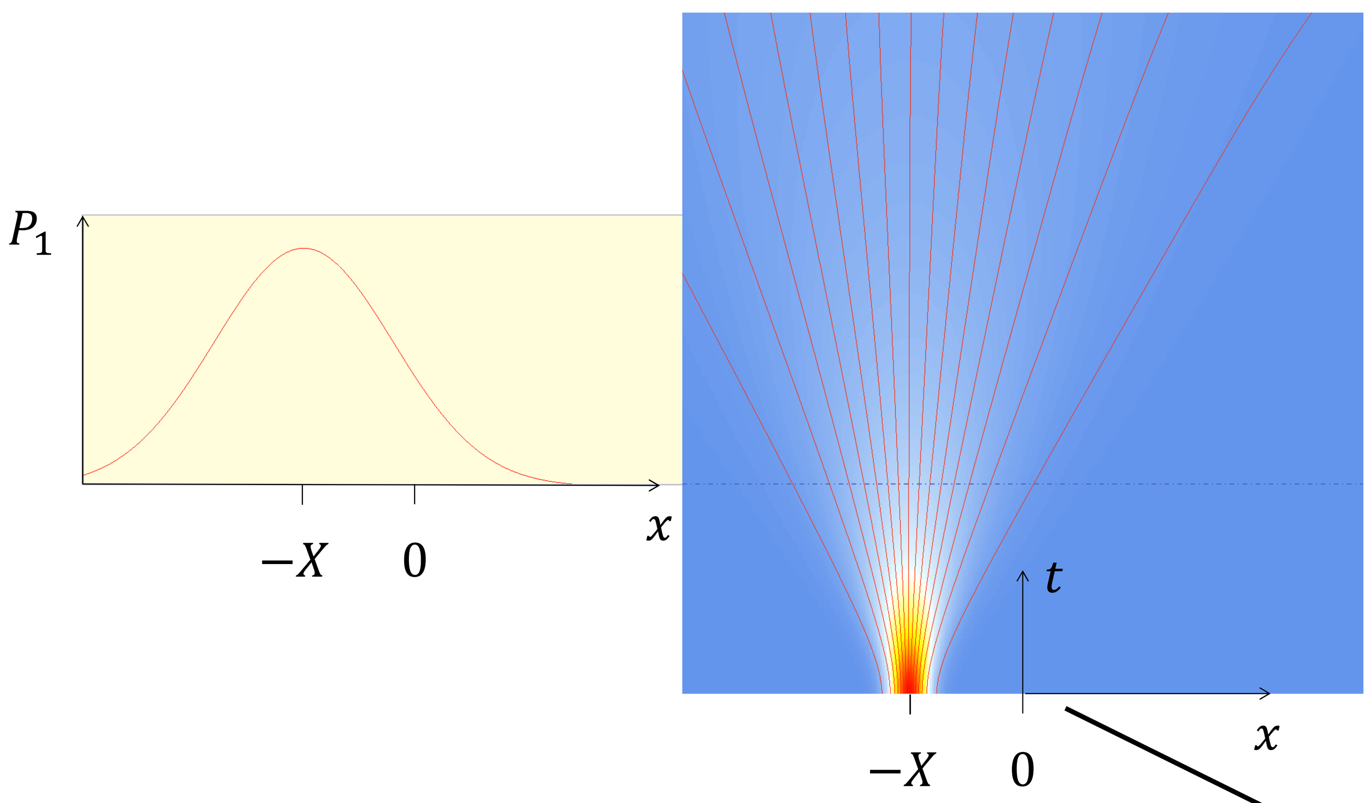
$$\varphi = 2mv_x\frac{x}{\hbar} - (X + v_x t)xD\frac{t}{\sigma^2\sigma_0^2}, \qquad \sigma = \sigma_0\sqrt{1 + \frac{u_0^2 t^2}{\sigma_0^2}}$$

**Diffusion rule via CML:**

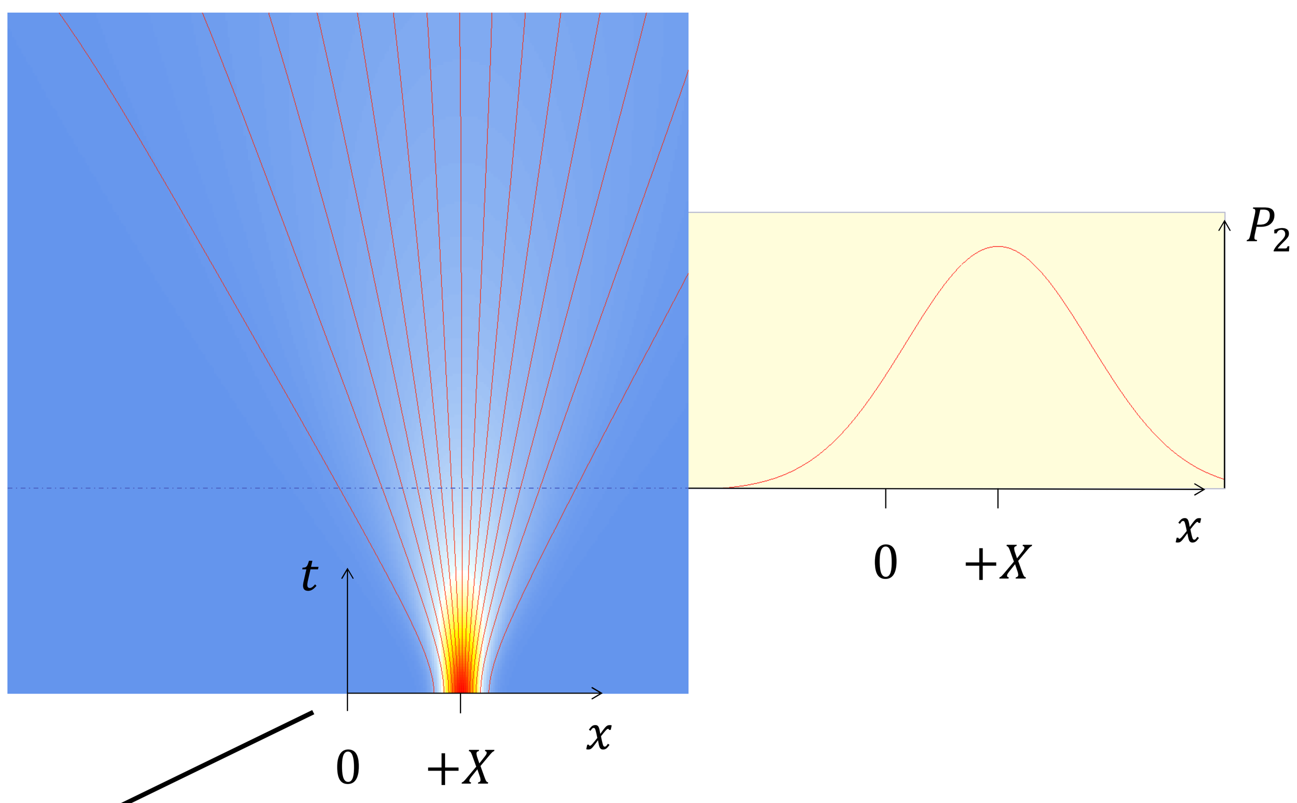
$$P[x,t+1] = P[x,t] + \frac{D[t+1]\Delta t}{\Delta x^2}\{P[x+1,t] - 2P[x,t] + P[x-1,t]\}, \qquad D[t] = u_0^2 t$$

**Simulation steps**

- CML computation of intensity distributions $P_1$ and $P_2$ due to diffusion rule
- Establishing phase differences $\varphi$ and superposition of wave amplitudes $\sqrt{P_1}$ and $\sqrt{P_2}$
- Computation of averaged trajectories, i.e., the contour lines of the resulting intensity $P$

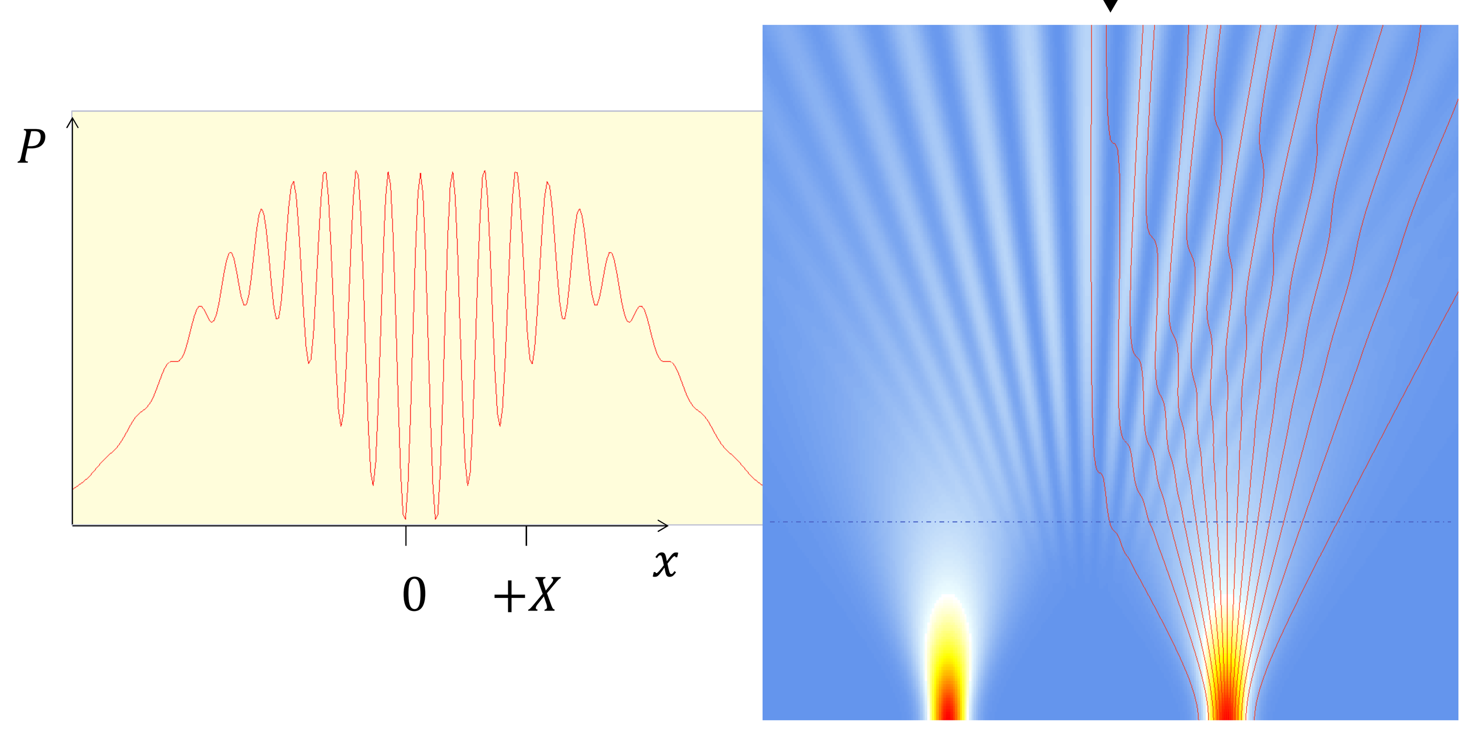








$$P = P_1 + P_2 + \sqrt{P_1 P_2}\cos\varphi\,, \qquad \varphi[x,t] = -Xx\frac{Dt}{\sigma^2\sigma_0^2}$$





*Computer simulation of interference pattern for velocities $v_{x,1} = v_{x,2} = 0$.*

*Trajectories (shown here for the right slit only), identical to Bohmian trajectories, obey „no crossing rule“ w.r.t. symmetry line.*

**References**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