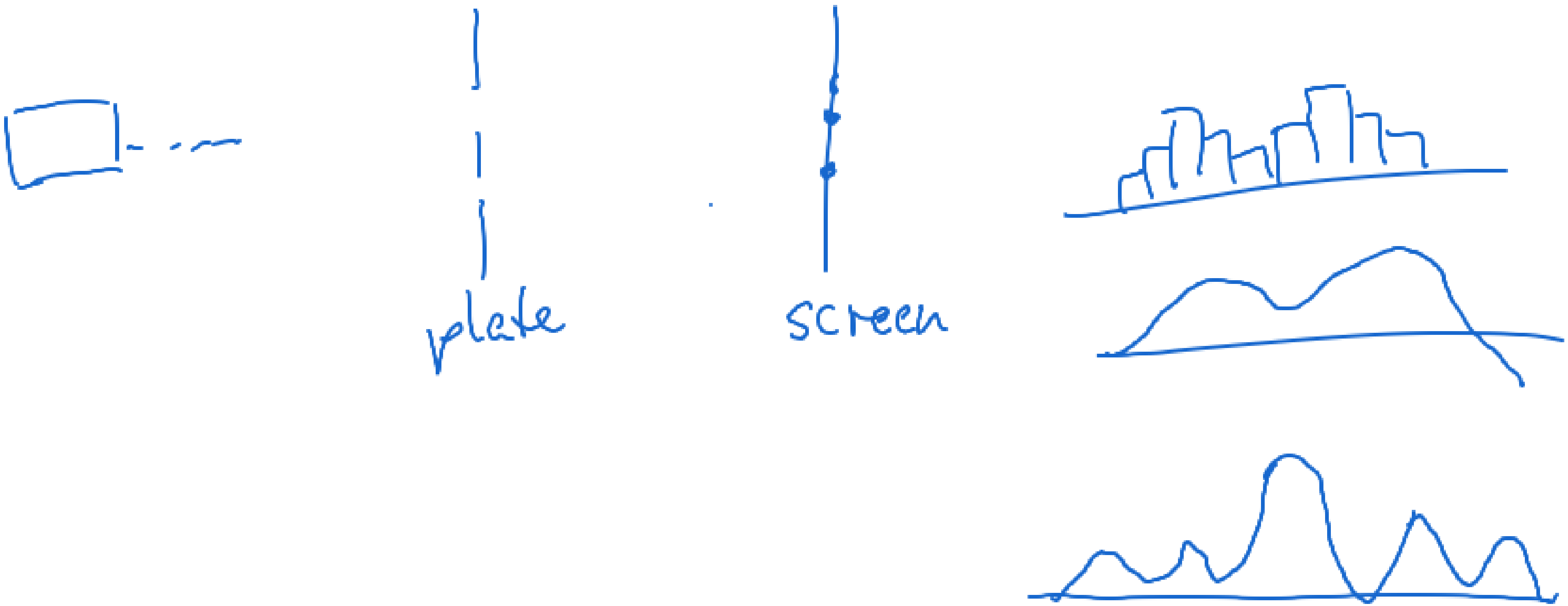
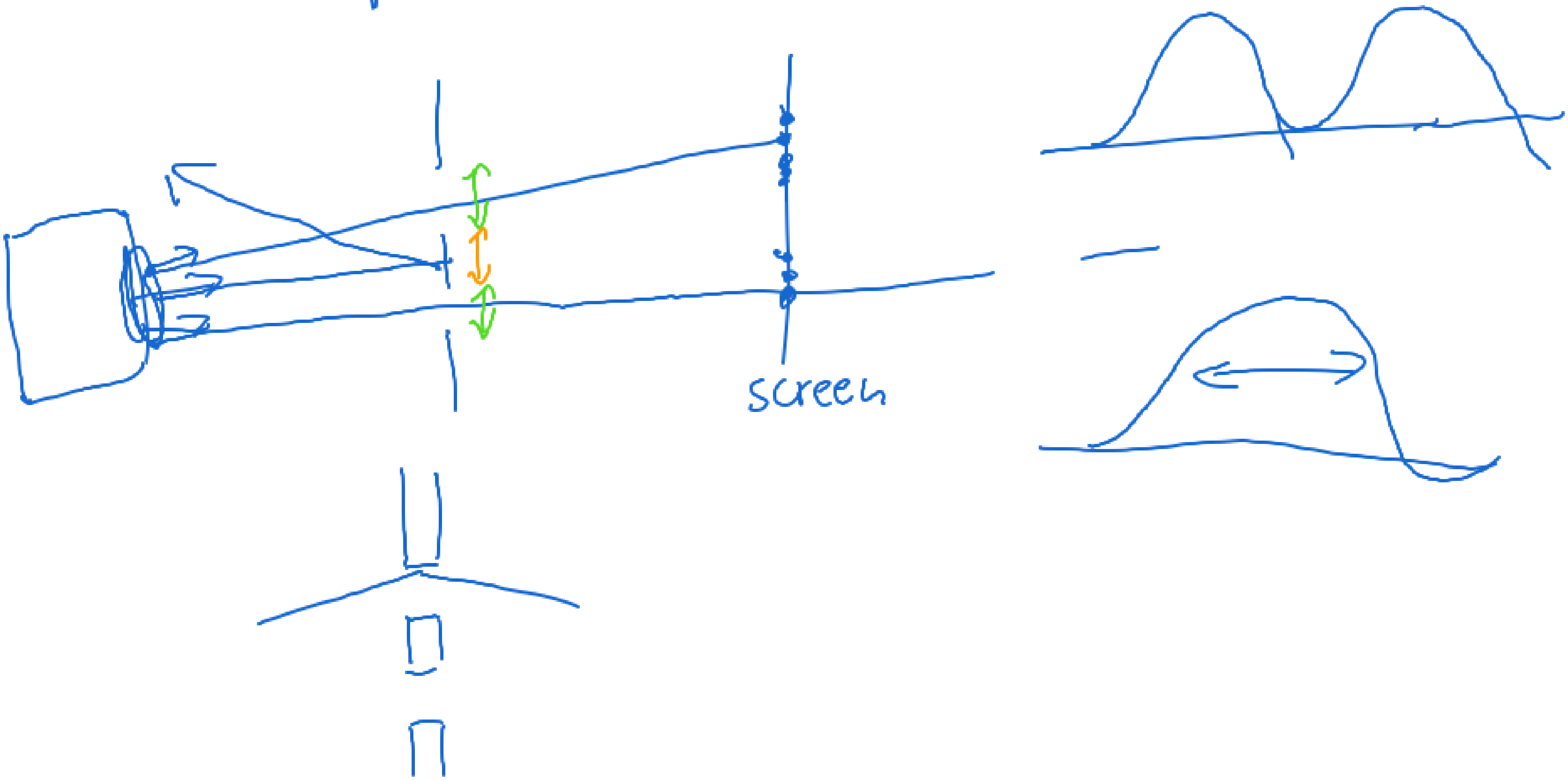
1.5 The Double-Slit Experiment

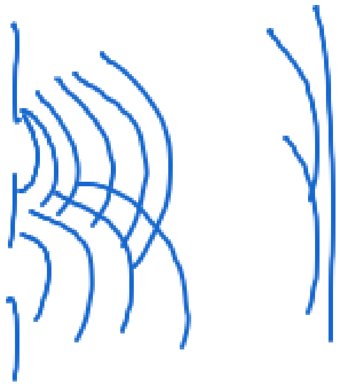
interference = diffraction



Double slit for classical particles

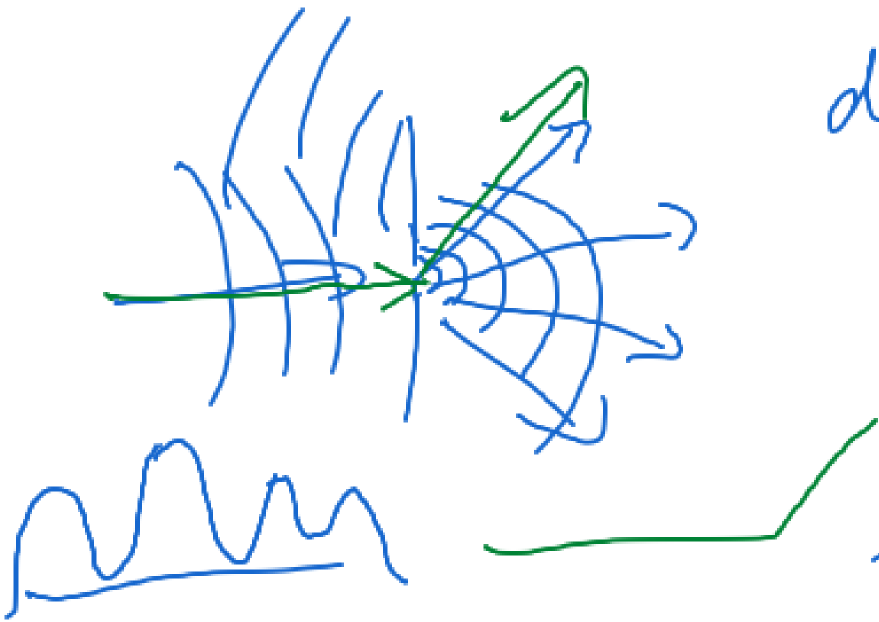


Doubleslit with classical waves



1) cont. distr.
2) spread, change of direction of propagation
3) constructive & de- structive interference

diffraction

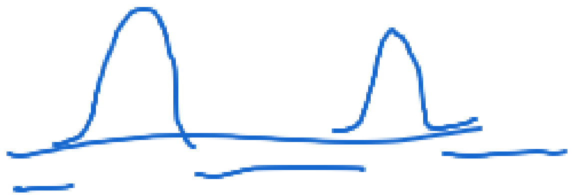


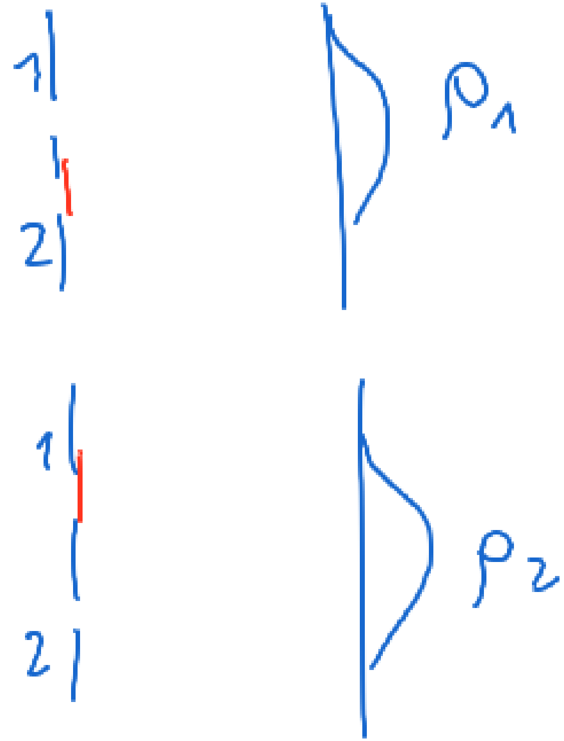
outgoing: (semi-circular)

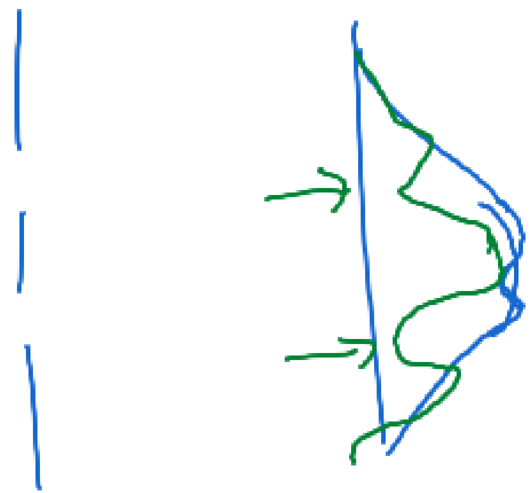
$$\cos\left(k\sqrt{x^2+y^2}\right) / \left(x^2+y^2\right)^{1/4}$$

energy $\propto$ amplitude^2

screen close to slits

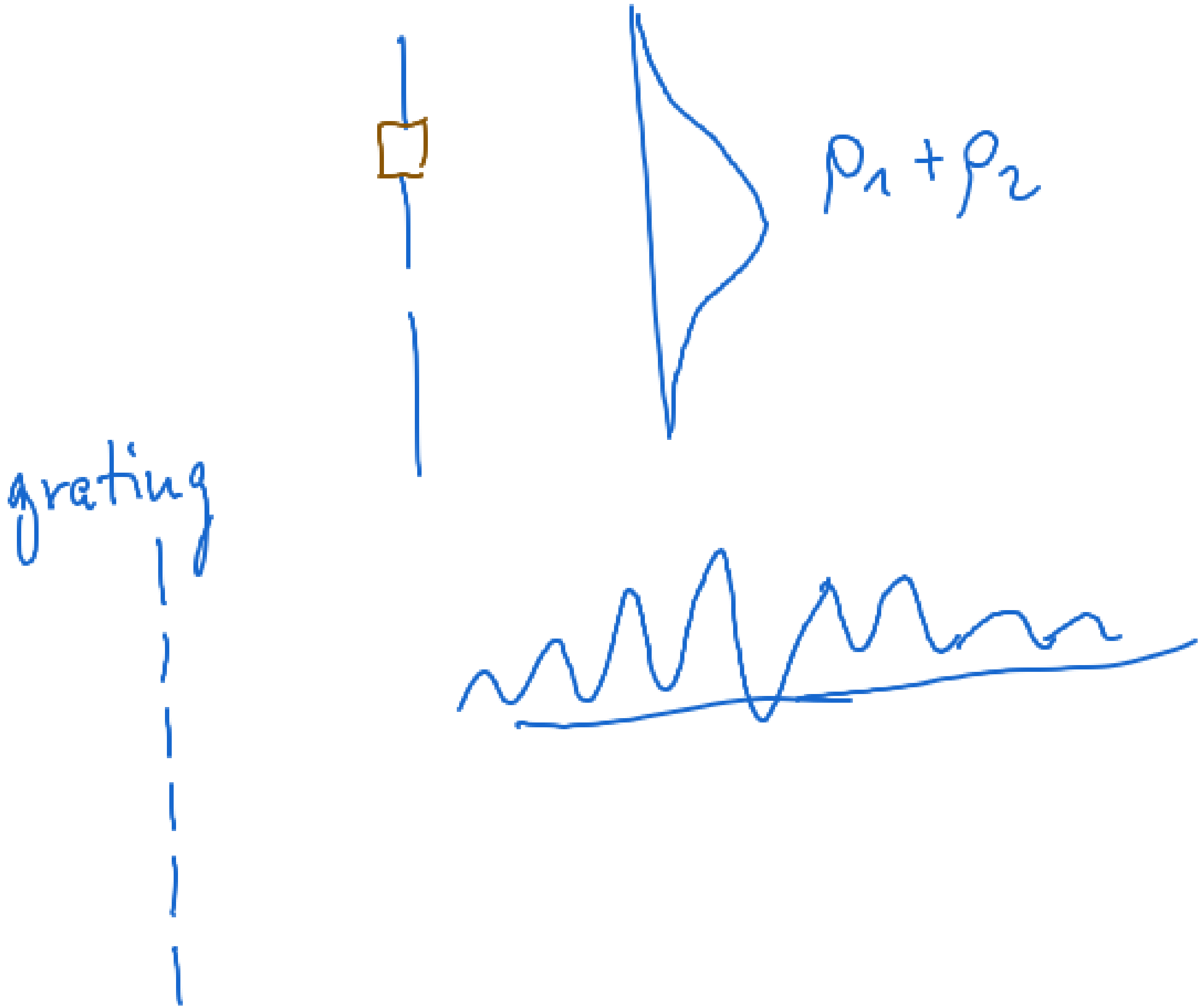






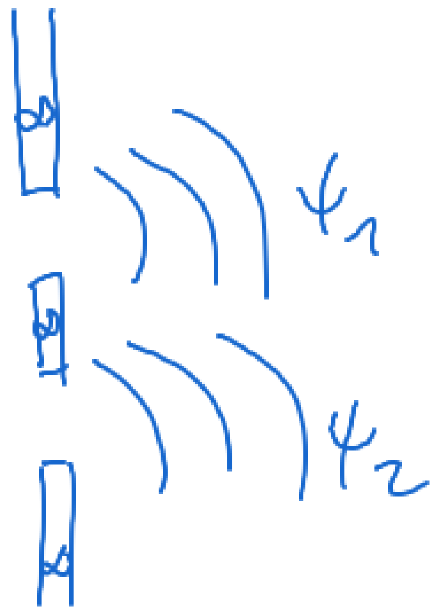
$$\rho_1 + \rho_2 \neq \rho_{12}$$

detectors at the slit



Schr eq, Born's rule

$V=0$



$\rho_1 + \rho_2 \neq \rho_{12}$: $\psi = \psi_1 + \psi_2$

$$\psi(t, \underline{x}) = \psi_1(t, \underline{x}) + \psi_2(t, \underline{x})$$

$$\rho_{12}(\underline{x}) = |\psi(\underline{x})|^2 = \underbrace{|\psi_1(\underline{x})|^2}_{\rho_1} + \underbrace{|\psi_2(\underline{x})|^2}_{\rho_2} + \underline{2\,\mathrm{Re}\,\psi_1^* \psi_2} .$$

On Feynman:

- Is there a genuine mystery?
- ~~Note:~~ mystery is not surprising?

Bohmian mechanics

quantum formalism = set of rules for making empirical predictions

Def 3-space, 1-time, N particles, $\underline{Q}_i(t) \in \mathbb{R}^3$, $t \in \mathbb{R}$, $i \in \{1, \dots, N\}$. Bohm's eq. of motion

$$\frac{d\underline{Q}_i}{dt} = \frac{\hbar}{m_i} \operatorname{Im} \frac{\nabla_i \Psi}{\Psi}(t, Q(t))$$

with $Q(t) = (\underline{Q}_1(t), \dots, \underline{Q}_N(t))$

Ψ = wave fct of the universe

$$i\hbar \frac{\partial \Psi}{\partial t} = -\sum_{i=1}^{N} \frac{\hbar^2}{2m_i} \nabla_i^2 \Psi + V\Psi .$$

Typicality law: $Q(0)$ is typical with respect to $\rho_0(q) = |\Psi_0(q)|^2 \quad \forall q \in \mathbb{R}^{3N}$.

or $Q(0)$ is random with prob density $\rho_0 = |\Psi_0|^2$.

Fact: emp. predictions of BM agree with quantum formalism.

Equivariance thm:

If $Q(0) \sim |\Psi_0|^2$ then $Q(t) \sim |\Psi_t|^2$ $\forall t \in \mathbb{R}$.