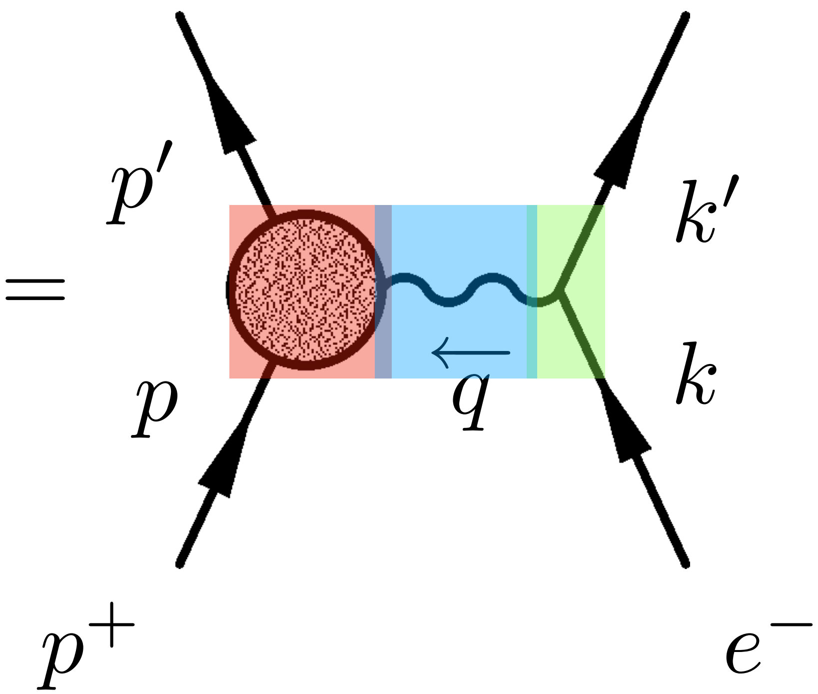
Elastic Scattering

Scattering Process	Cross Section
pointlike charge [no spin] on pointlike charge [no recoil, no spin]	$\left(\frac{d\sigma}{d\Omega}\right)_{\text{Rutherford}} = \frac{e^4 z^2 Z^2}{4E^2 \sin^4 \frac{\theta}{2}}$
pointlike charge [**spin**] on pointlike charge [no recoil, no spin]	$\left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott, no recoil}} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{R}} \cos^2 \frac{\theta}{2}$
pointlike charge [**spin**] on **extended** charge [no recoil, no spin]	$\left(\frac{d\sigma}{d\Omega}\right)_{\rho} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott, no recoil}} \lvert F(\underline{q}^2)\rvert^2$
pointlike charge [**spin**] on pointlike charge [**recoil**, no spin]	$\left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott, no recoil}} \cdot \frac{E'}{E}$
pointlike charge [**spin**] on pointlike charge [**recoil**, **spin**]	$\left(\frac{d\sigma}{d\Omega}\right) = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \cdot \left(1 + 2\tau \tan^2 \frac{\theta}{2}\right)$
pointlike charge [**spin**] on **extended** charge [**recoil**, **spin**]	$\left(\frac{d\sigma}{d\Omega}\right)_{\text{Rosenbluth}} = \left(\frac{d\sigma}{d\Omega}\right)_{\text{Mott}} \left[\frac{G_E^2(\underline{q}^2) + \tau G_M^2(\underline{q}^2)}{1+\tau} + 2\tau G_M^2(\underline{q}^2) \tan^2 \frac{\theta}{2}\right]$

Full QFT calculation of the Rosenbluth formula

$$i\mathscr{M} =$$

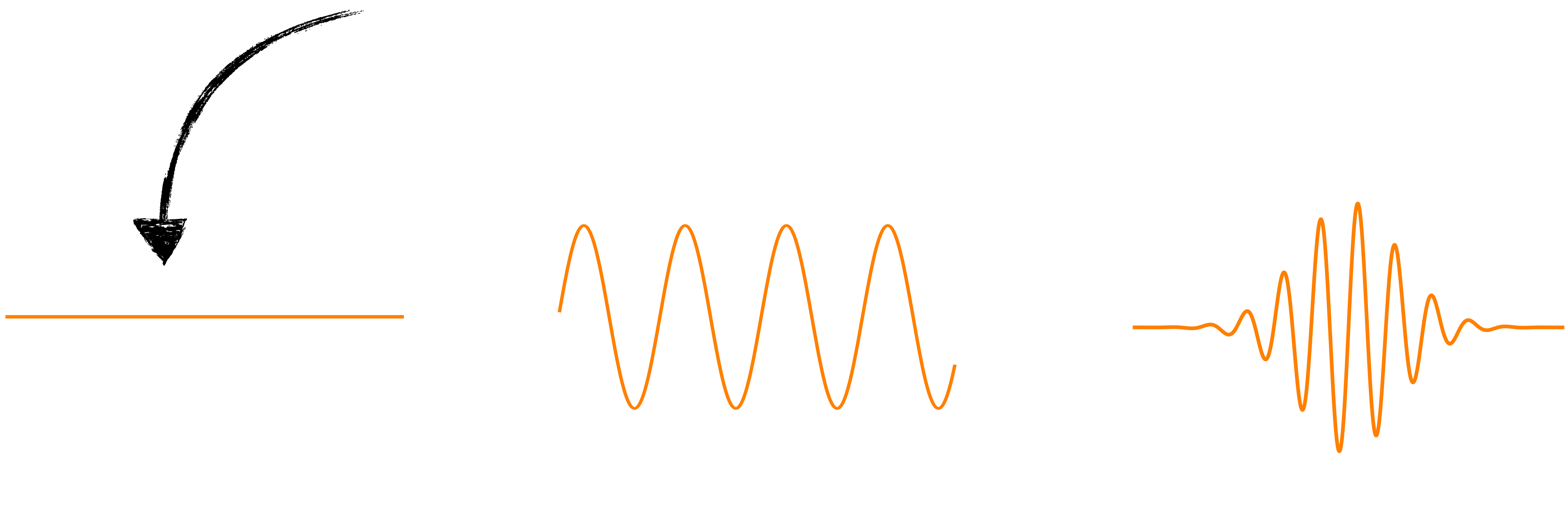


$$= \overline{u}(k')(-ie\gamma_\mu)u(k)\frac{-i}{q^2}\overline{u}(p')(-ie\Gamma^\mu)u(p).$$

Quantum field theory

What is a quantum field?

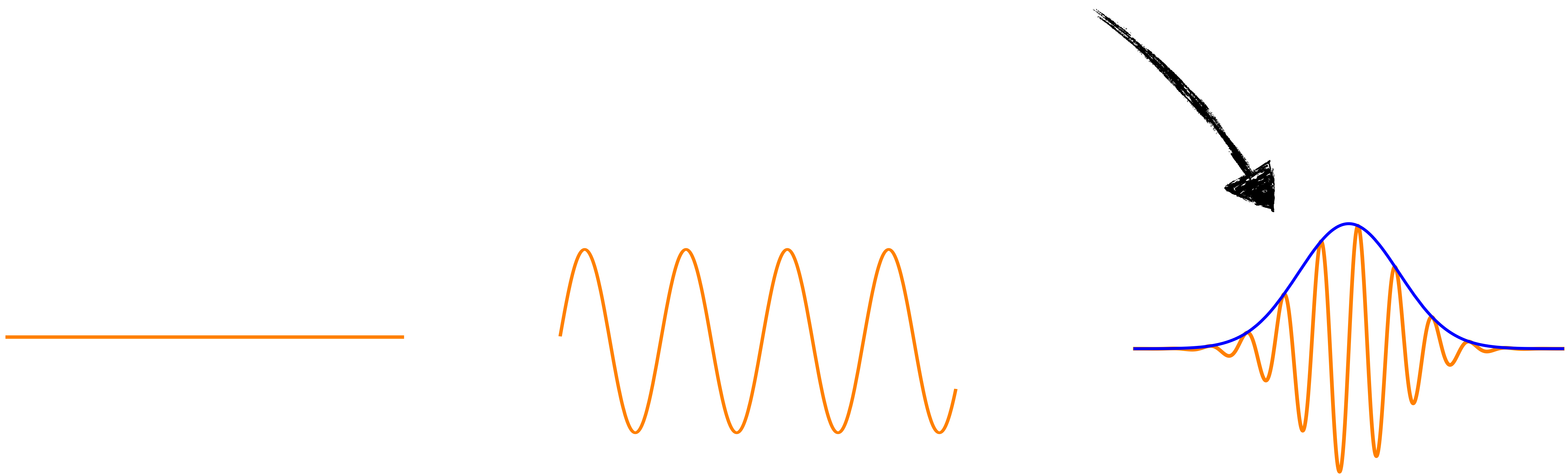
1-dimensional Field



Quantum field theory

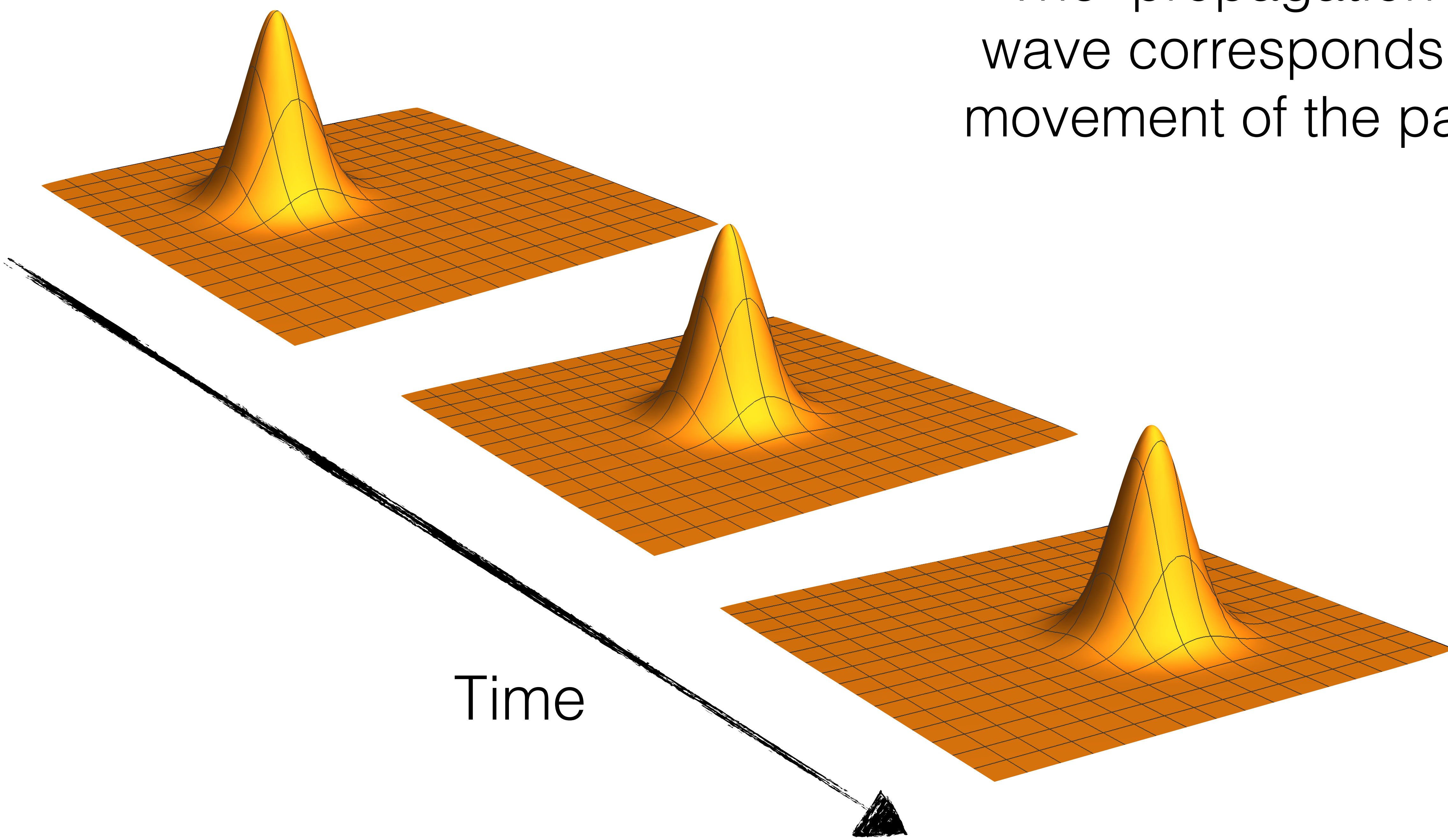
What is a quantum field?

smallest localised wave
can be interpreted as a
particle = quantum

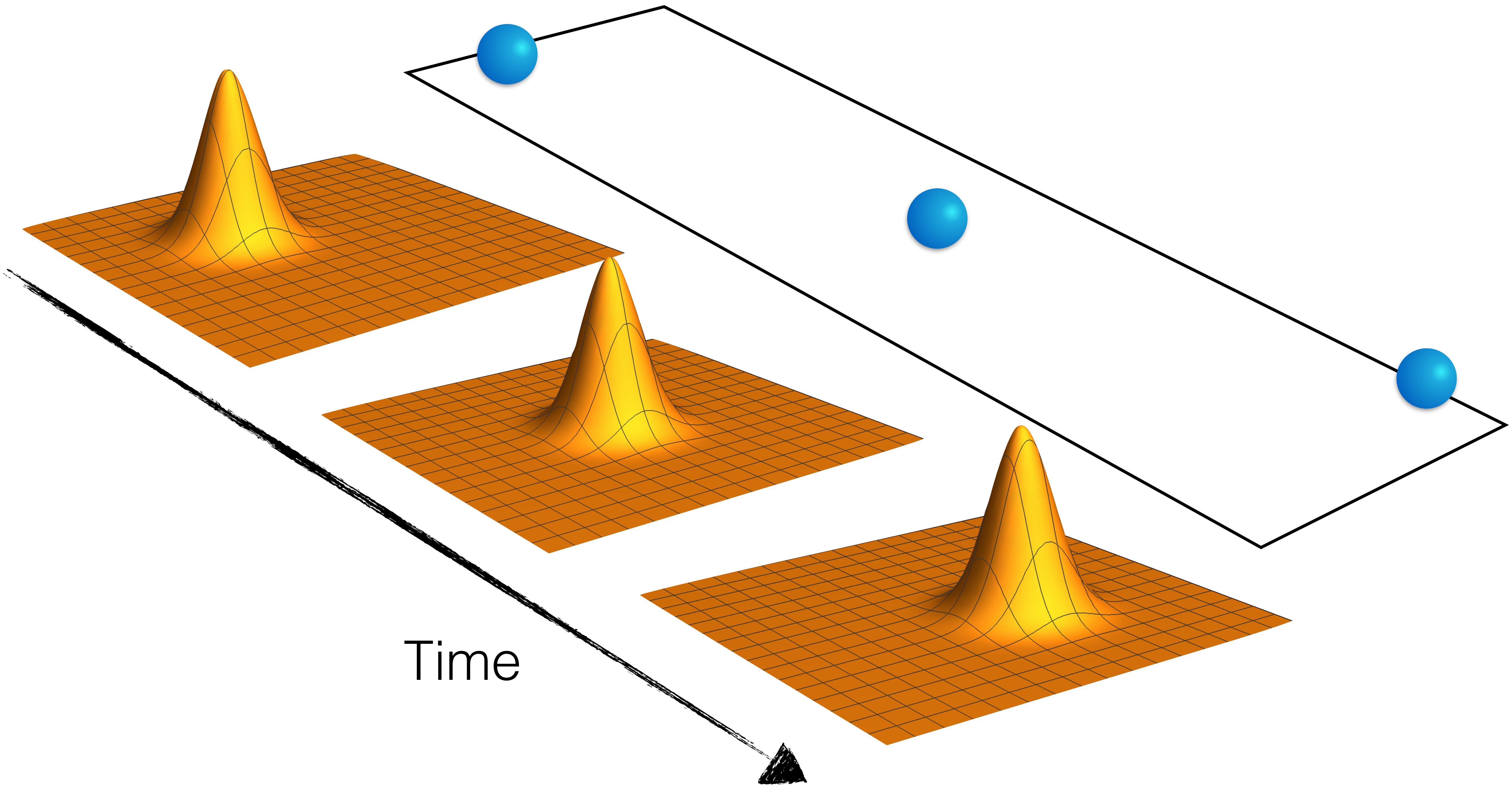


Quantum field theory

The propagation of this wave corresponds to the movement of the particle.

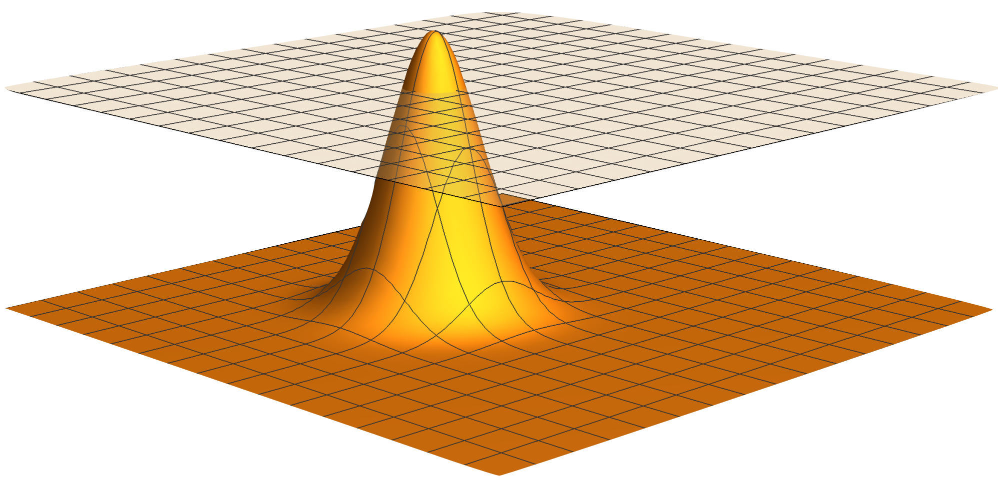


Quantum field theory



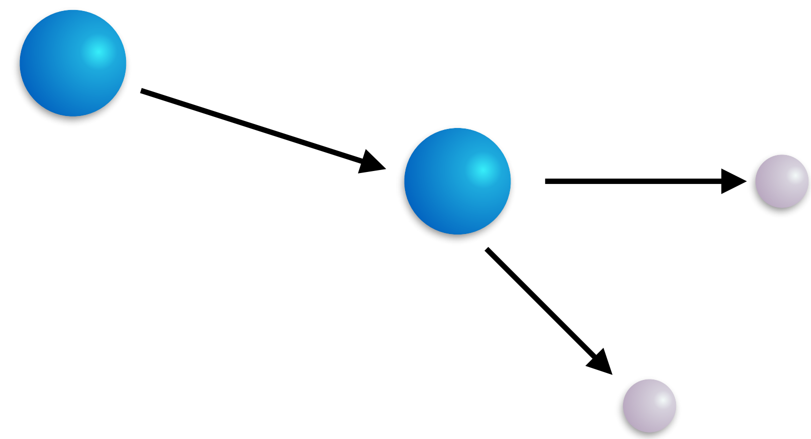
Quantum field theory

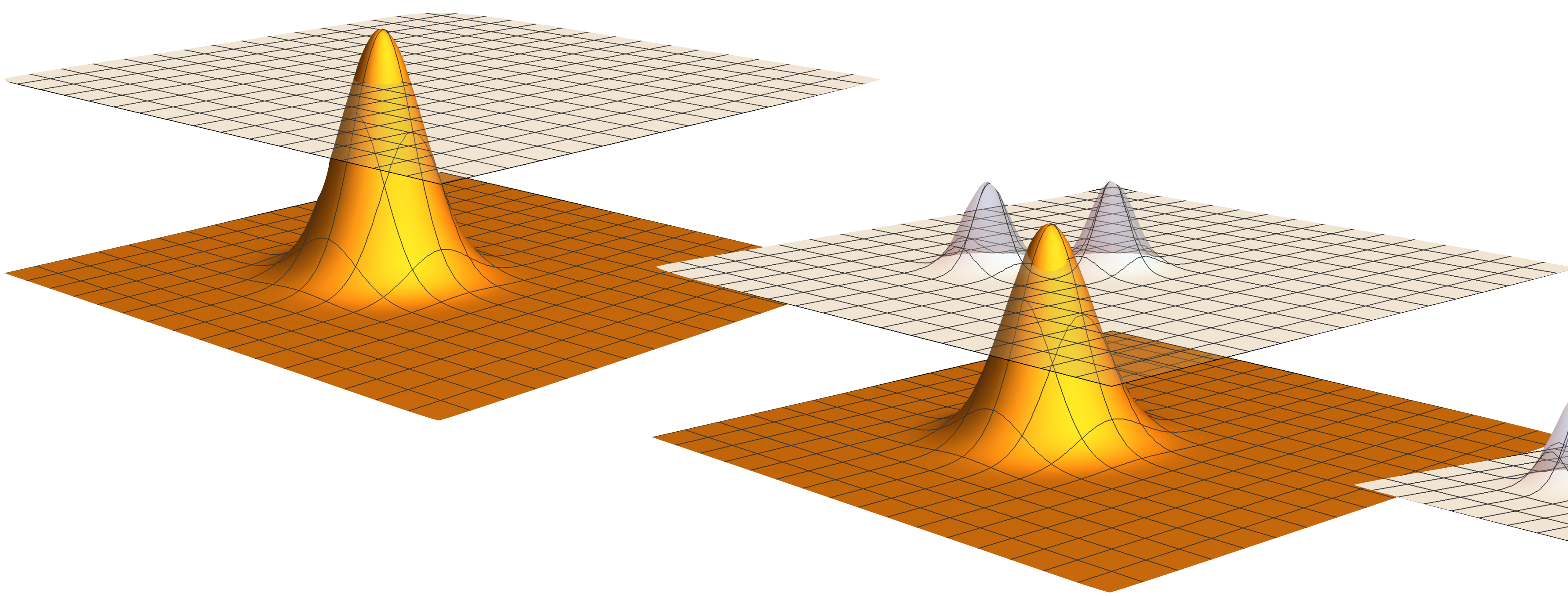
Quantum fields interact

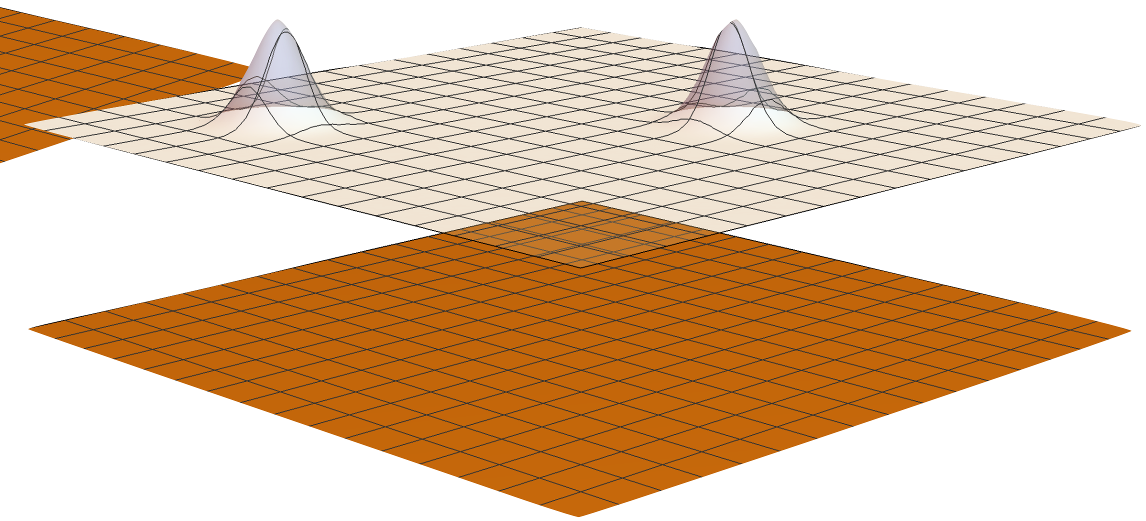


Quantum field theory

Quantum fields interact







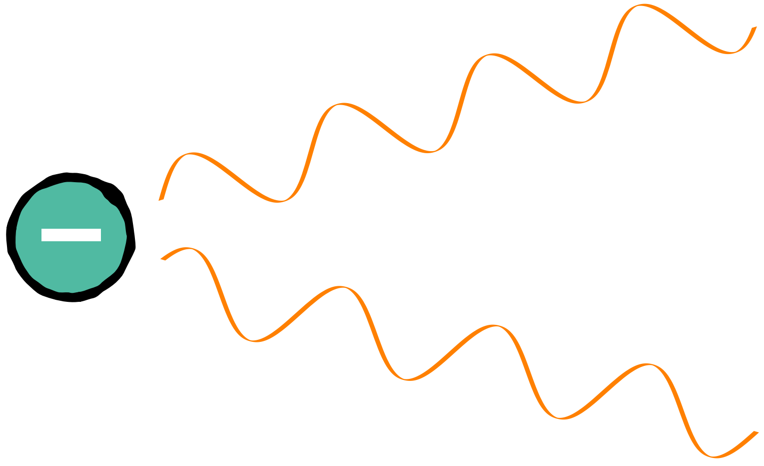
The decay of an elementary particle corresponds to the wave of one quantum field exciting waves in a different quantum field.

Quantum field theory

Certain quantities (quantum numbers) are conserved in this process, e.g. electric charge is conserved.

The lightest particle with a given set of quantum numbers is stable.

The electron is the lightest field with electric charge -1. It can interact with other quantum fields, but it can never decay.

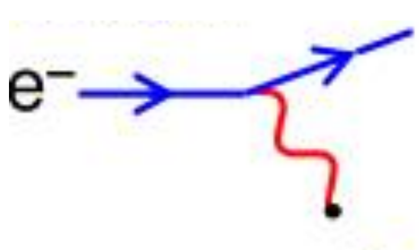


Inelastic scattering

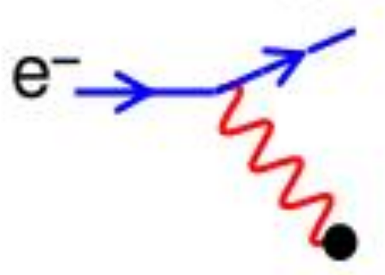
The photon wavelength determines the resolution of the scattering process

$\lambda \gg R_{\text{Proton}}$ | $\lambda \sim R_{\text{Proton}}$ | $\lambda < R_{\text{Proton}}$ | $\lambda \ll R_{\text{Proton}}$

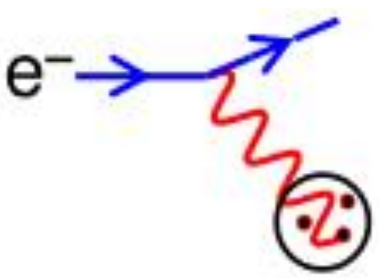
Rutherford



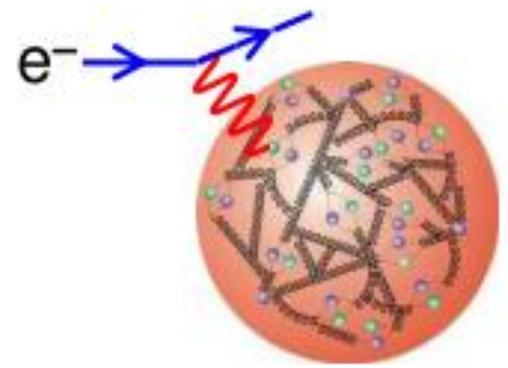
Rosenbluth



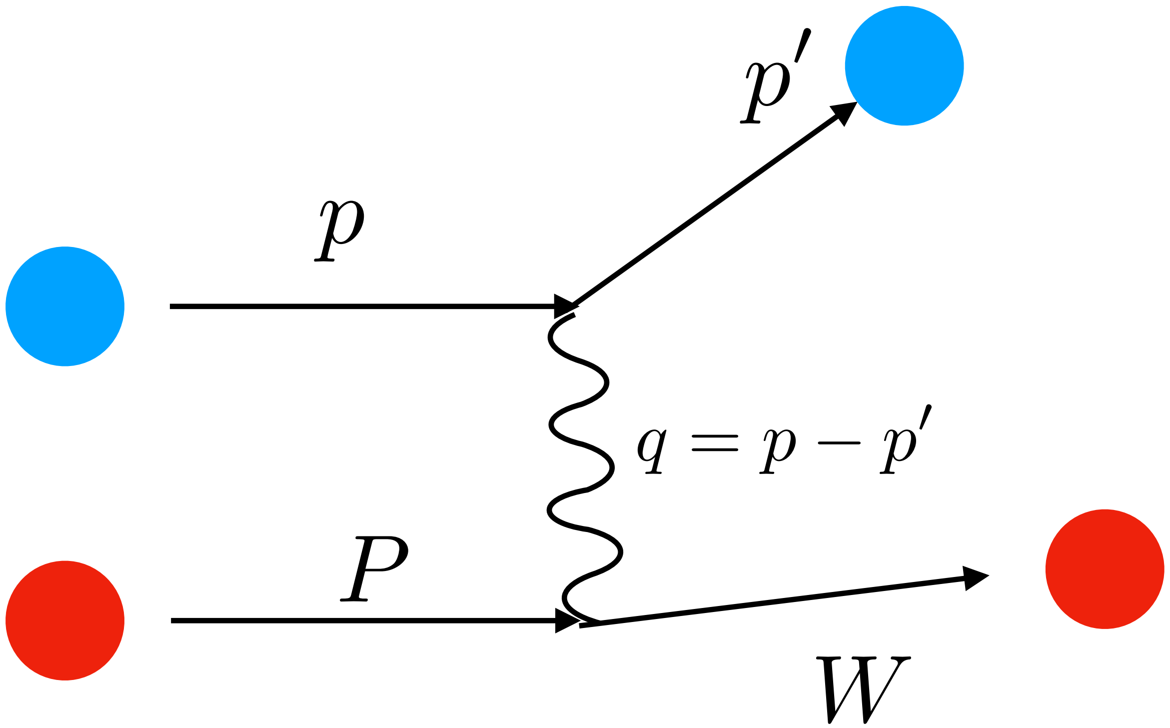
Inelastic



Deep inelastic



Inelastic scattering



Elastic scattering:
Kinetic energy conserved.
The number and type of initial
and final state particles is the same.

Inlastic scattering:
Kinetic energy not conserved.
The number and type of initial
and final state particles is the same.