Waves

Definition:

A wave is a perturbation of the equilibrium state propagating in space. It is accompanied by the transport of energy.

The perturbation can have any shape. If it is described by a harmonic function, the resulting wave is called a *harmonic wave*.

Characteristics:

- Waves propagate in a medium (*wave carrier*) which is unperturbed in its equilibrium state.

  Examples: Water (water waves)
  String (waves on a string)
  Air, water, … (sound waves)
  Electric and magnetic field (electromagnetic waves, e.g. light, heat radiation, …)

- To allow for the propagation of the perturbation, neighbouring points of the wave carrier have to be *coupled* (see coupled oscillators).

  Examples: Elastic forces (waves on strings, sound waves)
  Electromagnetic forces (electromagnetic waves)

- Waves are accompanied by the transport of *energy*, but not of mass. On the average, every point of the wave carrier is at rest.

  Example: In surface waves on the sea, the water moves approximately on a circular path around its equilibrium position when a wave passes.

- If the perturbation is parallel to the propagation of the wave, the wave is called *longitudinal*, if it is perpendicular to the propagation, it is a *transverse* wave.

  Examples: Transverse waves on strings
  Surface waves on water are transverse
  Electromagnetic waves are transverse
  Sound waves in air are longitudinal
  Seismic waves can be either longitudinal (p-waves) or transverse (s-waves)

  Remark: In diagrams of longitudinal waves, the displacement is usually graphed perpendicular to the direction of propagation for reasons of clarity.

- A wave is a phenomenon in space and time. In a static diagram, we represent either the shape of the wave at a given moment in time (displacement vs. position graph) or at a given point in space (displacement vs. time graph).

- Apart from phenomena familiar from moving particles (such as reflection), there are a number of effects particular for waves (e.g. interference, refraction, scattering, …). The distinction between particles and waves had to be reinterpreted with the acceptance of quantum physics (duality of particles and waves).

- Many wave types respect the principle of linear superposition, i.e. the perturbations of two superposed waves are simply added (see superposition of oscillations).