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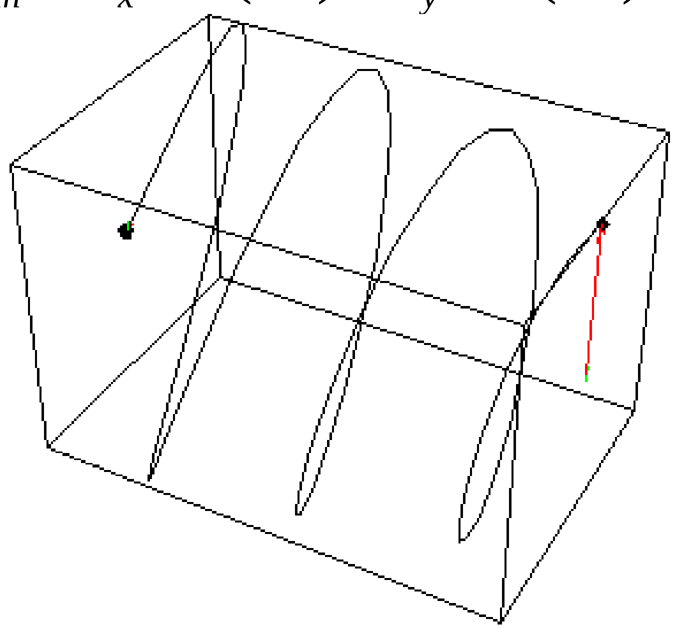
Conversion of polarization states

In a calcite crystal the index of refraction is different for two orthogonal axes.

This leads to a phase difference of **π/2** after a **λ/4 plate:**

$$\vec{E}_{in} = \vec{e}_x \cos(\omega t) + \vec{e}_y \cos(\omega t)$$

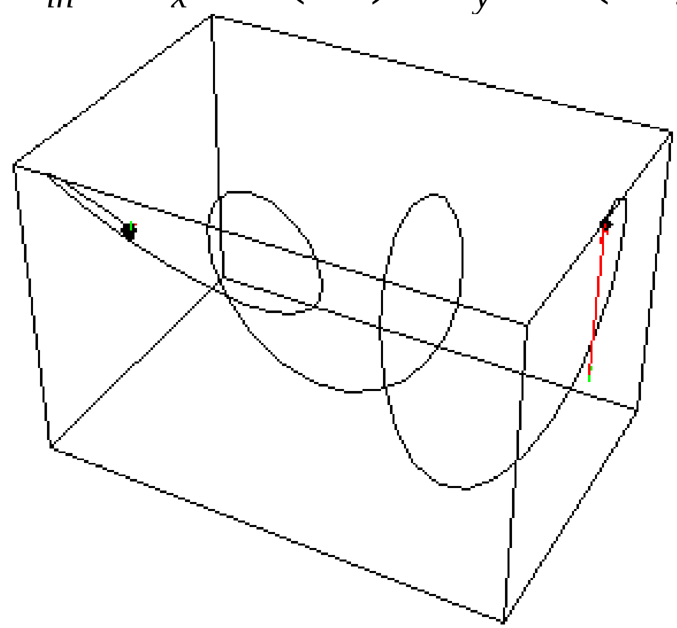


$$\vec{E}^R_{out} = \vec{e}_x \cos(\omega t) + \vec{e}_y \sin(\omega t)$$

x: slow axis

y: fast axis

$$\vec{E}_{in} = \vec{e}_x \cos(\omega t) - \vec{e}_y \cos(\omega t)$$



$$\vec{E}^L_{out} = \vec{e}_x \cos(\omega t) - \vec{e}_y \sin(\omega t)$$

Linear polarized photon states can be changed into circular polarized states and vice versa.

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Orthogonality and completeness

A state |A> is called **orthogonal** to a state |B> when the projection probability from |A> to |B> is zero.

Orthogonality is **reflexive**: if |A> is orthogonal to |B> then |B> is orthogonal to |A>.

An arbitrary light beam can be separated into two orthogonal linear polarized beams without loss of Intensity. The two linear polarization state are therefore called a **complete** set.
Similarly two counter rotating circular polarization states are a **complete** set.

The quantum state of photons in a beam of many photons can be determined by orienting an analyzer to have transmission 0. The quantum state of a single photon can however not be determined without running the risk of altering the quantum state.

Measurements influence the measured quantum state.

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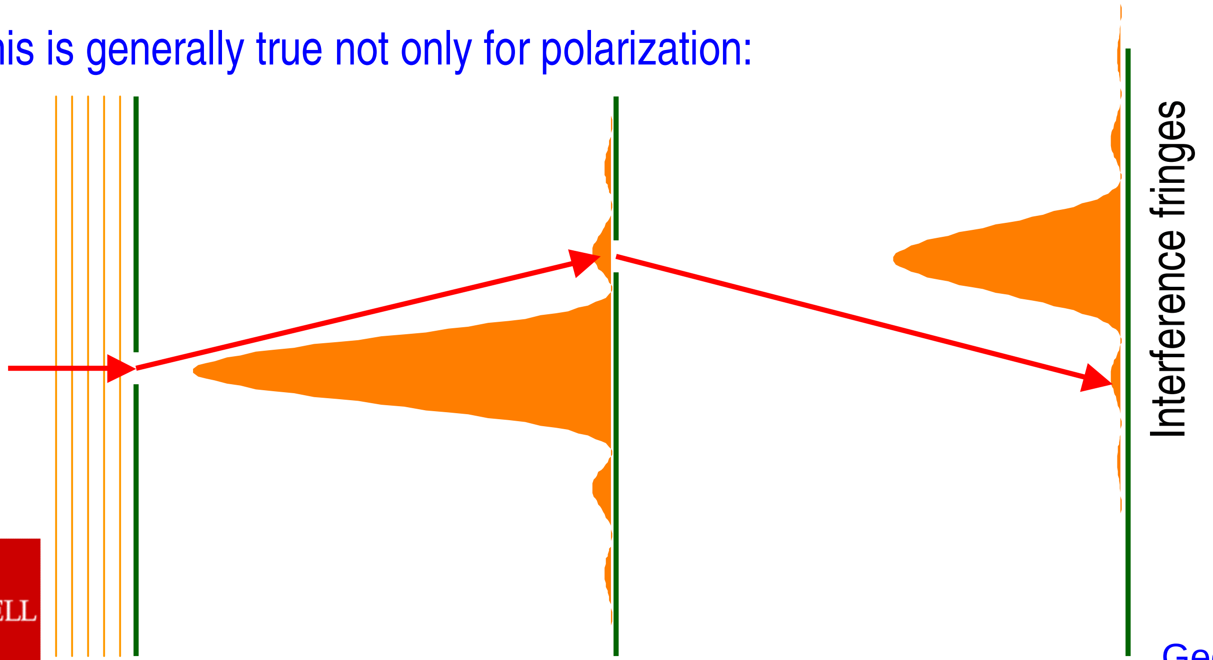
Statistical and classical properties of light

- One cannot associate a field vector to an individual photon.
- Wave properties of light can only be found when very large numbers of photons are investigated.

Particle wave duality:

Wave properties are an expression of the probabilistic or statistical behavior of large numbers of identically prepared quantum particles.

This is generally true not only for polarization:



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