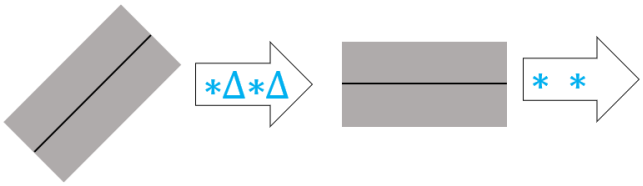
Lesson 4: Interpretative hypotheses

As we have seen, a single photon behaves in a probabilistic way (the probability law). In this lesson we want to understand why probabilities are used in quantum mechanics. In the following, we study two hypotheses in which we assume that the photons are distinguishable.

Hypothesis A: The statistical mixture theory

This hypothesis is analogues to a shuffled deck of French suited cards where we want to predict the colour of the top card, which can be red or black. As we do not know enough about the order of the cards, we do not know what the colour of the top card is. But we do know that there are an equal number of red and black cards, so the probability that the top card is red is 1/2.
In this hypothesis, we try to explain the reason of the probabilities behind the single photons – polariser interaction by assuming the same reason: each photon possesses a certain observable property, but we do not know of the properties of each photon.



Consider a specific example, when light with 45° polarisation is emitted onto a polariser with horizontal permitted direction. It is assumed that the photons cannot be in a superposition, when photons are emitted on a polariser with horizontal permitted direction, they are previously polarised in two ways, corresponding to certain transmission and absorption (just like the cards are red or black). But we do not know the polarisation of the individual photons: the fate of each photon is determined, but not knowing the properties of each photon forces us to use probability. With symbols, ◊◊◊◊ = *Δ*Δ must be hold.

Task 1. This hypothesis states that the reason of the probabilities in quantum mechanics are the lack of knowledge just like in cards. Try to refuse this hypothesis via a thought experiment!

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Hypothesis B: The co-existing properties hypothesis

This is an upgraded version of the previous one. Instead of one, two polarisation properties are assigned to the individual photons simultaneously: All photons possess the property of certain transmission through the polariser with 45° permitted direction and, in addition, half of the photons possesses the property of certain transmission through a polariser with horizontal permitted direction and the other half of them possess the property of certain absorption. Thus, a refutation as in the previous hypothesis cannot be applied, the property gives a result that is consistent with reality. Since we do not know which photon has which properties, this forces us to use probabilities.

Task 2. Try to refute this hypothesis via experiments consisting polarisers with horizontal and 45° permitted directions!

We see that probabilities from everyday life leads to a contradiction in QM, hence the **probabilistic** behaviour and the **indistinguishability** of photons are physical laws. The reason for the probabilities is the existence of **superposition** of photons.