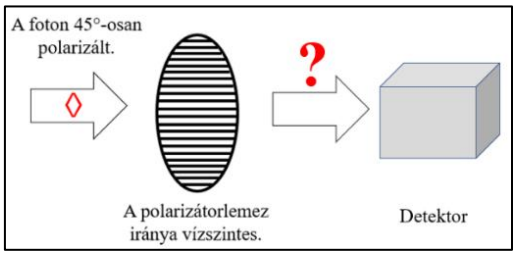
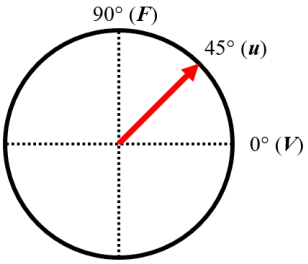
Lesson 5: The State Circle

Consider the following example: a single photon with 45° polarisation is emitted onto a polariser with horizontal permitted direction.



We know that a given observation can obtain mutually exclusive properties. In this case, this means that if we measure the photons that are initially polarised at 45° with a polariser with horizontal permitted direction, we either measure that a single photon is horizontally polarised (transmission) or that it is vertically polarised (absorption). The measurement therefore forces the photons into one of two mutually exclusive polarisation.

Unit vectors can be assigned to the polarisation directions. These vectors are called quantum states. The permitted states in a measurement are called **eigenstates**. It is useful to illustrate all states in a **state circle**, the example above is shown below. The red vector ***u*** indicates the state of the photon before the measurement, and the dashed lines show the permitted states after the measurement. It can be seen that the eigenstates are associated with mutually exclusive polarisation properties, and they are perpendicular to each other (orthogonal).



In the example above, the eigenstate ***H*** is associated to the transmission, and the eigenstate ***V*** to the absorption. The state ***u*** is a superposition state because it is not equal to any of the states that can be measured. This is “the” **superposition principle**. It can be seen that this superposition state (***u***) is equidistant from the two eigenstates, which illustrates that the possibility of transmission and absorption have equal probability (1/2). When a measurement is performed, this state of a single photon "collapses" into one of the eigenstates.

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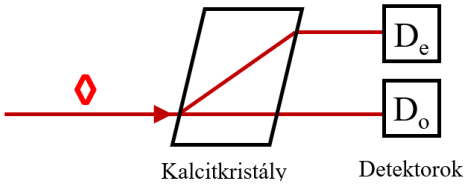
Task 1. A single photon with 30° polarisation are emitted onto a polariser with horizontal permitted direction, after which a detector is placed. Let sign the measurement with symbol "*A*".

a) Prepare the state circle for measurement *A*.

b) Which probability is larger, measuring the state corresponding to the transmission or absorption? How can we see this on the state circle?

As above, eigenvalues can be assigned to calcite crystal measurements.



Task 2. A single photon with 45° polarisation fall on a birefringent calcite crystal. The ordinary beam is polarised horizontally, and the extraordinary beam polarised vertically.

a) Prepare the state circle for measurement.

b) Which probability is larger, measuring the state corresponding to the transmission or absorption? How can we see this on the state circle?