Beam splitter with variable reflectivity

Coen de Graaf — Departament de Química Física i Inorgànica, URV

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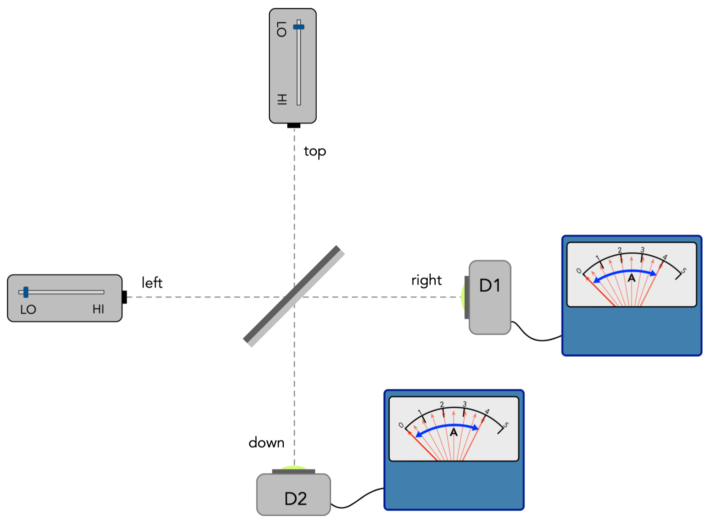
1. Convert the assigned transmission ratio (τ = %reflection/%transmission) of the beam splitter in probabilities for detecting the photon in D1 and D2 (p_{right} and p_{down}) when a photon is emitted from the left laser.



2. Write down the quantum state vector of the photon emitted by the left laser after passing through the beam splitter. Do the same for a photon emitted by the top laser.

3. Check that the probabilities for detecting the photon in D1 and D2 are indeed as expected from the transmission ratio.

4. Give the vector representation of the two quantum states after passing the beam splitter and check that they are orthogonal.

5. Make a rough graphical representation of the quantum states in the two-dimensional quantum vector space spanned by the basis vectors $|\text{right}\rangle$ and $|\text{down}\rangle$.

6. Derive the matrix that transforms the quantum states $|\text{left}\rangle$ and $|\text{top}\rangle$ into the quantum states that you found in item 2.

7. Generalize the particular expression of this beam splitter operator in terms of the transmission parameter τ