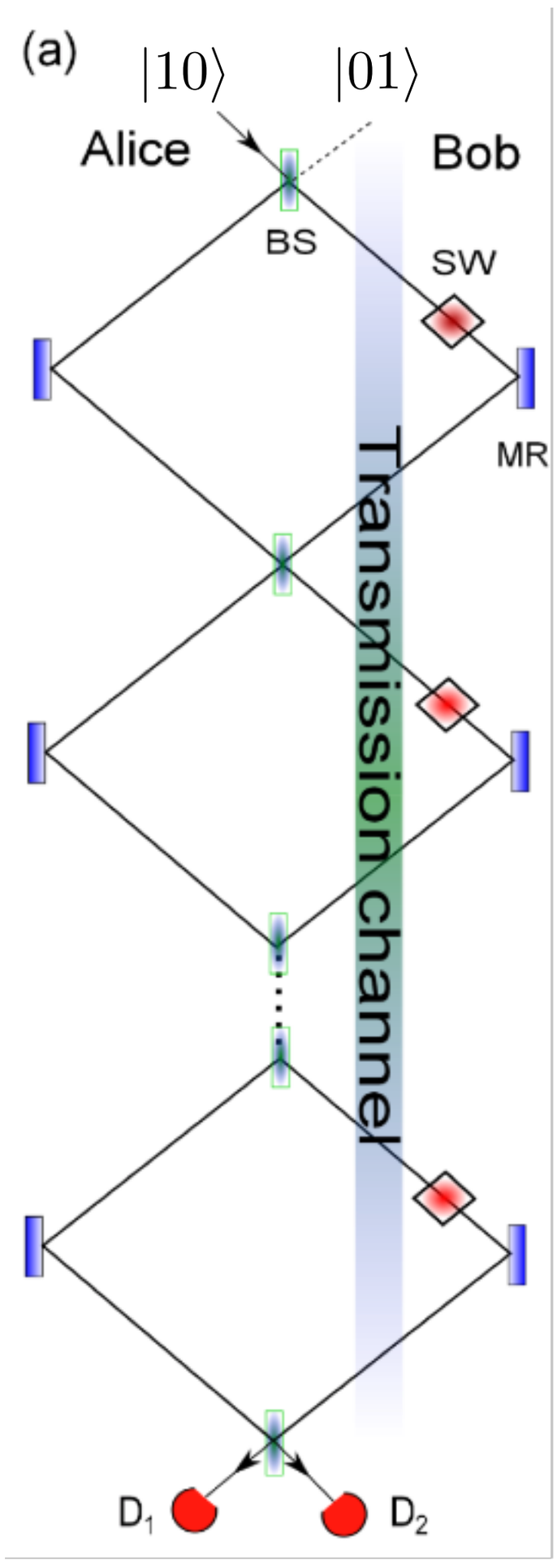
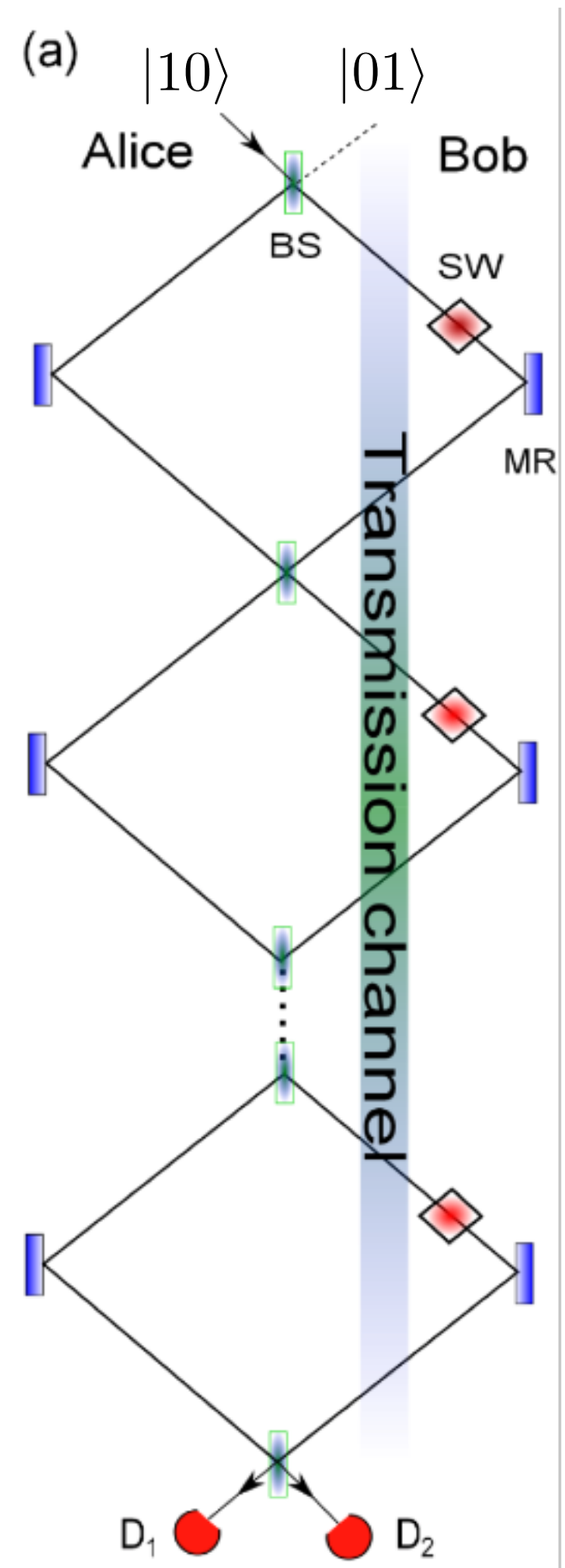


$$\hat{\mathrm{BS}} \doteq \begin{pmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{pmatrix}$$

$\{|10\rangle, |01\rangle\}$ basis

$\theta = \frac{\pi}{2N}$ (property of beam splitter)



$$\hat{\mathrm{BS}} \doteq \begin{pmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{pmatrix}$$

$\{|10\rangle, |01\rangle\}$ basis

$\theta = \frac{\pi}{2N}$ (property of beam splitter)

Bob permits photons:

$$\hat{\mathrm{BS}}^N |10\rangle = \begin{pmatrix} \cos(\pi/2) & \sin(\pi/2) \\ -\sin(\pi/2) & \cos(\pi/2) \end{pmatrix} |10\rangle$$

$$= |01\rangle \qquad \boxed{D_2}$$