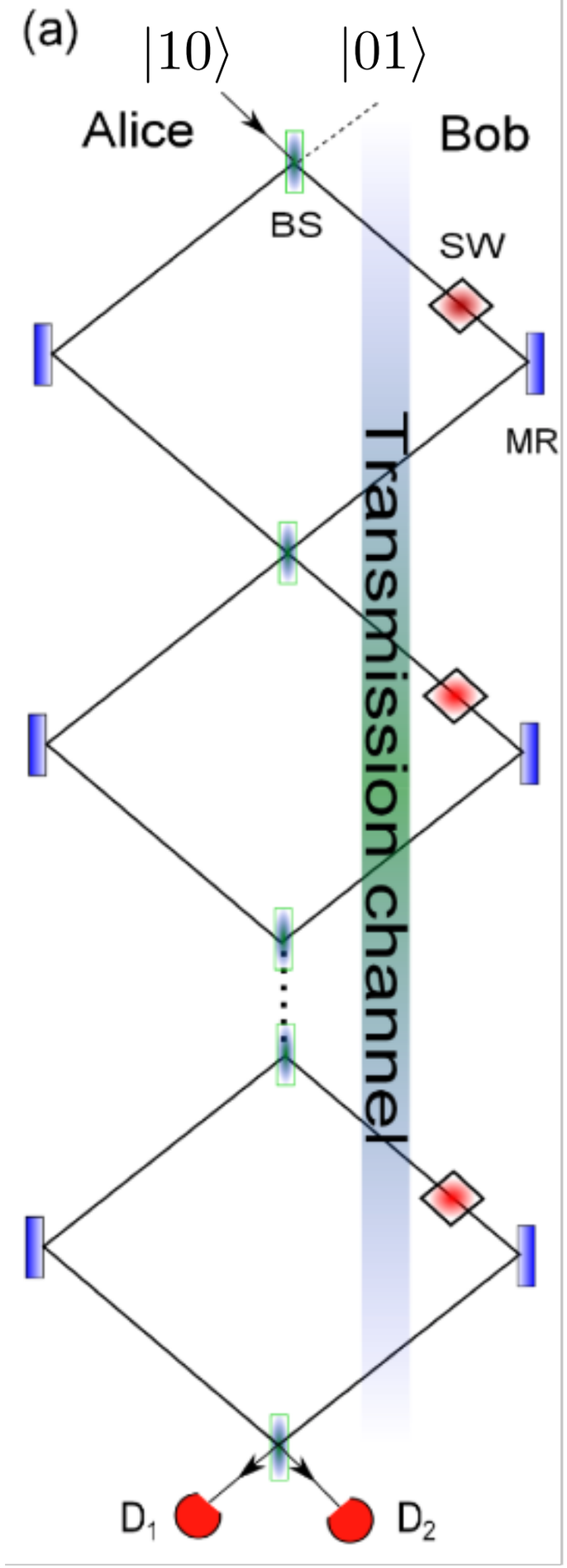


$$\hat{\mathrm{BS}} \doteq \begin{pmatrix} \cos(\theta) & \sin(\theta) \\ -\sin(\theta) & \cos(\theta) \end{pmatrix}$$

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

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

Bob permits photons:

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

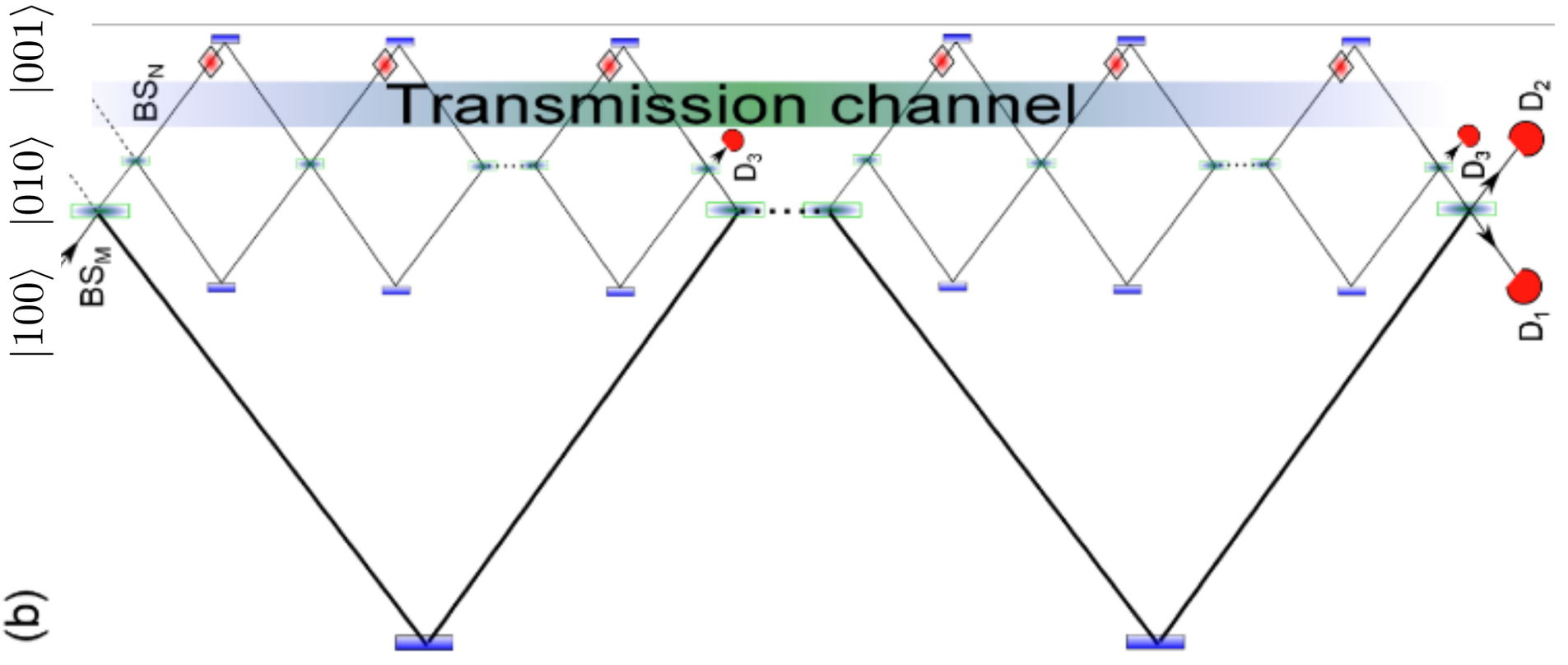
$$= |01\rangle \qquad \boxed{D_2}$$

Bob blocks photons:

$$|10\rangle \xrightarrow{\mathrm{BS}} \cos(\theta)\,|10\rangle + \sin(\theta)\,|01\rangle$$

$$\hat{\mathrm{BS}}_{|}^{N} |10\rangle = \cos^{N-1}(\theta)\,(\cos(\theta)\,|10\rangle + \sin(\theta)\,|01\rangle)$$

$$\approx |10\rangle \qquad \boxed{D_1}$$


(b)
|100⟩
|010⟩
|001⟩
BS_M
BS_N
Transmission channel
D_3
D_3
D_2
D_1