



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

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

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

Bob permits photons:

$$\begin{aligned} \hat{BS}^N |10\rangle &= \begin{pmatrix} \cos(\pi/2) & \sin(\pi/2) \\ -\sin(\pi/2) & \cos(\pi/2) \end{pmatrix} |10\rangle \\ &= |01\rangle \end{aligned} \quad \boxed{D_2}$$

Bob blocks photons:

$$\begin{aligned} |10\rangle &\xrightarrow{BS} \cos(\theta) |10\rangle + \sin(\theta) |01\rangle \\ \hat{BS}_1^N |10\rangle &= \cos^{N-1}(\theta) (\cos(\theta) |10\rangle + \sin(\theta) |01\rangle) \\ &\approx |10\rangle \end{aligned} \quad \boxed{D_1}$$