解答

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1.

$$\begin{aligned} \mathrm{BS1}|1\rangle &= \frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}\begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ &= \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ -1 \end{pmatrix} \\ &= \frac{1}{\sqrt{2}}(|0\rangle - |1\rangle) \end{aligned} \tag{1}$$

2.

$$\begin{aligned} \mathrm{BS2BS1}|1\rangle &= \frac{1}{\sqrt{2}}\begin{pmatrix} -1 & 1 \\ 1 & 1 \end{pmatrix}\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}\begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ &= \begin{pmatrix} -1 \\ 0 \end{pmatrix} \\ &= -|0\rangle \end{aligned} \tag{2}$$

光子は検出器 D0 で検出される。

3.

$$\begin{aligned} \mathrm{BS1}|1\rangle &= \frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}\begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ &= \frac{1}{\sqrt{2}}\begin{pmatrix} 1 \\ 1 \end{pmatrix} \\ &= \frac{1}{\sqrt{2}}(|0\rangle + |1\rangle) \end{aligned} \tag{3}$$

4.

$$\begin{aligned} \mathrm{BS2BS1}|1\rangle &= \frac{1}{\sqrt{2}}\begin{pmatrix} -1 & 1 \\ 1 & 1 \end{pmatrix}\frac{1}{\sqrt{2}}\begin{pmatrix} 1 & 1 \\ 1 & -1 \end{pmatrix}\begin{pmatrix} 1 \\ 0 \end{pmatrix} \\ &= \begin{pmatrix} 0 \\ 1 \end{pmatrix} \\ &= |1\rangle \end{aligned} \tag{4}$$

光子は検出器 D1 で検出される。