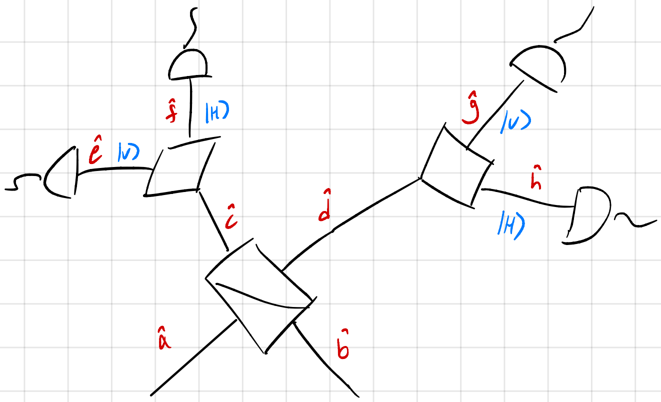


$$n_e = \hat{e}^\dagger \hat{e} = \frac{(a_v - b_v)^2}{2}$$

$$n_f = \hat{f}^\dagger \hat{f} = \frac{(a_H - b_H)^2}{2}$$

$$n_g = \hat{g}^\dagger \hat{g} = \frac{(a_v + b_v)^2}{2}$$

$$n_h = \hat{h}^\dagger \hat{h} = \frac{(a_H + b_H)^2}{2}$$

$$\hat{c} = \frac{1}{\sqrt{2}}(\hat{a} - \hat{b}) \qquad \hat{e} = |v\rangle\langle v|\, \hat{c} \qquad \hat{g} = |v\rangle\langle v|\, \hat{d}$$

$$\hat{d} = \frac{1}{\sqrt{2}}(\hat{a} - \hat{b}) \qquad \hat{f} = |H\rangle\langle H|\, \hat{c} \qquad \hat{h} = |H\rangle\langle H|\, \hat{d}$$

$$\hat{a} = a_H |H\rangle + a_v |v\rangle$$

$$\hat{b} = b_H |H\rangle + b_v |v\rangle$$

$$\hat{c} = \frac{1}{\sqrt{2}}\left[(a_H - b_H)|H\rangle + (a_v - b_v)|v\rangle \right]$$

$$\hat{d} = \frac{1}{\sqrt{2}}\left[(a_H + b_H)|H\rangle + (a_v + b_v)|v\rangle \right]$$

$$\hat{e} = \frac{a_v - b_v}{\sqrt{2}} |v\rangle \qquad \hat{g} = \frac{a_v + b_v}{\sqrt{2}} |v\rangle$$

$$\hat{f} = \frac{a_H - b_H}{\sqrt{2}} |H\rangle \qquad \hat{h} = \frac{a_H + b_H}{\sqrt{2}} |H\rangle$$

$$\hat{e}^\dagger \hat{e} = \langle v| \left(\frac{a_v - b_v}{\sqrt{2}}\right)\left(\frac{a_v - b_v}{\sqrt{2}}\right)|v\rangle = \frac{(a_v - b_v)^2}{2}$$

$$\hat{f}^\dagger \hat{f} = \langle H| \left(\frac{a_H - b_H}{\sqrt{2}}\right)\left(\frac{a_H - b_H}{\sqrt{2}}\right)|H\rangle = \frac{(a_H - b_H)^2}{2}$$

$$\hat{g}^\dagger \hat{g} = \langle v| \left(\frac{a_v + b_v}{\sqrt{2}}\right)\left(\frac{a_v + b_v}{\sqrt{2}}\right)|v\rangle = \frac{(a_v + b_v)^2}{2}$$

$$\hat{h}^\dagger \hat{h} = \langle H| \left(\frac{a_H + b_H}{\sqrt{2}}\right)\left(\frac{a_H + b_H}{\sqrt{2}}\right)|H\rangle = \frac{(a_H + b_H)^2}{2}$$

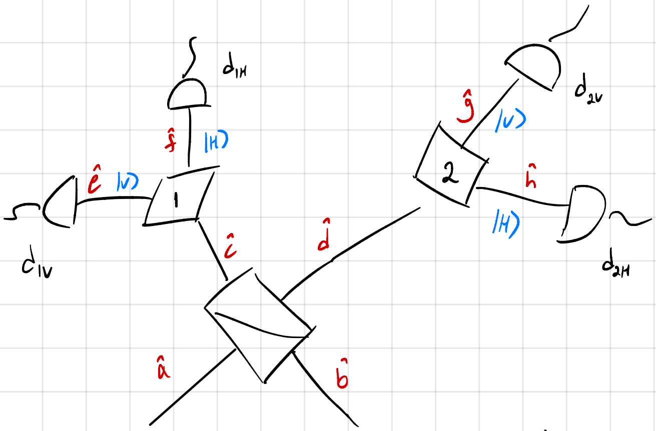
D_{1H}/D_{2V} or D_{1V}/D_{2H}

$$|\psi^-\rangle = \frac{1}{\sqrt{2}}\left(|01\rangle - |10\rangle\right)$$

D_{1H}/D_{1V} or D_{2H}/D_{2V}

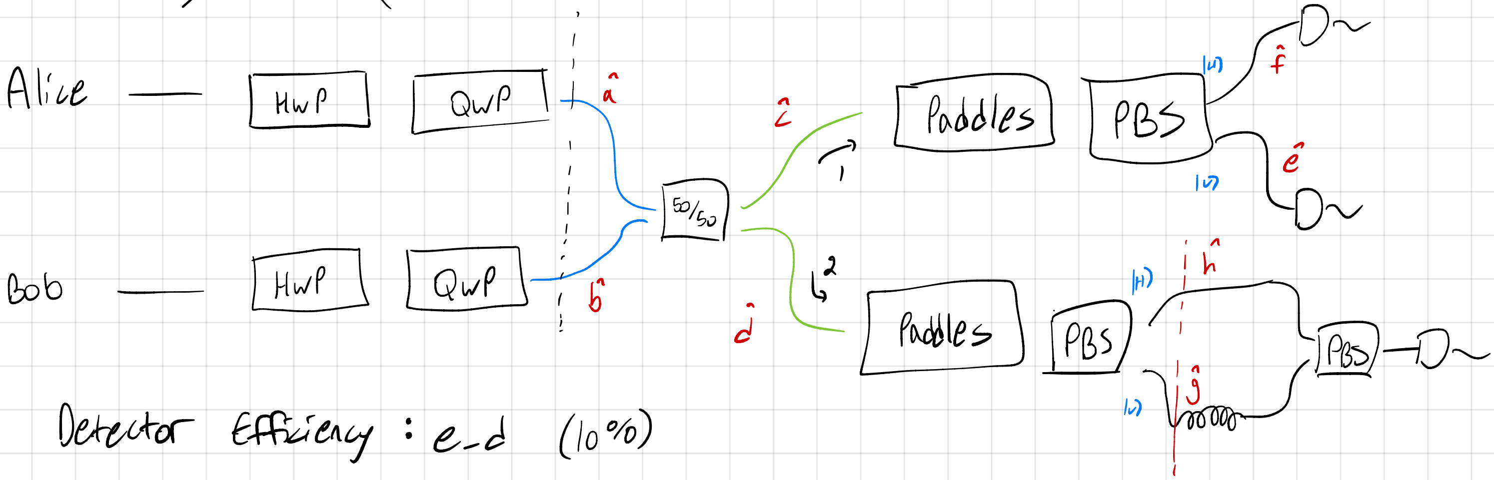
$$|\psi^+\rangle = \frac{1}{\sqrt{2}}\left(|01\rangle + |10\rangle\right)$$

Alice & Bob	$\lvert\psi^-\rangle$	$\lvert\psi^+\rangle$
Rectilinear	Bit flip	Bit flip
Diagonal	Bit flip	—



ToDo

- Privacy Amplification – 94% (only sacrifice 6% of bits)
- Error correction



Detector Efficiency : e_d (10%)

PBS 1 : e_p1

PBS 2 : e_p2

50/50 BS : e_b

HWP A : e_ha

QWP A : e_qa

HWP B : e_hb

QWP B : e_qb

Fiber → Free space → Fiber : e_f 90% transmission

$$|\psi_a\rangle = |H\rangle$$

$$|\psi_b\rangle = |H\rangle$$

$$\hat{a} = \left[(e\_f)(e\_ha)(e\_qa)\right]\left[a_h|H\rangle + a_v|V\rangle\right]$$

$$\hat{b} = \left[(e\_f)(e\_h_b)(e\_q_b)\right]\left[b_H|H\rangle + b_v|V\rangle\right]$$

$$\hat{c} = (e\_b)\left[\frac{\hat{a} - \hat{b}}{\sqrt{2}}\right]$$

$$\hat{d} = (e\_b)\left[\frac{\hat{a} + \hat{b}}{\sqrt{2}}\right]$$

$$\hat{f} = (e\_p1)\ \hat{c}_h$$

$$\hat{e} = (e\_p1)\ \hat{c}_v$$

$$\hat{h} = (e\_p2)\ \hat{d}_h$$

$$\hat{f} = (e\_p2)\ \hat{d}_v$$

$|\psi_a\rangle = |H\rangle$

$|\psi_b\rangle = |H\rangle$

$$\hat{a}' = \left[(e\_f)(e\_h a)(e\_g a)\right]\left[a_h|H\rangle + a_v|v\rangle\right]$$

$$\hat{b}' = \left[(e\_f)(e\_h_b)(e\_g_b)\right]\left[b_H|H\rangle + b_v|v\rangle\right]$$

$$\hat{c}' = (e\_b)\left[\frac{\hat{a}-\hat{b}}{\sqrt{2}}\right]$$

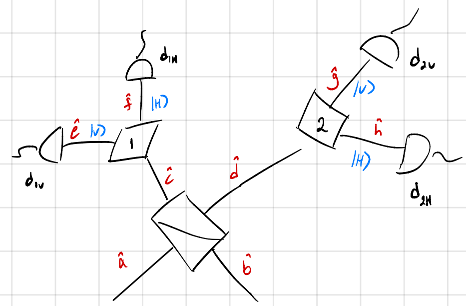
$$\hat{d}' = (e\_b)\left[\frac{\hat{a}+\hat{b}}{\sqrt{2}}\right]$$

$$\hat{f}' = (e\_p1)\,\hat{c}_h \qquad \hat{h}' = (e\_p2)\,\hat{d}_h$$

$$\hat{e}' = (e\_p1)\,\hat{c}_v \qquad \hat{f}' = (e\_p2)\,\hat{d}_v$$

$$\hat{a}' = \left[\overbrace{(e\_f)(e\_h a)(e\_g a)}^{a_e}\right]\hat{a}$$

$$\hat{b}' = \left[\underbrace{(e\_f)(e\_h_b)(e\_g b)}_{b_e}\right]\hat{b}$$



$$\hat{e} = \frac{a_v - b_v}{\sqrt{2}}|v\rangle \qquad \hat{g} = \frac{a_v + b_v}{\sqrt{2}}|v\rangle$$

$$\hat{f} = \frac{a_H - b_H}{\sqrt{2}}|H\rangle \qquad \hat{h} = \frac{a_H + b_H}{\sqrt{2}}|H\rangle$$

$$\hat{e}^+\hat{e} = \langle v|\left(\frac{a_v-b_v}{\sqrt{2}}\right)\left(\frac{a_v-b_v}{\sqrt{2}}\right)|v\rangle = \frac{(a_v-b_v)^2}{2}$$

$$\hat{f}^+\hat{f} = \langle H|\left(\frac{a_H-b_H}{\sqrt{2}}\right)\left(\frac{a_H-b_H}{\sqrt{2}}\right)|H\rangle = \frac{(a_H-b_H)^2}{2}$$

$$\hat{g}^+\hat{g} = \langle v|\left(\frac{a_v+b_v}{\sqrt{2}}\right)\left(\frac{a_v+b_v}{\sqrt{2}}\right)|v\rangle = \frac{(a_v+b_v)^2}{2}$$

$$\hat{h}^+\hat{h} = \langle H|\left(\frac{a_H+b_H}{\sqrt{2}}\right)\left(\frac{a_H+b_H}{\sqrt{2}}\right)|H\rangle = \frac{(a_H+b_H)^2}{2}$$

$$\hat{c} = \frac{(e\_b)}{\sqrt{2}}\left[(a_e a_h - b_e b_h)|H\rangle + (a_e a_v - b_e b_v)|v\rangle\right]$$

$$\hat{d} = \frac{(e\_b)}{\sqrt{2}}\left[(a_e a_h + b_e b_H)|H\rangle + (a_e a_v + b_e b_v)|v\rangle\right]$$

$$\hat{f} = \frac{\overbrace{(e\_b)(e\_p1)}^{e_f}}{\sqrt{2}}\left(\overbrace{a_e a_h}^{a_h'} - \overbrace{b_e b_h}^{b_h'}\right)|H\rangle$$

$$\hat{e} = \frac{(e\_b)(e\_p1)}{\sqrt{2}}\left(a_e a_v - b_e b_v\right)|v\rangle$$

$$\hat{h} = \frac{(e\_b)(e\_p2)}{\sqrt{2}}\left(a_e a_h + b_e b_h\right)|H\rangle$$

$$\hat{g} = \frac{(e\_b)(e\_p2)}{\sqrt{2}}\left(a_e a_v + b_e b_v\right)|v\rangle$$

$$N_f = \frac{(e\_f)^2(a_h' - b_h')^2}{2} \qquad d_{1v} = (e\_d)\,N_f$$

$$N_e = \frac{(e\_e)^2(a_v' - b_v')^2}{2} \qquad d_{1H} = (e\_d)\,N_e$$

$$N_h = \frac{(e\_h)^2(a_h' + b_h')^2}{2} \qquad d_{2v} = (e\_d)\,N_h$$

$$N_g = \frac{(e\_g)^2(a_v' + b_v')^2}{2} \qquad d_{2H} = (e\_d)\,N_g$$