2016 / 9 / 19 (월) (1).

$$PTH = (i\sigma_y \nu_x K)\big(\varepsilon_0(\vec{k})\sigma_0\tau_x\nu_0 + \varepsilon'(\vec{k})\sigma_0\tau_0\nu_0 + \varepsilon_{1d}(\vec{k})\sigma_z\tau_y\nu_0$$
$$+ t_c\tau_x\sigma_0\nu_x + t_c'\tau_y\sigma_z\nu_x\big)$$

$$= \varepsilon_0(\vec{k})\, i\sigma_y\nu_0\tau_x + \varepsilon'(\vec{k})\, i\sigma_y\nu_x\tau_0 + \varepsilon_{1d}(-\sigma_x)(-\tau_y)\nu_x$$
$$+ t_c\tau_x i\sigma_y + t_c'(-\tau_y)(-\sigma_x)$$

$$HPT = \big(\varepsilon_0(\vec{k})\sigma_0\tau_x\nu_0 + \varepsilon'(\vec{k})\sigma_0\tau_0\nu_0 + \varepsilon_{1d}(\vec{k})\sigma_z\tau_y\nu_0$$
$$+ t_c\tau_x\sigma_0\nu_x + t_c'\tau_y\sigma_z\nu_x\big)(i\sigma_y\nu_x K)$$

$$= \big(\varepsilon_0(\vec{k})\, i\sigma_y\tau_x\nu_x + \varepsilon'(\vec{k})\, i\sigma_y\tau_0\nu_x + \varepsilon_{1d}(\vec{k})\sigma_x\tau_y\nu_x$$
$$+ t_c\tau_x i\sigma_y + t_c'\tau_y\sigma_x\big)$$

$[H, PT] = 0.$

$$G_x H = (i\sigma_x)\big(\varepsilon_0(\vec{k})\sigma_0\tau_x\nu_0 + \varepsilon'(\vec{k})\sigma_0\tau_0\nu_0 + \varepsilon_{1d}(\vec{k})\sigma_z\tau_y\nu_0$$
$$+ t_c\tau_x\sigma_0\nu_x + t_c'\tau_y\sigma_z\nu_x\big)$$

$$HG_x = \big(\varepsilon_0(\vec{k})\sigma_0\tau_x\nu_0 + \varepsilon'(\vec{k})\sigma_0\tau_0\nu_0 + \varepsilon_{1d}(\vec{k})\sigma_z\tau_y\nu_0$$
$$+ t_c\tau_x\sigma_0\nu_x + t_c'\tau_y\sigma_z\nu_x\big)(i\sigma_x)$$

2016/9/19 (월) (1).

$$|J_z=\tfrac{1}{2}\rangle = \frac{1}{\sqrt{3}}\left(|d_{yz}\downarrow\rangle + i|d_{zx}\downarrow\rangle + |d_{xy}\uparrow\rangle \right)$$

$$PT|J_z=\tfrac{1}{2}\rangle = \frac{1}{\sqrt{3}}\left(PT|d_{yz}\downarrow, A\rangle - iPT|d_{zx}\downarrow A\rangle + PT|d_{xy}\uparrow, A\rangle \right)$$

$$= \frac{1}{\sqrt{3}}\Big(|d_{yz}\uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-i\,|d_{zx}\uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-|d_{xy}\downarrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^* \Big)$$

$P:\ (x,y,t) \longrightarrow (-x+\tfrac{1}{2}, -y+\tfrac{1}{2}, t) \times \nu_x\tau_x$

$T:\ (x,y,t) \longrightarrow (x,y,-t) \times i\sigma_y K$

$G_x:\ (x,y,t) \longrightarrow (-x+\tfrac{1}{2}, +y+\tfrac{1}{2}, t) \times i\sigma_x \tau_x$

$G_y:\ (x,y,t) \longrightarrow (x+\tfrac{1}{2}, -y+\tfrac{1}{2}, t) \times i\sigma_y\tau_x$

$S_x = G_yP:\ (x,y,t) \xrightarrow{P} (-x+\tfrac{1}{2}, -y+\tfrac{1}{2}, t) \times \nu_x\tau_x \xrightarrow{G_y} (-x+1, y, t) \times i\sigma_y\nu_x$

$M_z:\ (x,y,t) \longrightarrow (x+\tfrac{1}{2}, y+\tfrac{1}{2}, t) \times i\sigma_z\nu_x\tau_x$

$PT:\ (x,y,t) \longrightarrow (-x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t) \times i\sigma_y\nu_x\tau_x K.$

2016/9/19 (월) (2).

$$G_x PT \left| J_z = \tfrac{1}{2} \right\rangle = \frac{1}{\sqrt{3}} \Big(G_x \left| d_{yz} \uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t \right\rangle^*$$

$$-i G_x \left| d_{zx} \uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t \right\rangle^*$$

$$- G_x \left| d_{xy} \downarrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t \right\rangle^* \Big)$$

$$= \frac{1}{\sqrt{3}} \Big(+i \left| d_{yz} \uparrow, A, \nu=2, x, -y+1, -t \right\rangle^*$$

$$- \left| d_{zx} \uparrow, A, \nu=2, x, -y+1, -t \right\rangle^*$$

$$+ i \left| d_{xy} \downarrow, A, \nu=2, x, -y+1, -t \right\rangle^* \Big)$$

$$G_x \left| J_z = \tfrac{1}{2} \right\rangle = \frac{1}{\sqrt{3}} \Big(G_x \left| d_{yz} \downarrow \right\rangle + i G_x \left| d_{zx} \downarrow \right\rangle + G_x \left| d_{xy} \uparrow \right\rangle \Big)$$

$$= \frac{1}{\sqrt{3}} \Big(i \left| d_{yz} \downarrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle$$

$$+ \left| d_{zx} \downarrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle$$

$$-i \left| d_{xy} \uparrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle \Big)$$

$$PT G_x \left| J_z = \tfrac{1}{2} \right\rangle = \frac{1}{\sqrt{3}} \Big(-i\, PT \left| d_{yz} \downarrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle$$

$$+ PT \left| d_{zx} \downarrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle$$

$$+ i\, PT \left| d_{xy} \uparrow, B, \nu=1, -x+\tfrac{1}{2}, y+\tfrac{1}{2}, t \right\rangle \Big)$$

$$= \frac{1}{\sqrt{3}} \Big(-i \left| d_{yz} \uparrow, A, \nu=2, x, -y, -t \right\rangle^*$$

$$+ \left| d_{zx} \uparrow, A, \nu=2, x, -y, -t \right\rangle^*$$

$$-i \left| d_{xy} \downarrow, A, \nu=2, x, -y, -t \right\rangle^* \Big)$$

$$G_x PT \left| J_z = \tfrac{1}{2} \right\rangle = -e^{ik_y} PT G_x \left| J_z = \tfrac{1}{2} \right\rangle$$

$$S_x PT\,|J_z=\tfrac{1}{2}\rangle = \frac{1}{\sqrt{3}}\Big(S_x\,|d_{yz}\uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-i\,S_x\,|d_{zx}\uparrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-S_x\,|d_{xy}\downarrow, B, \nu=2, -x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*\Big)$$

$$=\frac{1}{\sqrt{3}}\Big(-|d_{yz}\downarrow, B, \nu=1, x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-i\,|d_{zx}\downarrow, B, \nu=1, x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$+|d_{xy}\uparrow, B, \nu=1, x+\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*\Big)$$

$$S_x\,|J_z=\tfrac{1}{2}\rangle = \frac{1}{\sqrt{3}}\Big(|d_{yz}\uparrow, A, \nu=2, -x+1, y, t\rangle$$

$$+i\,|d_{zx}, \uparrow, A, \nu=2, -x+1, y, t\rangle$$

$$+|d_{xy}, \downarrow, A, \nu=2, -x+1, y, t\rangle\Big)$$

$$PTS_x\,|J_x=\tfrac{1}{2}\rangle = \frac{1}{\sqrt{3}}\Big(PT\,|d_{yz}\uparrow, A, \nu=2, -x+1, y, t\rangle$$

$$+i\,PT\,|d_{zx}, \uparrow, A, \nu=2, -x+1, y, t\rangle$$

$$+PT\,|d_{xy}, \downarrow, A, \nu=2, -x+1, y, t\rangle\Big)$$

$$=\frac{1}{\sqrt{3}}\Big(-|d_{yz}, \downarrow, B, \nu=1, x-\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$-i\,|d_{zx}, \downarrow, B, \nu=1, x-\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*$$

$$+|d_{xy}\uparrow, B, \nu=1, x-\tfrac{1}{2}, -y+\tfrac{1}{2}, -t\rangle^*\Big)$$

$$S_x PT\,|J_z=\tfrac{1}{2}\rangle = e^{-ik_x}\,PTS_x\,|J_z=\tfrac{1}{2}\rangle$$

At $k_x=\pi$ $\quad S_x PT = -PTS_x$