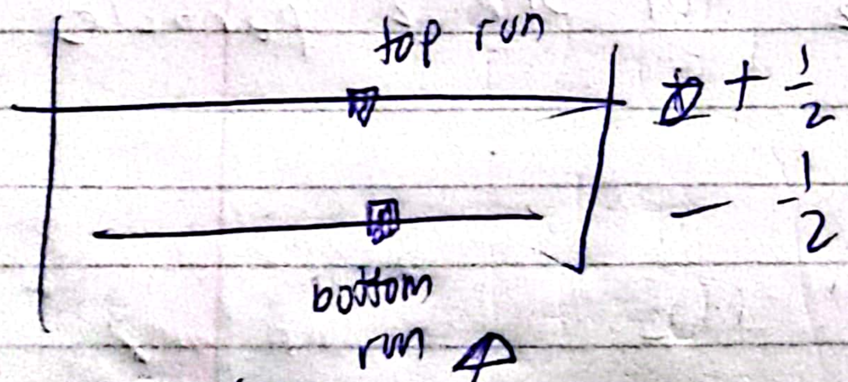
$$L_\pm = L_x \pm i L_y$$

$$S_\pm = S_x \pm i S_y$$

ladder operations since they have list of rise & fall values



only (+) or (−) values with no continuous list of values

no values higher than maximum value and so it is 0.

$$S_+ \chi_+ = 0$$

$$S_- \chi_- = 0$$

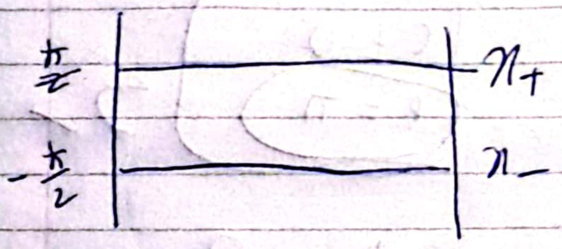
no values higher than minimum value so 0.

$$S_\pm |s\ m\rangle = \hbar\sqrt{s(s+1)-m(m\pm 1)}\;|s\ m\pm 1\rangle$$

Matrix representation in terms of $S_{\pm}$: S_x, S_y

$L_{\pm} = L_x \pm i L_y$

$S_{\pm} = S_x \pm i S_y$



$S_+ \chi_+ = 0$ [top run]

$S_- \chi_- = 0$ [bottom run]

$$S_{\pm} |s m\rangle = \hbar \sqrt{s(s+1) - m(m \pm 1)}\, |s \; m \pm 1\rangle$$

Why m is orientation of spin which is devied in two quantum value [+] & [-]

REBECCA

$$S_+ \chi_- = \hbar \sqrt{\underbrace{\left(\tfrac{1}{2}\left(\tfrac{1}{2}+1\right)\right)}_{\text{positive spin value}} - \underbrace{\left(-\tfrac{1}{2}\right)\left(-\tfrac{1}{2}+1\right)}_{\text{negative m value due to } \chi_- \text{ value}}}\; \underbrace{\left|\tfrac{1}{2} \quad -\tfrac{1}{2}+1\right\rangle}$$

positive spin

negative χ_- so negative m

$$= \hbar \sqrt{\frac{3}{4} + \frac{1}{4}}\, \left|\frac{1}{2} \quad \frac{1}{2}\right\rangle$$

$$= \hbar \left|\frac{1}{2} \quad \frac{1}{2}\right\rangle$$

$$\hbar \chi_+$$

$$S_+ \chi_- = \hbar \chi_+$$

Summary

$$S_+ \chi_+ = 0$$
$$S_+ \chi_- = \hbar \chi_+$$
$$S_- \chi_+ = \hbar \chi_-$$
$$S_- \chi_- = 0$$

$$\begin{pmatrix} c & d \\ e & f \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix} = 0$$

$$\begin{pmatrix} c \\ e \end{pmatrix} = 0$$

$$c = 0$$
$$e = 0$$

$$S_+ \chi_- = h \chi_+$$

$$\begin{pmatrix} c & d \\ e & f \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = h \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} d \\ f \end{pmatrix} = \begin{pmatrix} \hbar \\ 0 \end{pmatrix}$$

$$\boxed{\begin{matrix} d = \hbar \\ f = 0 \end{matrix}}$$

$$\begin{pmatrix} c & d \\ e & f \end{pmatrix} \begin{pmatrix} 1 \\ 0 \end{pmatrix}$$

$$\begin{pmatrix} c \\ e \end{pmatrix} = \hbar \begin{pmatrix} 0 \\ 1 \end{pmatrix}$$

$$\boxed{\begin{matrix} c = 0 \\ e = \hbar \end{matrix}} \quad S_-$$

$$S_- \chi_- = 0$$

$$\begin{pmatrix} c & d \\ e & f \end{pmatrix} \begin{pmatrix} 0 \\ 1 \end{pmatrix} = \hbar \begin{pmatrix} 0 \\ 0 \end{pmatrix}$$

$$\boxed{\begin{matrix} \begin{matrix} d \\ f \end{matrix} = \begin{matrix} 0 \\ 0 \end{matrix} \\ d = 0 \\ f = 0 \end{matrix}}$$

$$\begin{matrix} c=0 & f=0 \\ e=0 & d=\hbar \end{matrix}$$ matrix values

ket position values $$\begin{matrix} c=0 & f=0 \\ e=0 & d=1 \end{matrix}$$

$$S_+ = \begin{pmatrix} c & d \\ e & f \end{pmatrix} \begin{pmatrix} 0 & \hbar \\ 0 & 0 \end{pmatrix} = \hbar \begin{pmatrix} 0 & 1 \\ 0 & 0 \end{pmatrix}$$

$$S_+ = S_x \cancel{\pm} i S_y \qquad S_x = \frac{1}{2}(S_+ + S_-)$$

$$S_- = S_x - i S_y \qquad S_y = \frac{1}{2i}(S_+ - S_-)$$

$$S_x = \frac{1}{2}\left[\begin{pmatrix} 0 & \hbar \\ 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ \hbar & 0 \end{pmatrix}\right]$$

$$S_x = \frac{1}{2}\begin{pmatrix} 0 & \hbar \\ \hbar & 0 \end{pmatrix} \Rightarrow S_x = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

$$\frac{1}{2}\left[\begin{pmatrix} 0 & \hbar \\ 0 & 0 \end{pmatrix} + \begin{pmatrix} 0 & 0 \\ \hbar & 0 \end{pmatrix}\right]$$

$$\frac{1}{2}\begin{bmatrix} 0 & \hbar \\ \hbar & 0 \end{bmatrix} = \frac{\hbar}{2}\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$$

$$\boxed{S_y = \frac{\hbar}{2}\begin{pmatrix} 0 & -2 \\ 2 & 0 \end{pmatrix}} \quad \boxed{S_z = \frac{\hbar}{2}\begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix}}$$

same process