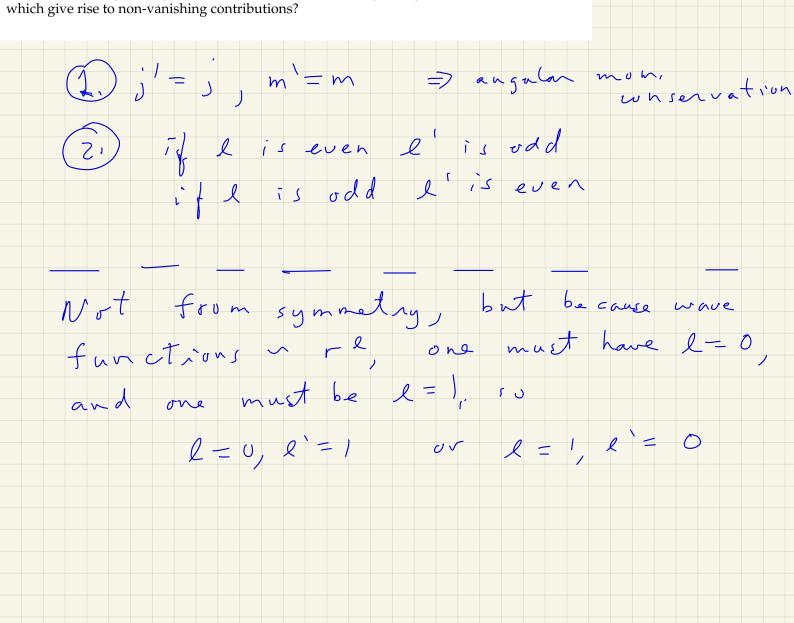


$$V = \lambda \left[\delta^3(\mathbf{x}) \mathbf{S} \cdot \mathbf{p} + \mathbf{S} \cdot \mathbf{p} \delta^3(\mathbf{x}) \right]$$

where S and p are the spin and momentum operators of the electron, and the nucleus is assumed to be situated at the origin. As a result, the ground state of an alkali atom, usually characterized by $|n,\ell,j,m\rangle$ actually con6ains tiny contributions from other eigenstates as follows

$$|n,\ell,j,m
angle
ightarrow |n,\ell,j,m
angle + \sum_{n',\ell',j',m'} C_{n',\ell',j',m'} |n',\ell',j',m'
angle$$

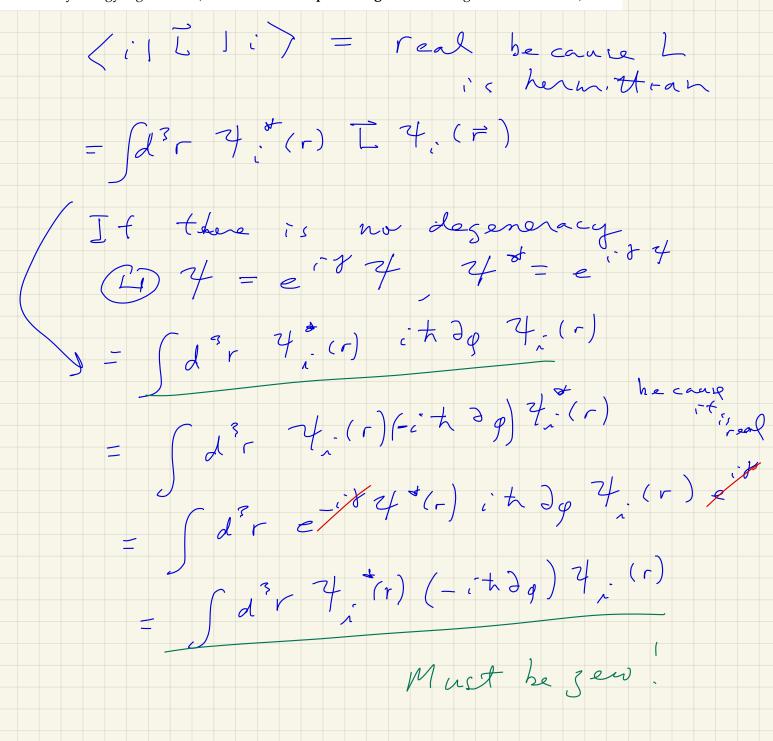
On the basis of symmetry considerations *alone*, what can you say about (n', ℓ', j', m') which give rise to non-vanishing contributions?



3. Suppose a spinless particle is bound to a fixed center by a potential V(x) so asymmetrical that no two energy levels are degenerate. Using time-reversal invariance prove

$$\langle L \rangle = 0.$$

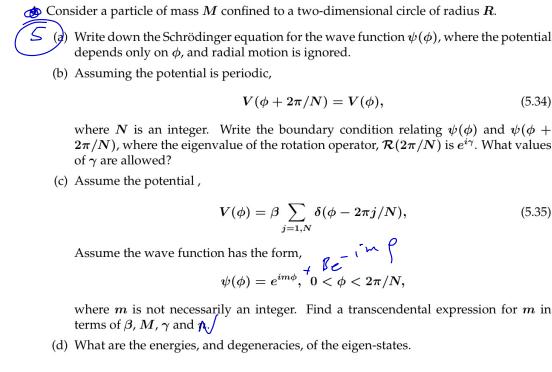
for any energy eigenstate. (This is known as quenching of orbital angular momentum.)

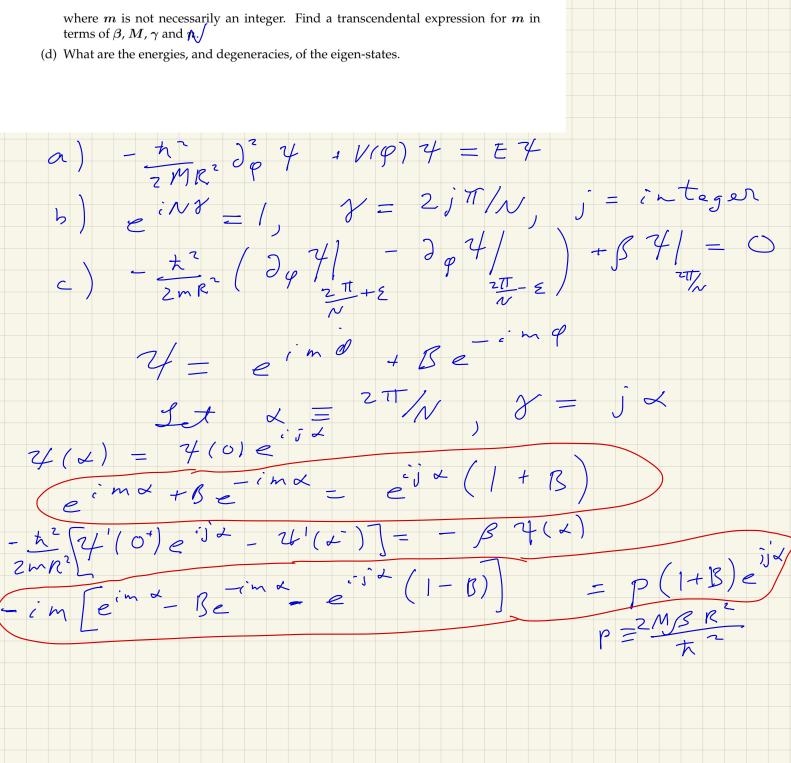


4. Consider the time-reversal operator for spin-1/2 particles, $\Theta = \sigma_y K$, where K takes the complex conjugate of all quantities to its right. Show that Θ commutes with the rotation operator,

 $\mathcal{R}(ec{ heta}) = \cos(heta) + i ec{\sigma} \cdot \hat{ heta} \sin(heta).$

$$\begin{bmatrix}
\Theta, i6x \\
 \end{bmatrix} = \begin{cases}
G_3 & K & (i6x) - (i6x) & G_3 & K \\
 \end{bmatrix} & K & (i6x) - (i6x) & G_3 & K \\
 \end{bmatrix} & K & (i6x) - (i6x) & G_3 & K \\
 \end{bmatrix} & K & (i6x) - (i6x) & G_3 & K \\
 \end{bmatrix} & K & G_3 & K & G_3 & K & G_3 & K \\
 \end{bmatrix} & G_3 & K & G_3 & K & G_3 & K & G_3 & G_3$$





(5.34)

(5.35)

(eim x + Be-im x = eij x (1+B) $2mn^{2}$ $\frac{1}{2}$ $\frac{1}$ [-im[eim x-Be-im x-e-jx (1-B)] = e (jx p (1+B)) = einx - eijx eijx - einx IB = Reijx + ie imx ieijx $\frac{i(m-j)}{2} = \frac{-im}{m} = \frac$ $\frac{e}{\left(\frac{e}{m}+i\right)} = \frac{e^{-i(m+j)} x}{\left(\frac{e}{m}+i\right)} + i = \frac{e^{-i(m+j)} x}{\left(\frac{e}{m}+i\right)}$ $i+\left(-\frac{P}{m}-i\right)e^{i(m-j)d}+ie^{-2ijd}-ie^{i(m+j)d}$ $= -i + i = i \left(m+j \right) \times -i = -\left(m-i \right) = -\left(m+j \right) \times$ $2i-2ie^{i(m-j)}$ $+2ie^{-2ij}$ $-2ie^{-(m+j)}$

$$B = e^{i7a} - e^{ika}$$

$$e^{ika} - e^{-i7a}$$

$$e^{ika} - e^{-i7a}$$

$$= e^{i7a} - e^{ika} + e^{i6a}$$

$$- e^{i6a} + e^{i6a}$$

$$- e^{i6a}$$