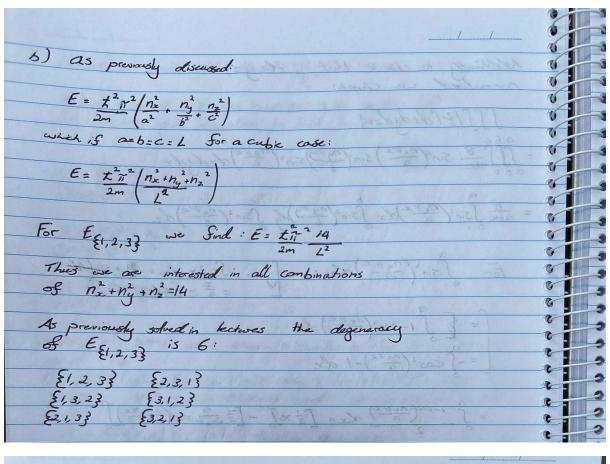
PHYS2941 Problem set 5

By Samuel Allpass s4803050

	6
	0
<i>C</i> :	0
Given we understand that -2mt must	
remain constant, so too must the seem on the lost	
For Schrödingers equation to hold true i.e:	
The state of the s	
and the state of t	
$\frac{i}{f(x)}\frac{\partial^2 f(x)}{\partial x^2} = k_{\infty}^2$	
5(x) 2x2 0 3 4 0 30 100 30 0 3 = (2 p x)	6-11
0(x) 2 2 10 10 10 10 10 00 00 00 00 00 00 00 00	
1 12/11 : 3	
1 033 = ky	
$\frac{1}{9(9)}\frac{\partial^2 g(9)}{\partial y^2} = ky^2$	
$\frac{1}{2} \partial h(z) = h_2$	
the state of the s	-
Where k terms were chase & sinker to the 7-D box	
(ase	1
To similar fostion for the 1-D case for k= 100	
	The
	113
4 = Asin(kx) and thus in over case!	3
	1
$f(x) = 4 \sin(k_x x)^{\frac{1}{2}} g(y) = \sin(k_y y) \sqrt{\frac{2}{b}}$ $k(z) = \sin(k_z z) \sqrt{\frac{2}{b}}$	3
6(2) = 50 (b-2) 12	3
(1) Sin (12 4) 50	3
And thus:	3
And thus: \Jabo	
$P(x,y,z) = 4 \sin(k_x x) \sin(k_y y) \sin(k_z z)$	5
which are the 1-D case k= ar	
When as in the	
which as in the 1-D case $k = \frac{\pi n}{a}$; $\overline{F}(x,y,z) = \frac{1}{a} \sin\left(\frac{\pi n_x}{a}\right) \sin\left(\frac{\pi n_y}{b}\right) \sin\left(\frac{\pi n_z}{c}\right)$	13
1(4),2) 125111 (4)	
Simbole just as for In Fax (1)22	0
Similarly, just as for 1-D $E = \frac{\pi}{2m} (\frac{\pi}{a})^2 n^2$ the total E will be the sum of each dimensions	0
The lord L will be the Jum at each dimensions	-
E- +2/11/2 +2/12/2 +2/12/2 2 12 1/12 12 12	
E= t () n2 + t () -2 + t () n2 = t 1 / 12 + t () n2 = t 1 / 12 + t () n2 = t 1 / 12 + t () n2	-
2m(0) 2m(0) 2m (0)	-0
	-

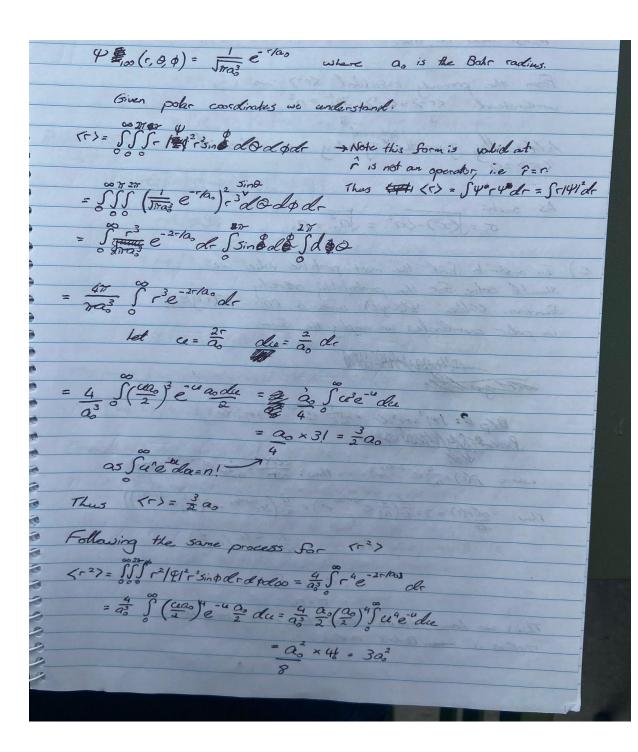
Additionally to check that I(x,y,z) is normalised we check: SSSIFI dedydz=1 = SSS abc Sin2 (nxiix) sin2 (nxiix) sin2 (nziiz) dzdydx = abc Ssin2 (merx) dx Ssin2 (ny ry) dy Ssin2 (nz rz) dz For $\int_{0}^{a} \sin^{2}\left(\frac{n_{x}\pi x}{a}\right) dx$ = $\int_{0}^{a} \frac{1-\cos(2nx\pi x)}{a} dx = \left[\frac{1}{2}x\right]_{0}^{a} - \left[\frac{1}{2}\frac{a}{2n_{x}\pi}\sin(\frac{2n_{x}\pi x}{a})\right]_{0}^{a}$ = 2 + a Sin (2nx 11) Thus the solution Follows: = \frac{8}{2} \left(\frac{a}{2} + \frac{a}{4n_2\tau} \Sin(2n_2\tau)\right)\left(\frac{b}{2} + \frac{b}{4n_2\tau} \Sin(2n_2\tau)\right)\left(\frac{c}{2} + \frac{c}{4n_2\tau} \Sin(2n_2\tau)\right) However, as n for x, y and z must follow the 1-D solutions n= 1,2,3,... we find sin (2nir) = 0 always = $\frac{8}{abc} \left(\frac{a}{2}\right) \left(\frac{b}{2}\right) = 1$ Thus $\Re(x, y, z)$ is

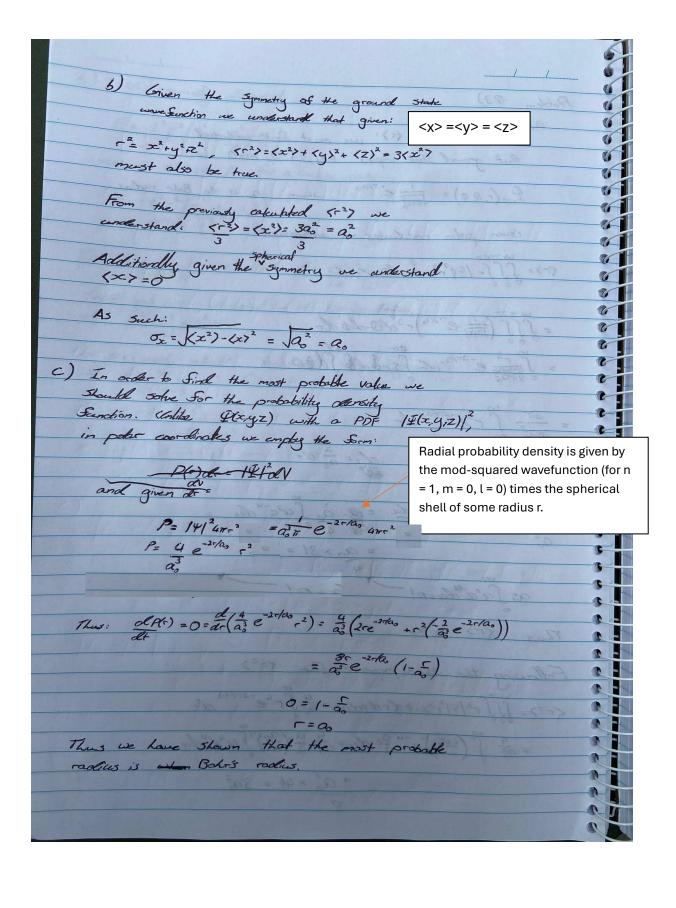


Problem	9.3)	Shore	b) love the source of the wound	
a)			long him them been so workship	
	First to	Sind	(+) we must first earlesstand	
+	that grow,	nd Stake	(+)' we must first understand in place $n=1$, (=0, $m=0$ i.e.	

First to first the ground state of high-organis electron

we understand Y_{100} $Y_{mlm} = R_{nl}(f) Y_{l}^{m}(\theta, \phi)$ $= i \left(\frac{r}{na_{0}}\right)^{l+1} e^{-f_{l}na_{0}} \sqrt{\frac{r}{na_{0}}} \cdot \sqrt{\frac{2y_{1}}{na_{0}}} \frac{(l-m)!}{(l-m)!} e^{imd} P_{l}^{m} \cosh \theta$ $= i \left(\frac{r}{na_{0}}\right)^{l+1} e^{-f_{l}na_{0}} \sqrt{\frac{r}{na_{0}}} \cdot \sqrt{\frac{2y_{1}}{na_{0}}} \frac{(l-m)!}{(l-m)!} e^{imd} P_{l}^{m} \cosh \theta$ $= i \left(\frac{r}{na_{0}}\right)^{l} e^{-f_{l}na_{0}} \sqrt{\frac{r}{na_{0}}} \cdot \sqrt{\frac{$





Problem 10.2) $\begin{bmatrix} \hat{L}_{x}, \hat{L}_{y} \end{bmatrix} = (y\hat{p}_{2} - z\hat{p}_{y})(z\hat{p}_{x} - x\hat{p}_{z}) - (z\hat{p}_{x} - x\hat{p}_{z})(y\hat{p}_{z} - z\hat{p}_{y})$ $= y\hat{p}_{z}^{2}z\hat{p}_{z}^{2} - y\hat{p}_{z}^{2}x\hat{p}_{z}^{2} - z\hat{p}_{z}^{2}\hat{p}_{z}^{2} + z\hat{p}_{z}^{2}\hat{p}_{z}^{2}$ $= z\hat{p}_{x}y\hat{p}_{z}^{2} + z\hat{p}_{x}z\hat{p}_{z}^{2} + x\hat{p}_{z}y\hat{p}_{z}^{2} - x\hat{p}_{z}z\hat{p}_{y}^{2}$ $= [y\hat{p}_{z}, z\hat{p}_{z}^{2}] - [y\hat{p}_{z}, x\hat{p}_{z}^{2}] - [z\hat{p}_{y}, z\hat{p}_{x}] + [z\hat{p}_{y}, x\hat{p}_{z}]$ $\Rightarrow \hat{P}_{z} \hat{p}_{y} \hat{p}_{z}^{2} + z\hat{p}_{z}^{2}\hat{p}_{z}^{2} + z\hat{p}_{z}^{2}\hat{p}_{z}^{2} + z\hat{p}_{z}^{2}\hat{p}_{z}^{2}$ $= [y\hat{p}_{z}, z\hat{p}_{z}^{2}] - [y\hat{p}_{z}, x\hat{p}_{z}^{2}] - [z\hat{p}_{y}, z\hat{p}_{z}^{2}] + [z\hat{p}_{y}, x\hat{p}_{z}^{2}]$

$$= g\hat{p}_{x}(\hat{P}_{z},z) - gx[\hat{R}_{z},\hat{P}_{z}] - \hat{g}\hat{R}_{z}(z,z) + x\hat{p}_{y}[z,\hat{P}_{z}]$$

$$= g\hat{R}_{x}(-i\hbar) *-0 - 0 + x\hat{R}_{y}(i\hbar)$$

$$= i\hbar(x\hat{P}_{y} - g\hat{P}_{z}) = i\hbar L_{z}$$
This exact some process is used to show:
$$[\hat{L}_{y},\hat{L}_{z}] = i\hbar\hat{L}_{x} \quad \text{and} \quad [\hat{L}_{z},\hat{L}_{x}] = i\hbar\hat{L}_{y}$$

[Ly, Lz] = [z\hat{p}_2-scp_2, scp-y\hat{p}_2] = (zê-xê)(xê-yê) - (xê-yê)(zê-xê) = zp, xp, -zp, yp, -xp, xp, +xp, yp, -xêzê +xêxê +ypzê - yêxxê = $[z\hat{p}_{x}, x\hat{p}] - [z\hat{p}_{x}, y\hat{p}] - [x\hat{p}_{x}, x\hat{p}] + [x\hat{p}_{x}, y\hat{p}_{x}]$ = ZPG [ê, Ê] - Zy[Px, Py] - E[E, Fy] + FE[E, Px] DE CONORDADO = zp(it) - 0 - 0 + ypz(it) = it (2Pg -9P2) = it (x) [12, 62] = [2] - yPz - yPz - yzp] = अद्भेष्ट - अद्देन पहे पहे + पहे रहे - yê xê +xê zê +yê yê 3-yê zê = xp[kg,y]- xy[kz,ky]- kk[y,y]+ yzk[y,kg] = xp2(it)-0-0+zp(it) = it Lig

Commentators tell us is two variables can be

simultaneously measured without an uncertainty principle
i.e & a commutator of 0 results in no uncertainty

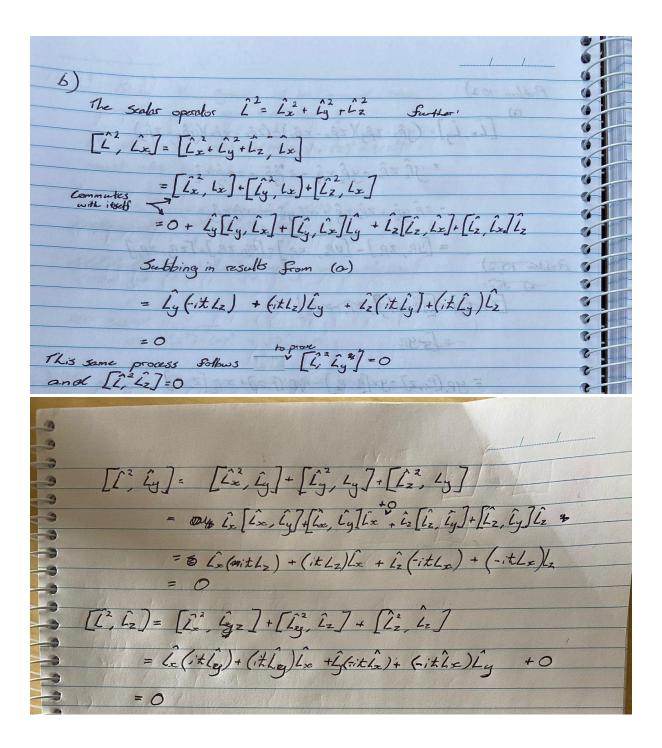
principle.

Thus these commentators tell us that each Ls

stores an uncertainty principle with the other angular

momentums qual to it times the other angular

momentum.

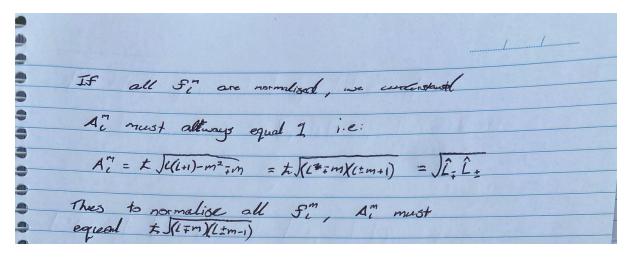


This result this as that to total argular momentum and one directional component of the angular momentum can be similariously principle.

C) [$\hat{l}_{2}, x] = [x\hat{g}_{2}, y\hat{g}_{2}], x] = [x\hat{g}_{1}, x] - [y\hat{g}_{2}, x]$ $= x[\hat{g}_{1}, x] + [\hat{g}_{1}, x]\hat{g}_{2} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ = 0 + 0 - yit - 0 = yit $[\hat{l}_{2}, y] = [x\hat{g}_{1}, y\hat{g}_{2}, y\hat{g}_{2}] = [x\hat{g}_{2}, x] - [y\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$ $= x[\hat{g}_{1}, x] + [x, x]\hat{g}_{1} - y[\hat{g}_{2}, x] - [y, x]\hat{g}_{2}$

 $\begin{bmatrix} \hat{L}_{2}, z \end{bmatrix} \cdot \begin{bmatrix} x \hat{g} - y \hat{k}_{z}, z \end{bmatrix} - \begin{bmatrix} x \hat{g}_{z} \cdot z \end{bmatrix} - \begin{bmatrix} y \hat{k}_{z} \cdot z \end{bmatrix}$

Robben 10.3) First to show Li is the Hermitian conjugate of Li. Thus: \(\lambda_{l,m}\) = \(\lambda_{l,m}\rangle = \lambda_{l,m}\rangle = \lambda_{l,m L+ = Lx + ily (C, m = (1, m) = (1, m (6x + idg) | 1, m) = \$\int_{\int_{\infty}}^{2\tau_{\infty}} \left(\frac{\gamma_{\infty}}{(\phi_{\infty})} \left(\gamma_{\infty}^{\infty}) \right) \frac{\gamma_{\infty}}{(\phi_{\infty})} \delta d\phi we understand that (Cx + iby) = Lx-iby (Lx-iLy)= Lx+iLy and thus (Lx tily) = (Lx 7 ily) as he and by are = 55 (Y"(0,0))* (Lx = iLy) Y"(0,0) dogdo = < l, m / (lx = ily) 1, m> = < l, m / [+ l, m > Thus we have shown that Li is the Hermitian conjugate of Lt Now we find (5" | L, L, 5") = <((L=)+f=/L=5=) = < L+ 5" / L+ 5") = < A" 5" 1 / A" 5" 1) - (5 mil) (5 mil) (5 mil) Further: \\ S" | L. L. S" > = \\ S" | L - Lz + Lz S" \\ = t 2 ((((+1)-m2 +m) (5 m+1) (m+1)
= (Am)2 (5 m+1) 5 m+1) Thus we understand that L.L. = (A?)



Expanding on this, we understand that for f_l^m to be normalised, for $L_{\pm}f_l^m$, $< f_l^{m\pm 1}|$ $f_l^{m\pm 1}>=1$ must be satisfied for any m or l. Thus, our derivation of A^m_l ensures this as $L_{\pm}f_l^m=A_l^m$ $f_l^{m\pm 1}$ is satisfied given f_l^m was already normalised.

9	we also note that when m goes outside the bounds of l, An goes to O as expected, i.e. m=l o- m=-l,
9	bounds of 1 1th and 10
-	the state of 1, Me goes to 0 as expected,
•	1.2: m=1 or m=-1, 2
-	$ \begin{array}{cccccccccccccccccccccccccccccccccccc$
9	Correct Correct
-	Sign in = and 7 is used.
-	50- m=l: A= = t ((-(x(+(-1)) = 0
-	m=- (A') = t. ((+-1VI-1-1) =0
	$m=-(A_{i}^{m}=t)(1+-1)(1-1)=0$ Fell off the ladder!
	The District: