I. Χρήσιμες φυσικές σταθερές

Σωματίδιο	Μάζα (Kgr)	Φορτίο (Cb)
Ηλεκτρόνιο (e)	$m_e = 9{,}1091\times10^{-31}$	$q_e = -1{,}6021\times10^{-19}$
Πρωτόνιο (p)	$m_p = 1{,}6725\times10^{-27}$	$q_p = +1{,}6021\times10^{-19}$
Νετρόνιο (n)	$m_n = 1{,}6748\times10^{-27}$	0
$\lvert q_e\rvert = \lvert q_p\rvert \approx 1{,}6\times10^{-19}$ Cb		

$c = 3\times10^{8}$ m/s
$1J = 6{,}24\times10^{18}$ eV
$k_B = 1{,}38\times10^{-23}$ J/K $= 8{,}62\times10^{-5}$ eV/K
$K_e = 9\times10^{9}$ Nm^2/Cb^2
$h = 6{,}62\times10^{-34}$ Js
$\hbar = h/2\pi = 1{,}05\times10^{-34}$ Js
$hc = 19{,}86\times10^{-26}$ Jm $= 12412$ eVm

II. Χρήσιμοι μαθηματικοί τύποι

$$(a+b)^n = a^n + \frac{n}{1!}a^{n-1}b + \frac{n(n-1)}{2!}a^{n-2}b^2 + \cdots$$

$$(1+x)^n = 1 + nx + \frac{n(n-1)}{2!}x^2 + \cdots$$

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \cdots$$

$$\ln(1\pm x) = \pm x - \tfrac{1}{2}x^2 \pm \tfrac{1}{3}x^3 - \cdots$$

$$\left.\begin{aligned} \sin x &= x - \frac{x^3}{3!} + \frac{x^5}{5!} - \cdots \\ \cos x &= 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \cdots \\ \tan x &= x + \frac{x^3}{3} + \frac{2x^5}{15} + \cdots \quad |x| < \pi/2 \end{aligned}\right\} x \text{ in radians}$$

$$\sin^2\theta + \cos^2\theta = 1 \qquad \csc^2\theta = 1 + \cot^2\theta$$

$$\sec^2\theta = 1 + \tan^2\theta \qquad \sin^2\frac{\theta}{2} = \tfrac{1}{2}(1-\cos\theta)$$

$$\sin 2\theta = 2\sin\theta\cos\theta \qquad \cos^2\frac{\theta}{2} = \tfrac{1}{2}(1+\cos\theta)$$

$$\cos 2\theta = \cos^2\theta - \sin^2\theta \qquad 1 - \cos\theta = 2\sin^2\frac{\theta}{2}$$

$$\tan 2\theta = \frac{2\tan\theta}{1-\tan^2\theta} \qquad \tan\frac{\theta}{2} = \sqrt{\frac{1-\cos\theta}{1+\cos\theta}}$$

$$\sin(A\pm B) = \sin A\cos B \pm \cos A\sin B$$

$$\cos(A\pm B) = \cos A\cos B \mp \sin A\sin B$$

$$\sin A \pm \sin B = 2\sin[\tfrac{1}{2}(A\pm B)]\cos[\tfrac{1}{2}(A\mp B)]$$

$$\cos A + \cos B = 2\cos[\tfrac{1}{2}(A+B)]\cos[\tfrac{1}{2}(A-B)]$$

$$\cos A - \cos B = 2\sin[\tfrac{1}{2}(A+B)]\sin[\tfrac{1}{2}(B-A)]$$

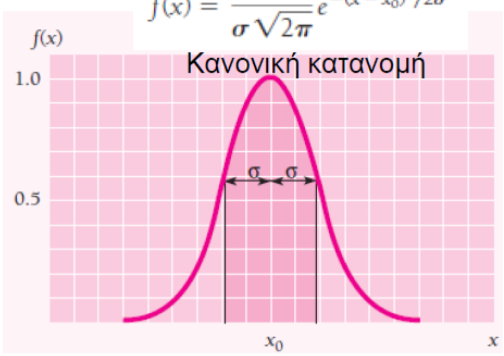
Για x <<1 :

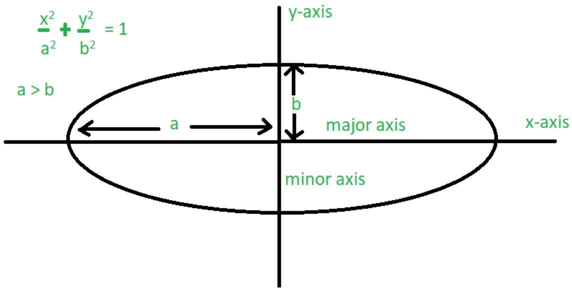
$$(1+x)^n \approx 1 + nx \qquad \sin x \approx x$$

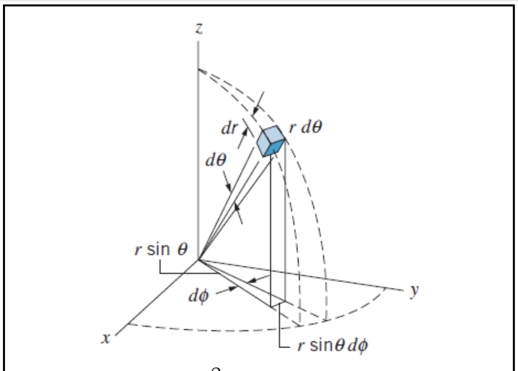
$$e^x \approx 1 + x \qquad \cos x \approx 1$$

$$\ln(1\pm x) \approx \pm x \qquad \tan x \approx x$$

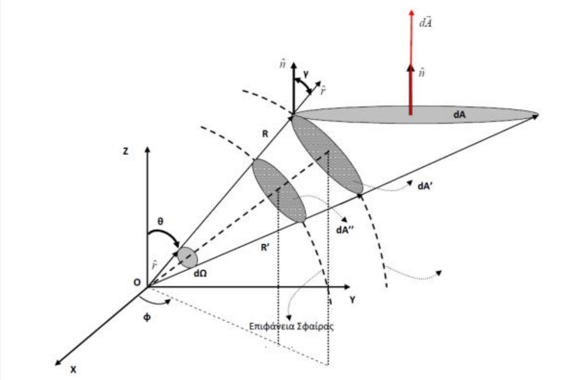
$$f(x) = \frac{1}{\sigma\sqrt{2\pi}}e^{-(x-x_0)^2/2\sigma^2}$$







$$dV = r^2\sin\theta\, dr\, d\theta\, d\varphi$$



$$d\Omega = \frac{dA'}{R^2} = \frac{dA''}{R'^2} = \sin\theta\, d\theta\, d\varphi$$

III. Χρήσιμοι τύποι της Κυματικής

Κυματική εξίσωση: $\frac{\partial^2 y(x,t)}{\partial x^2} = \frac{1}{\upsilon^2}\frac{\partial^2 y(x,t)}{\partial t^2}$

Πυκνότητα ενέργειας κύματος: $u = \frac{<E>}{V}$ | Ένταση κύματος: $I = \upsilon u$ | $\left(\frac{dE}{dt}\right)_{ave} = IA = \upsilon u A$

Κυματοπακέτα:

$$y(x,t) = \sum_i A_i \cos(k_i x - \omega_i t) = R_e\left\{\sum_i A_i e^{i(k_i x - \omega_i t)}\right\}$$

$$y(x,t) = \int_{k_0-\Delta k}^{k_0+\Delta k} \mathrm{A}(k)\cos\left[kx - \omega(k)t\right]dk = \int_{k_0-\Delta k}^{k_0+\Delta k} \mathrm{A}(k)e^{i[kx-\omega(k)t]}dk \quad | \quad \mathrm{A(k)} = \begin{cases} \neq 0, & k_0 - \Delta k < k < k_0 + \Delta k \\ 0, & \text{αλλού} \end{cases}$$

$$y(x,0) = y_0(x) = \int_{-\infty}^{+\infty} A(k)\cos(kx)dk = \int_{-\infty}^{+\infty} \mathrm{A}(k)e^{ikx}dk$$

$$y(x,t) = \int_{-\infty}^{+\infty} \mathrm{A}(k)\cos\left[kx - \omega(k)t\right]dk = \int_{-\infty}^{+\infty} \mathrm{A}(k)e^{i[kx-\omega(k)t]}dk$$

$$\upsilon_g = \frac{d\omega(k)}{dk} = \frac{d(\upsilon_p k)}{dk} = \upsilon_p + k\frac{d\upsilon_p}{dk} = \upsilon_p - \lambda\frac{d\upsilon_p}{d\lambda}$$

$$\upsilon_g = \frac{d\omega(k)}{dk} = \left(\frac{d\omega}{dk}\right)_{k=k_0}$$

IV. Χρήσιμοι τύποι της Κλασικής Στατιστικής Φυσικής

$$\mathrm{P} = \frac{1}{\zeta}e^{-\frac{\varepsilon}{k_B T}} \quad | \quad \zeta = \iiint\iiint e^{-\frac{\varepsilon}{k_B T}} dp_x dp_y dp_z dx dy dz \quad | \quad \varepsilon = \frac{p^2}{2m} + U(\vec{r})$$

$$\bar{\varepsilon} = -\frac{1}{\zeta}\frac{\partial\zeta}{\partial\beta} \quad | \quad \beta = \frac{1}{k_B T}$$

V. Χρήσιμοι τύποι της Θεωρίας Σχετικότητας

Ταχύτητα του φωτός: $c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$

Σχετικιστική ορμή: $\vec{p} = \frac{m_0 \vec{\upsilon}}{\sqrt{1-\upsilon^2/c^2}}$ | Σχετικιστική μάζα: $m = \frac{m_0}{\sqrt{1-\upsilon^2/c^2}}$

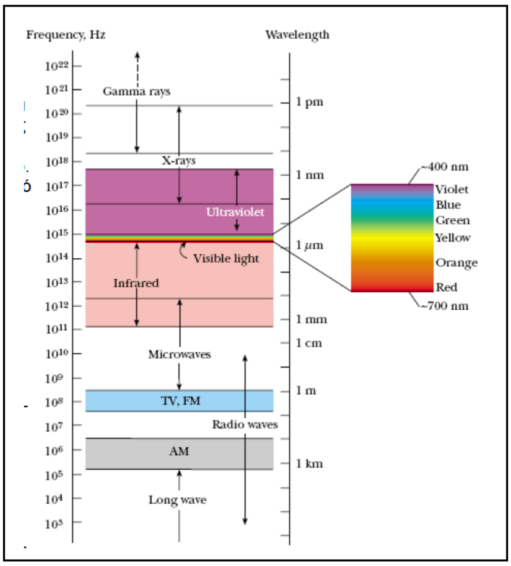
Σχετικιστική κινητική ενέργεια: $K = \frac{m_0 c^2}{\sqrt{1-\upsilon^2/c^2}} - m_0 c^2$

Για ελεύθερο σωμάτιο: $E = \sqrt{\left(m_0 c^2\right)^2 + (cp)^2}$

$$E = K + E_0 = K + m_0 c^2 = \frac{m_0 c^2}{\sqrt{1-\upsilon^2/c^2}} = mc^2$$

$$pc = \sqrt{\left(K + m_0 c^2\right)^2 - \left(m_0 c^2\right)^2} = \sqrt{K^2 + 2Km_0 c^2} = K\sqrt{1 + \frac{2m_0 c^2}{K}}$$

Για σωμάτιο σε πεδίο δυνάμεως: $E = K + U + m_0 c^2 = mc^2$



VI. Ηλεκτρομαγνητικά κύματα

$$\vec{E}(x,t) = E_0 \sin(kx - \omega t)\,\hat{j}$$

$$\vec{B}(x,t) = B_0 \sin(kx - \omega t)\hat{k}$$

$$\vec{B}(x,t) = \frac{\vec{E}(x,t)}{c}, \quad c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$$

$$u = \varepsilon_0 E^2$$

$$I = cu = c\varepsilon_0 E^2$$

VII. Μέλαν σώμα

Αφετική Ικανότητα: $\alpha = \dfrac{P}{A}$, $d\alpha = \rho_T(f)df$, $d\alpha = \rho_T(\lambda)d\lambda$

Πυκνότητα Ενέργειας: $u = \dfrac{E}{V}$, $du = u_T(f)df$, $du = u_T(\lambda)d\lambda$

$$\rho(f,T) = \frac{c}{4}u(f,T), \quad \rho(\lambda,T) = \frac{c}{4}u(\lambda,T)$$

Νόμος Stefan – Boltzmann: $\alpha = \sigma T^4$, $\sigma = 5,67037 \times 10^{-8}$ $[W / m^2 K^4]$

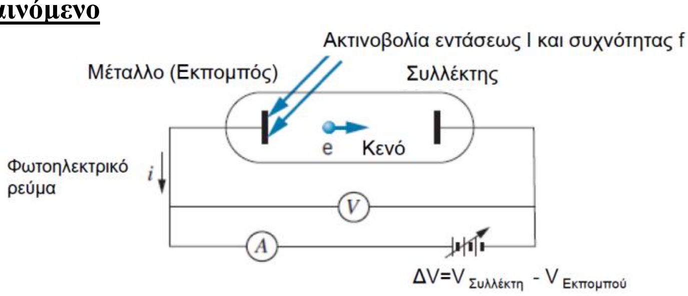
Νόμος Wien: $\lambda_{\max} T = \sigma\tau\alpha\theta\varepsilon\rho\acute{\alpha} = 2,8978 \times 10^{-3}$ [mK], $\dfrac{f_{\max}}{T} = \sigma\tau\alpha\theta\varepsilon\rho\acute{\alpha} = 5,889 \times 10^{10}$ $[\mathrm{HzK}^{-1}]$

Ασυμπτωτικός νόμος Wien: $\rho(f,T) = C_1 f^3 e^{-\frac{C_2 f}{T}}$, $\gamma\iota\alpha\ f \to \infty$

Νόμος Rayleigh-Jeans: $\rho(f,T) = \dfrac{2\pi}{c^2} f^2 k_B T$, $\rho(\lambda,T) = \dfrac{2\pi c}{\lambda^4} k_B T$

Νόμος Planck: $\rho(f,T) = \dfrac{2\pi h}{c^2} \dfrac{f^3}{e^{\frac{hf}{k_B T}} - 1}$, $\rho(\lambda,T) = \dfrac{2\pi hc^2}{\lambda^5} \dfrac{1}{e^{\frac{hc}{\lambda k_B T}} - 1}$

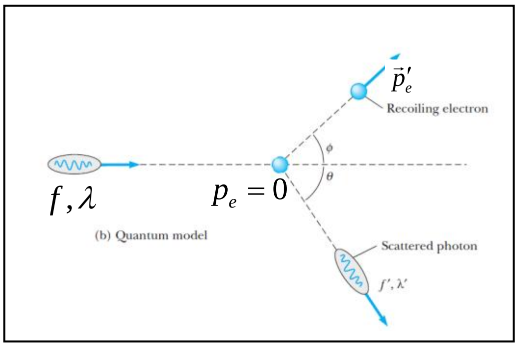
VIII. Φωτοηλεκτρικό φαινόμενο



<u>Πειραματική μελέτη:</u> $K_{\max} = \dfrac{1}{2} m_e \upsilon^2{}_{\max} = q_e \Delta V_S$ | <u>Φωτοηλεκτρική εξίσωση του Einstein:</u> $hf = \phi + \dfrac{1}{2} m_e \upsilon^2$

<u>Συχνότητα αποκοπής:</u> $f_c = \dfrac{\phi}{h}$

IX. Φαινόμενο Compton



$$\Delta\lambda = \lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta)$$

Μήκος κύματος Compton: $\lambda_C = \dfrac{h}{m_e c} \simeq 2,4 \times 10^{-2}\ \mathring{A}$

X. Φάσμα του Υδρογόνου

$$\frac{1}{\lambda} = R_H\left(\frac{1}{m^2}-\frac{1}{n^2}\right)\begin{cases} m = 1,2,3,4,..... \\ n = m+1,\ m+2,\ m+3,..... \end{cases}$$

$$f = cR_H\left(\frac{1}{m^2}-\frac{1}{n^2}\right)\begin{cases} m = 1,2,3,4,..... \\ n = m+1,\ m+2,\ m+3,..... \end{cases}$$

$$R_H = 1,09677576\times 10^7\, m^{-1} = \sigma\tau\alpha\theta\varepsilon\rho\acute{\alpha}\ Rydberg$$

$$cR_H = 3,29\times 10^{15}\, s^{-1}$$

XI. Ατομικό πρότυπο του Bohr για τα Μονοηλεκτρονιακά Άτομα

$$L = m_e \upsilon r = n\hbar = n\frac{h}{2\pi},\ n = 1,2,3,........$$

$$r_n = \frac{\hbar^2}{ZK_e m_e q_e^2}n^2 = 4\pi\varepsilon_0\frac{\hbar^2}{Zm_e q_e^2}n^2,\ n = 1,2,3,.... \quad | \quad r_n = \frac{1}{Z}\alpha_0 n^2,\ n = 1,2,3,....$$

Ακτίνα Bohr: $\alpha_0 = r_1(Z=1) = \frac{\hbar^2}{K_e m_e q_e^2} = 4\pi\varepsilon_0\frac{\hbar^2}{m_e q_e^2} \approx 0,53\times 10^{-8}cm = 0,53\,\overset{o}{\mathrm{A}}$

$$\upsilon_n = \frac{ZK_e q_e^2}{\hbar}\frac{1}{n} = \frac{Zq_e^2}{4\pi\varepsilon_0\hbar}\frac{1}{n},\ n = 1,2,3,....$$

$$E_n = -\frac{Z^2K_e^2 m_e q_e^4}{2\hbar^2 n^2} = -\frac{Z^2K_e^2 2\pi^2 m_e q_e^4}{h^2n^2} = -\frac{Z^2 m_e q_e^4}{8\varepsilon_0{}^2h^2n^2} = -\frac{13,6}{n^2}Z^2\ eV,\ n = 1,2,3,...$$

$$R_\infty = \frac{m_e q_e^4}{8c\varepsilon_0{}^2h^3} = 1,0973732\times 10^7\, m^{-1}$$

Σχετικιστική διόρθωση – Σταθερά λεπτής υφής: $\alpha = \frac{K_e q_e^2}{\hbar c} = \frac{1}{137},\ \upsilon_n = \frac{Z}{n}\frac{c}{137}$

XII. Κανόνας κβάντωσης Wilson- Sommerfeld

$$\oint p_q dq = nh,\ \ n = 0,1,2,3...$$

XIII. Σύγχρονη Κβαντομηχανική

$$i\hbar\frac{\partial\Psi(x,t)}{\partial t} = -\frac{\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2} + U(x)\Psi(x,t)$$

$$i\hbar\frac{\partial\Psi(\vec r,t)}{\partial t} = -\frac{\hbar^2}{2m}\nabla^2\Psi(\vec r,t) + U(\vec r)\Psi(\vec r,t),\ \ \nabla^2 = \frac{\partial^2}{\partial x^2}+\frac{\partial^2}{\partial y^2}+\frac{\partial^2}{\partial z^2}$$

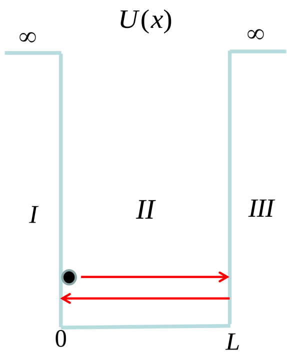
Για σωμάτιο καθορισμένης ενέργειας:

$$-\frac{\hbar^2}{2m}\frac{\partial^2\Psi(x,t)}{\partial x^2} + U(x)\Psi(x,t) = E\Psi(x,t)$$

$$-\frac{\hbar^2}{2m}\nabla^2\Psi(\vec r,t) + U(x)\Psi(\vec r,t) = E\Psi(\vec r,t)$$

$$\Psi(x,t) = \psi(x)e^{-\frac{i}{\hbar}Et} \quad | \quad \frac{d^2\psi(x)}{dx^2} + \frac{2m}{\hbar^2}\left[E - U(x)\right]\psi(x) = 0$$

XIV. Απειρόβαθο Πηγάδι



$$U(x)=\begin{cases}0 & ,0\le x\le L\\ \infty, & \alpha\lambda\lambda o\acute{\upsilon}\end{cases}$$

$$\psi_n(x)=\sqrt{\frac{2}{L}}\sin\left(\frac{n\pi}{L}x\right),\ n=1,2,3...$$

$$\mathrm{E}_n=n^2\frac{\pi^2\hbar^2}{8mL^2},\quad n=1,2,3...$$

XVI. Αρμονικός Ταλαντωτής

$$U(x)=\frac{1}{2}\kappa x^2=\frac{1}{2}m\omega^2x^2,\quad \omega=\sqrt{\frac{\kappa}{m}}$$

$$\psi_n(x)=\left(\frac{\alpha}{\pi}\right)^{\frac{1}{4}}\left(\frac{2^{-n}}{n!}\right)^{\frac{1}{2}}\mathrm{e}^{-\frac{\alpha x^2}{2}}\mathrm{H}_n\left(\alpha^{\frac{1}{2}}x\right),\ n=0,1,2,3...$$

$$\mathrm{H}_n(y)=(-1)^n\mathrm{e}^{y^2}\frac{d^n\left(\mathrm{e}^{-y^2}\right)}{dy^n}$$

$$\alpha=\frac{m\omega}{\hbar}$$

n	$H_n(y)$
0	1
1	$2y$
2	$4y^2-2$
3	$8y^3-12y$
4	$16y^4-48y^2+12$
5	$32y^5-160y^3+120y$

$$E=\left(n+\frac{1}{2}\right)\hbar\omega,\ n=0,1,2,3...$$

XVII. Μονοηλεκτρονιακά Άτομα στα πλαίσια της Σύγχρονης Κβαντομηχανικής

1.Κυματοσυναρτήσεις:

$$\psi_{n\ell m_\ell}(r,\theta,\varphi)=R_{n\ell}(r)\Theta_{\ell m_\ell}(\theta)\Phi_{m_\ell}(\varphi)=R_{n\ell}(r)Y_{\ell m_\ell}(\theta,\varphi)$$

$$\frac{1}{r^2}\frac{d}{dr}\left(r^2\frac{dR}{dr}\right)+\left[\frac{2m_e}{\hbar^2}\left(E+\frac{1}{4\pi\varepsilon_0}\frac{Zq_e^2}{r}\right)-\frac{\ell(\ell+1)}{r^2}\right]R=0$$

$$\frac{1}{\sin\theta}\frac{d}{d\theta}\left(\sin\theta\frac{d\Theta}{d\theta}\right)+\left[\ell(\ell+1)-\frac{m_\ell^{\ 2}}{\sin^2\theta}\right]\Theta=0$$

$$\frac{d^2\Phi}{d\varphi^2}+m_\ell^{\ 2}\Phi=0$$

Πυκνότητες πιθανότητας:

$$P(r)=\left|R_{n\ell}(r)\right|^2r^2,\quad P(\theta)=\left|\Theta_{\ell m_\ell}(\theta)\right|^2,\quad P(\varphi)=\left|\Phi_{m_\ell}(\varphi)\right|^2,\quad \left|Y_{\ell m_\ell}(\theta,\varphi)^2\right|=\frac{1}{2\pi}\left|\Theta_{\ell m_\ell}(\theta)\right|^2$$

2. Στροφορμή:

$$L=\sqrt{\ell(\ell+1)}\hbar \qquad L_z=m_\ell\hbar$$

$$\ell=0,1,2,3,...........(n-1)$$

$$m_\ell=-\ell,\ ....,0,......,\ \ell$$

$$\vec{\mu}_L=-\frac{|q_e|}{2m_e}\vec{L}\quad\Big|\quad \mu_{L,z}=-\frac{|q_e|}{2m_e}L_z=-\frac{|q_e|}{2m_e}m_\ell\hbar=-m_\ell\mu_B\quad\Big|\quad \mu_B=\frac{|q_e|\hbar}{2m_e}=9{,}274\times10^{-24}J/T$$

3. Spin:

$$S = \sqrt{s(s+1)}\hbar \quad , \; s = \frac{1}{2}$$

$$S_z = m_s \hbar$$

$$m_s = \pm s = \pm \frac{1}{2}$$

$$\vec{\mu}_S = -\frac{|q_e|}{m_e}\vec{S} \quad | \quad \mu_{S,z} = -2\mu_B m_S = \pm \mu_B$$

4. Σύνθεση Στροφορμών:

$$\vec{J} = \vec{L} + \vec{S}$$

$$J = \sqrt{j(j+1)}\hbar \qquad J_z = m_j \hbar$$

$$j = \ell + s, \; ...., |\ell - s|$$

$$m_j = -j, \; ...., 0, ..., j$$

$$\vec{\mu} = \vec{\mu}_L + \vec{\mu}_S \Rightarrow \vec{\mu} = -\frac{|q_e|}{2m_e}\left(\vec{L} + 2\vec{S}\right)$$

5. Επιτρεπόμενες Μεταβάσεις: $\Delta\ell = \pm 1, \quad \Delta m_\ell = 0, \pm 1$

ΑΤΟΜΟ ΥΔΡΟΓΟΝΟΥ

n	l	m_l	$\Phi(\phi)$	$\Theta(\theta)$	$R(r)$	$\psi(r, \theta, \phi)$
1	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{2}{a_0^{3/2}} e^{-r/a_0}$	$\frac{1}{\sqrt{\pi}\, a_0^{3/2}} e^{-r/a_0}$
2	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{1}{2\sqrt{2}\, a_0^{3/2}}\left(2 - \frac{r}{a_0}\right) e^{-r/2a_0}$	$\frac{1}{4\sqrt{2\pi}\, a_0^{3/2}}\left(2 - \frac{r}{a_0}\right) e^{-r/2a_0}$
2	1	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{6}}{2}\cos\theta$	$\frac{1}{2\sqrt{6}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	$\frac{1}{4\sqrt{2\pi}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}\cos\theta$
2	1	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{3}}{2}\sin\theta$	$\frac{1}{2\sqrt{6}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}$	$\frac{1}{8\sqrt{\pi}\, a_0^{3/2}} \frac{r}{a_0} e^{-r/2a_0}\sin\theta\, e^{\pm i\phi}$
3	0	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{1}{\sqrt{2}}$	$\frac{2}{81\sqrt{3}\, a_0^{3/2}}\left(27 - 18\frac{r}{a_0} + 2\frac{r^2}{a_0^2}\right) e^{-r/3a_0}$	$\frac{1}{81\sqrt{3\pi}\, a_0^{3/2}}\left(27 - 18\frac{r}{a_0} + 2\frac{r^2}{a_0^2}\right) e^{-r/3a_0}$
3	1	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{6}}{2}\cos\theta$	$\frac{4}{81\sqrt{6}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}$	$\frac{\sqrt{2}}{81\sqrt{\pi}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}\cos\theta$
3	1	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{3}}{2}\sin\theta$	$\frac{4}{81\sqrt{6}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}$	$\frac{1}{81\sqrt{\pi}\, a_0^{3/2}}\left(6 - \frac{r}{a_0}\right)\frac{r}{a_0} e^{-r/3a_0}\sin\theta\, e^{\pm i\phi}$
3	2	0	$\frac{1}{\sqrt{2\pi}}$	$\frac{\sqrt{10}}{4}(3\cos^2\theta - 1)$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{81\sqrt{6\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}(3\cos^2\theta - 1)$
3	2	±1	$\frac{1}{\sqrt{2\pi}} e^{\pm i\phi}$	$\frac{\sqrt{15}}{2}\sin\theta\cos\theta$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{81\sqrt{\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}\sin\theta\cos\theta\, e^{\pm i\phi}$
3	2	±2	$\frac{1}{\sqrt{2\pi}} e^{\pm 2i\phi}$	$\frac{\sqrt{15}}{4}\sin^2\theta$	$\frac{4}{81\sqrt{30}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}$	$\frac{1}{162\sqrt{\pi}\, a_0^{3/2}} \frac{r^2}{a_0^2} e^{-r/3a_0}\sin^2\theta\, e^{\pm 2i\phi}$