

DA MECÂNICA QUÂNTICA À NANOTECNOLOGIA

JOÃO PENEDONES
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Escola de Verão de Física



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UNIVERSIDADE DO PORTO

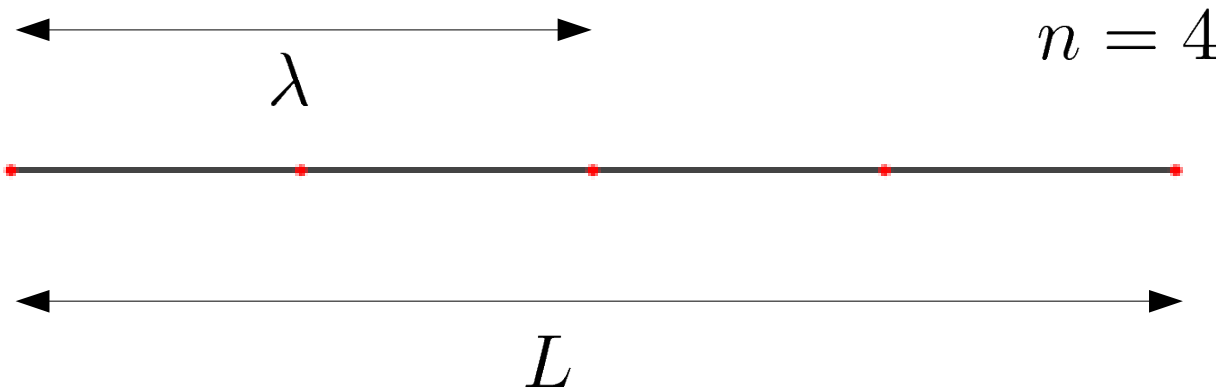
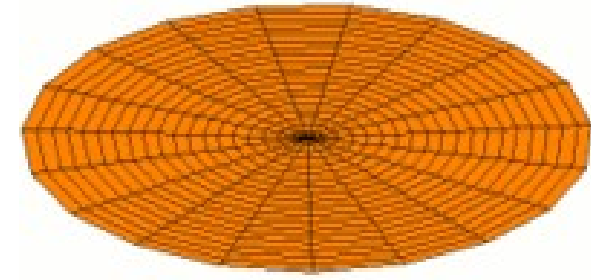
Plano do Curso:

- **Experiência da dupla fenda**
- **Mecânica Quântica em todo o lado**
- **Nanotecnologia**
- **Interpretações da Mecânica Quântica**

Mecânica quântica em todo o lado

Quantificação de Energia

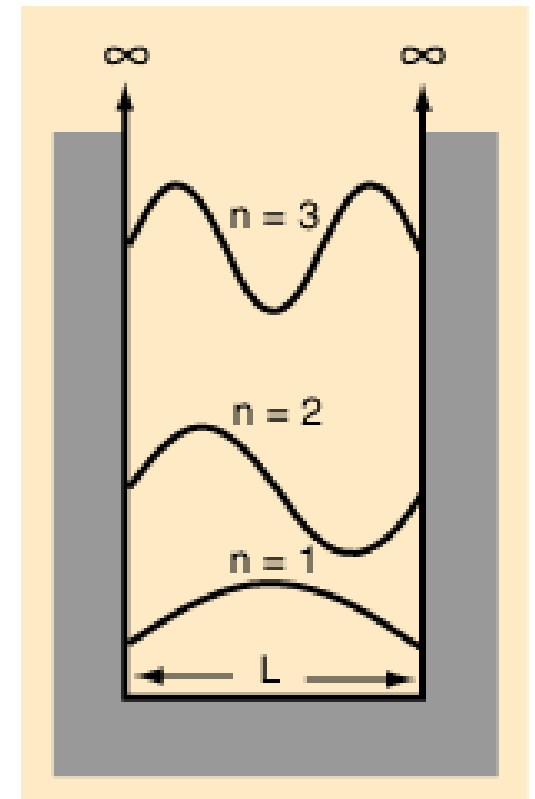
Ondas estacionárias



Electrão numa caixa

$$E = \frac{1}{2}mv^2 = \frac{p^2}{2m} = \frac{h^2}{2m\lambda^2} = \frac{h^2}{8mL^2}n^2$$

$p = mv$ $p = \frac{h}{\lambda}$ $L = n \frac{\lambda}{2}$



O Átomo de Hidrogénio

Força eléctrica = Força centrípeta

$$k \frac{e^2}{r^2} = m \frac{v^2}{r}$$

Relação de De Broglie

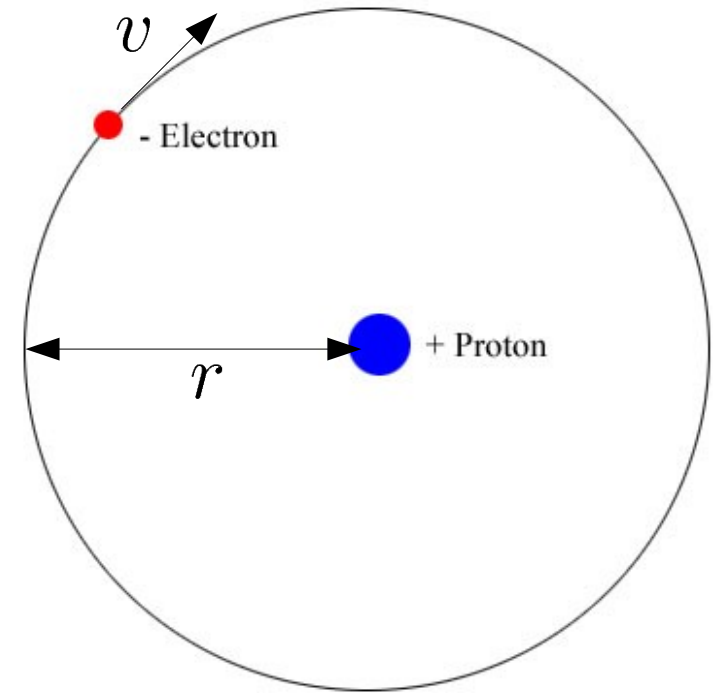
$$p = mv = \frac{h}{\lambda}$$

Condição de estacionaridade

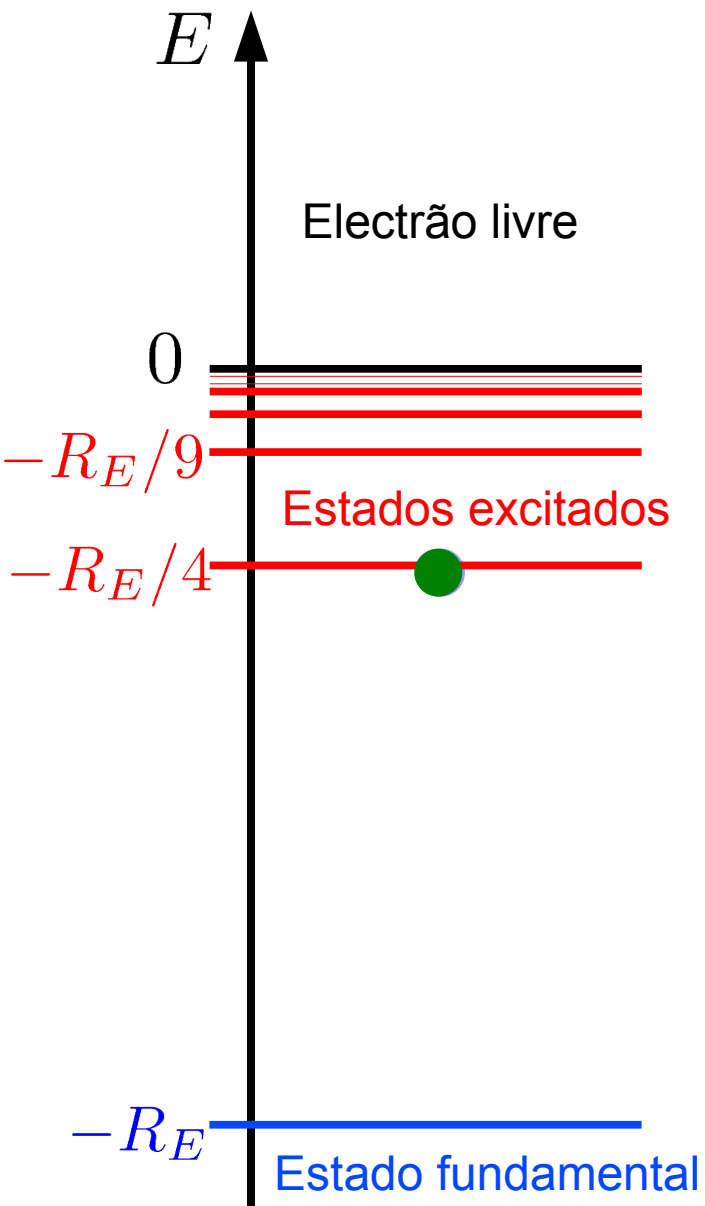
$$2\pi r = n\lambda$$

Quantificação de energia

$$E = \frac{1}{2}mv^2 - k \frac{e^2}{r} = -\frac{R_E}{n^2}, \quad R_E = \frac{2\pi^2 k^2 e^4 m}{h^2} = 13,6 \text{ eV}$$



O Átomo de Hidrogénio



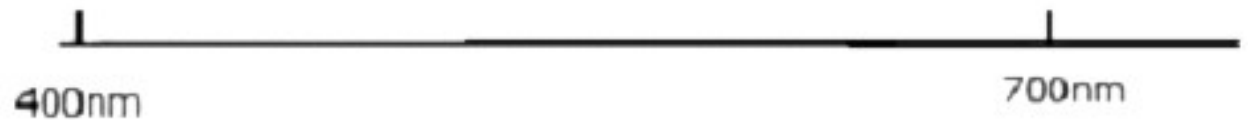
Energia do fóton

$$E_{\text{fotao}} = -\Delta E_{\text{electrao}}$$

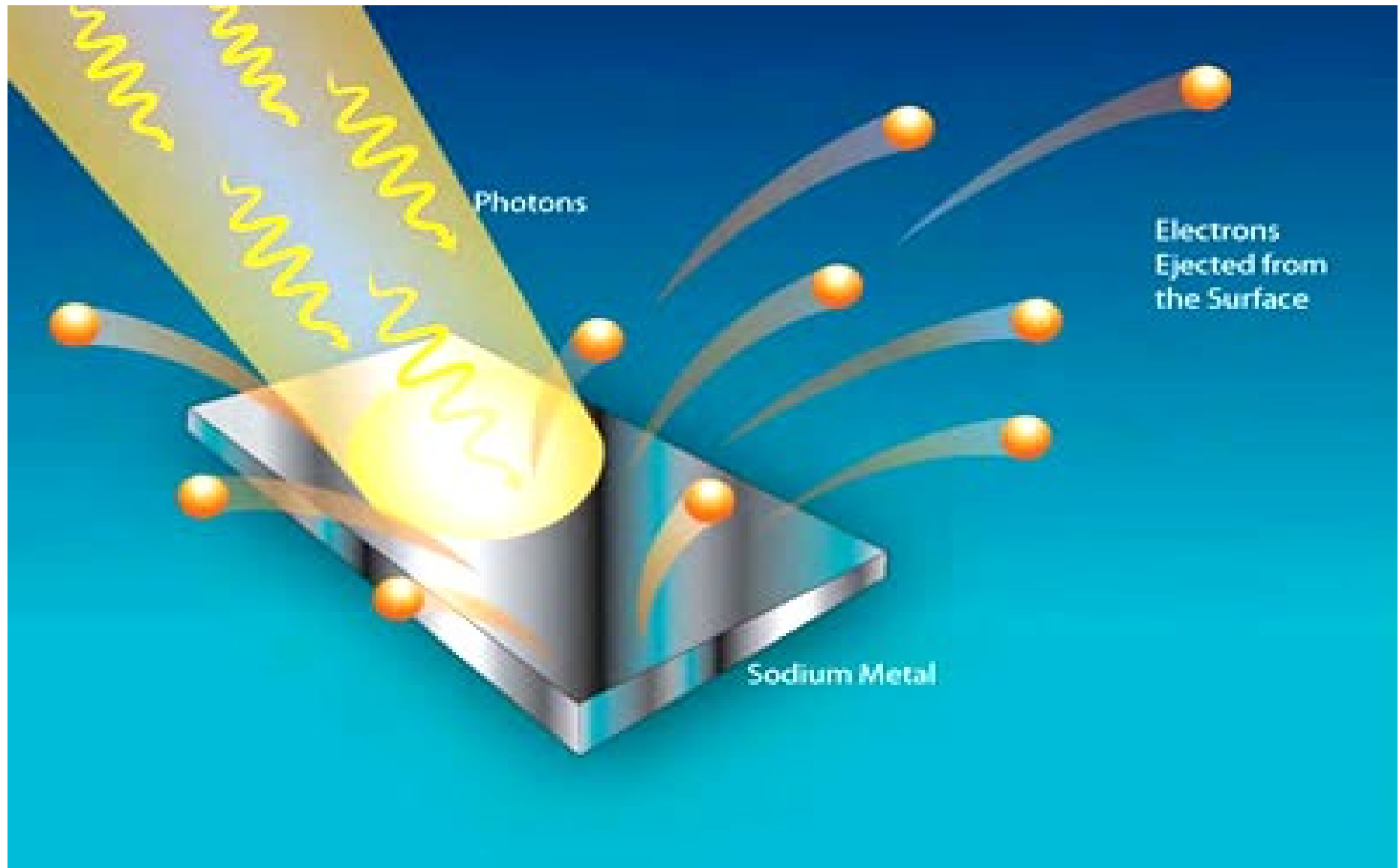
Hydrogen Absorption Spectrum



Hydrogen Emission Spectrum



O Efeito fotoeletrico



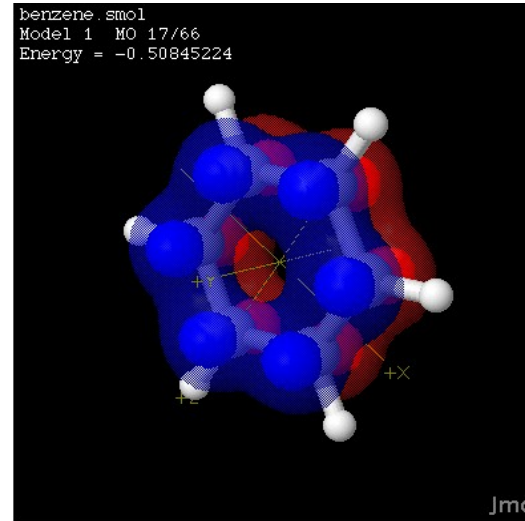
Átomos

Periodic Table of the Elements

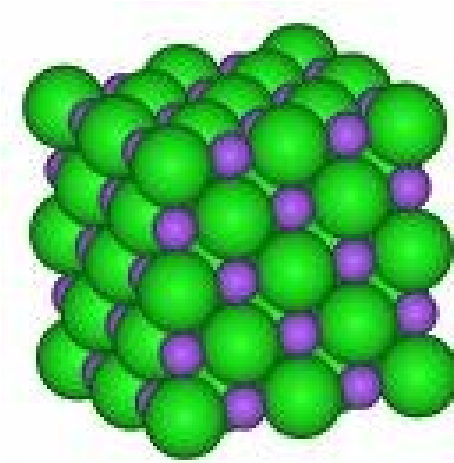
1																	2																																																								
3	4											5	6	7	8	9	10																																																								
Li	Be											B	C	N	O	F	Ne																																																								
11	12											13	14	15	16	17	18																																																								
Na	Mg											Al	Si	P	S	Cl	Ar																																																								
19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36																																																								
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr																																																								
37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54																																																								
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	I	Xe																																																								
55	56	57	72	73	74	75	76	77	78	79	80	81	82	83	84	85	86																																																								
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn																																																								
87	88	89	104	105	106	107	108	109	110																																																																
Fr	Ra	Ac	Unq	Unp	Unh	Uns	Uno	Une	Unn																																																																
<table border="1"> <tr> <td>58</td><td>59</td><td>60</td><td>61</td><td>62</td><td>63</td><td>64</td><td>65</td><td>66</td><td>67</td><td>68</td><td>69</td><td>70</td><td>71</td> </tr> <tr> <td>Ce</td><td>Pr</td><td>Nd</td><td>Pm</td><td>Sm</td><td>Eu</td><td>Gd</td><td>Tb</td><td>Dy</td><td>Ho</td><td>Er</td><td>Tm</td><td>Yb</td><td>Lu</td> </tr> <tr> <td>90</td><td>91</td><td>92</td><td>93</td><td>94</td><td>95</td><td>96</td><td>97</td><td>98</td><td>99</td><td>100</td><td>101</td><td>102</td><td>103</td> </tr> <tr> <td>Th</td><td>Pa</td><td>U</td><td>Np</td><td>Pu</td><td>Am</td><td>Cm</td><td>Bk</td><td>Cf</td><td>Es</td><td>Fm</td><td>Md</td><td>No</td><td>Lr</td> </tr> </table>																		58	59	60	61	62	63	64	65	66	67	68	69	70	71	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	90	91	92	93	94	95	96	97	98	99	100	101	102	103	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr
58	59	60	61	62	63	64	65	66	67	68	69	70	71																																																												
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90	91	92	93	94	95	96	97	98	99	100	101	102	103																																																												
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr																																																												

■ hydrogen ■ poor metals
■ alkali metals ■ nonmetals
■ alkali earth metals ■ noble gases
■ transition metals ■ rare earth metals

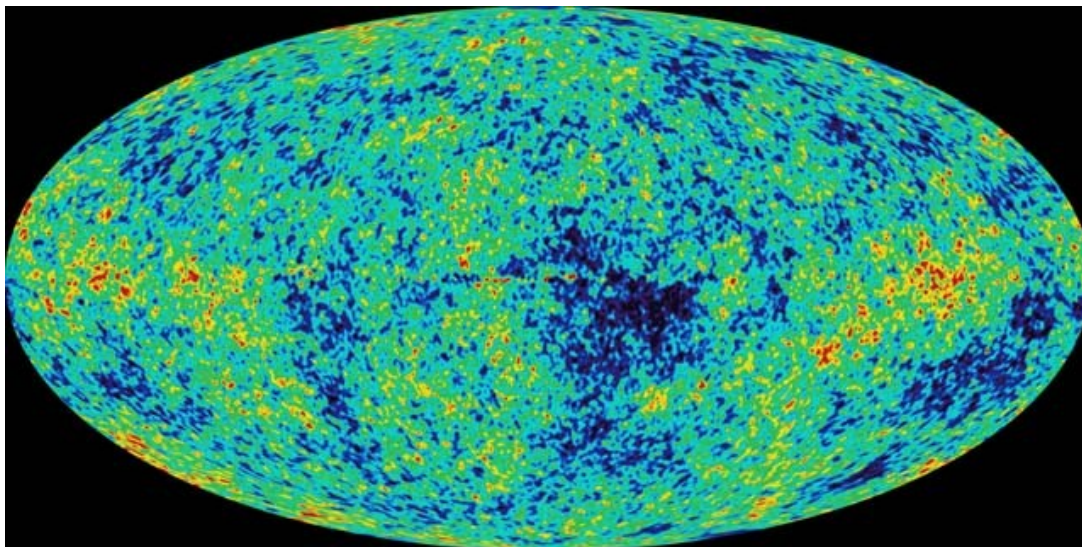
Moléculas



Sólidos



Big-Bang



Partículas Elementares

Quarks	<i>u</i> up	<i>c</i> charm	<i>t</i> top	Force Carriers
	<i>d</i> down	<i>s</i> strange	<i>b</i> bottom	
Leptons	ν_e electron neutrino	ν_μ muon neutrino	ν_τ tau neutrino	Force Carriers
	<i>e</i> electron	μ muon	τ tau	
			γ photon	Force Carriers
			<i>g</i> gluon	
			<i>Z</i> Z boson	Force Carriers
			<i>W</i> W boson	
			I II III	
Three Families of Matter				