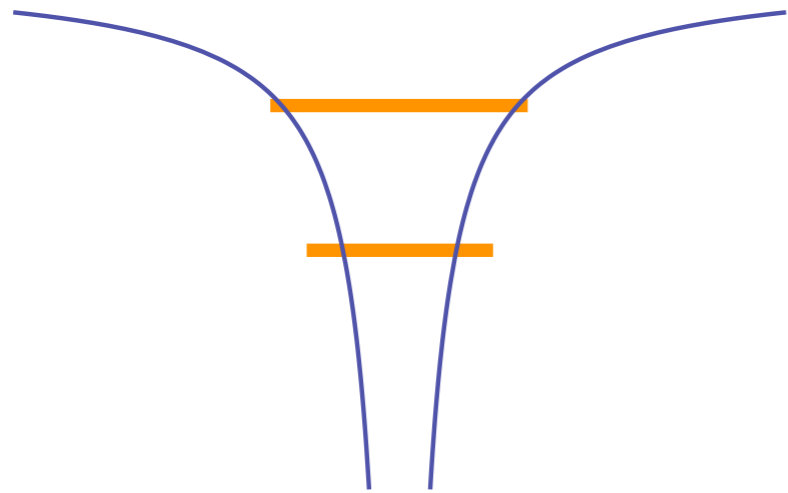


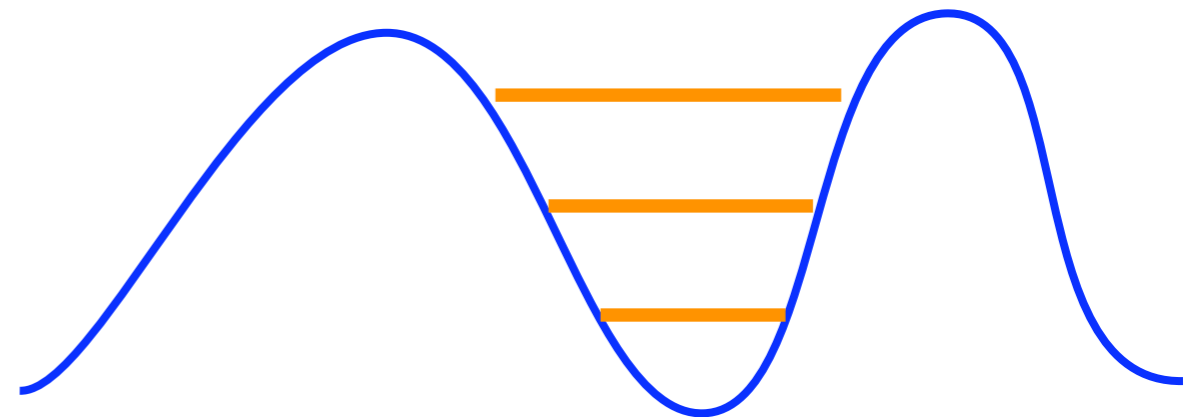
Mesterséges atomok

Pályi András

ELTE Fizikai Intézet, Anyagfizikai Tanszék



valódi atom



**mesterséges atom
("kvantumdot")**

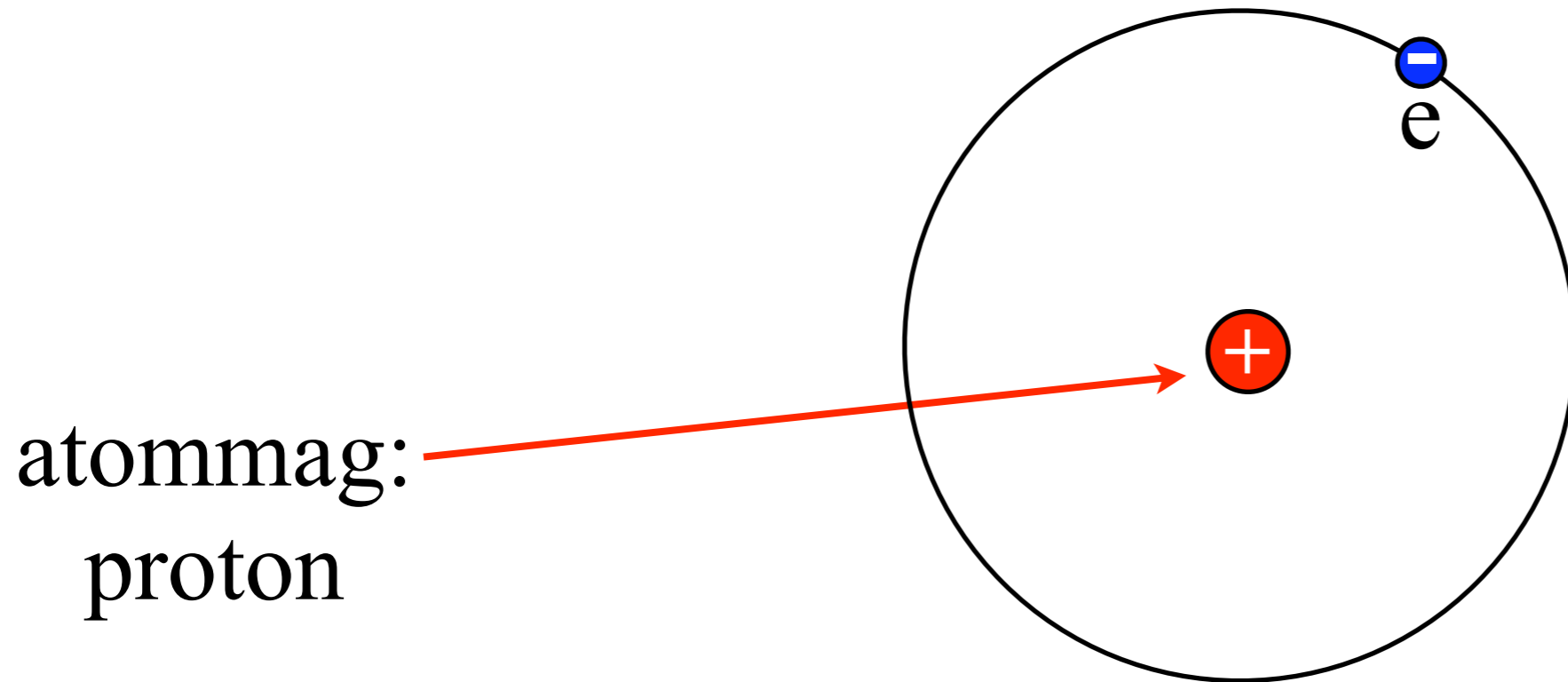
„Atomoktól a csillagokig”, ELTE, 2012. február 2.

1. Valódi atomok

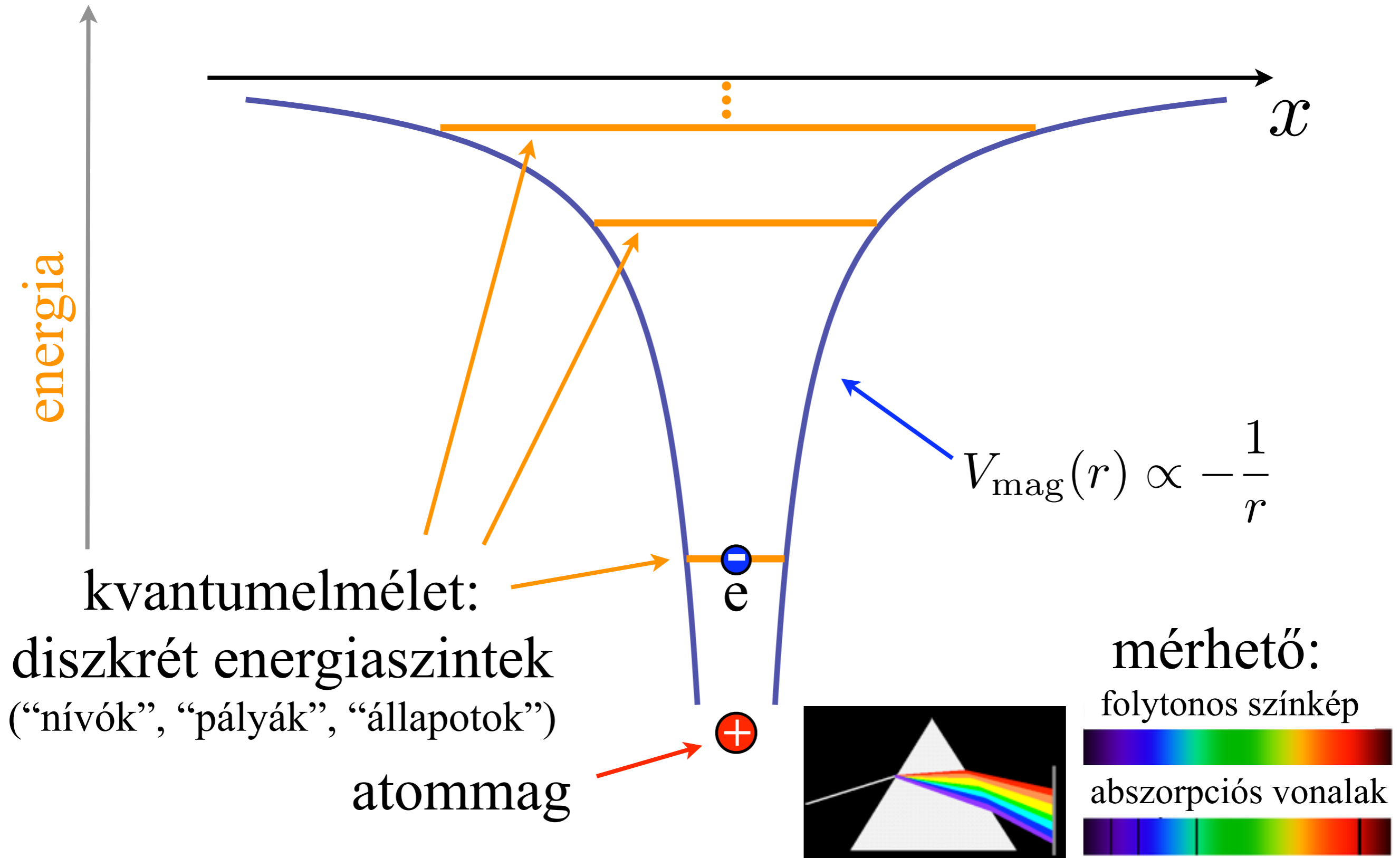
Group →	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
↓ Period																			
1	1 H																		2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo	

Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Hidrogénatom



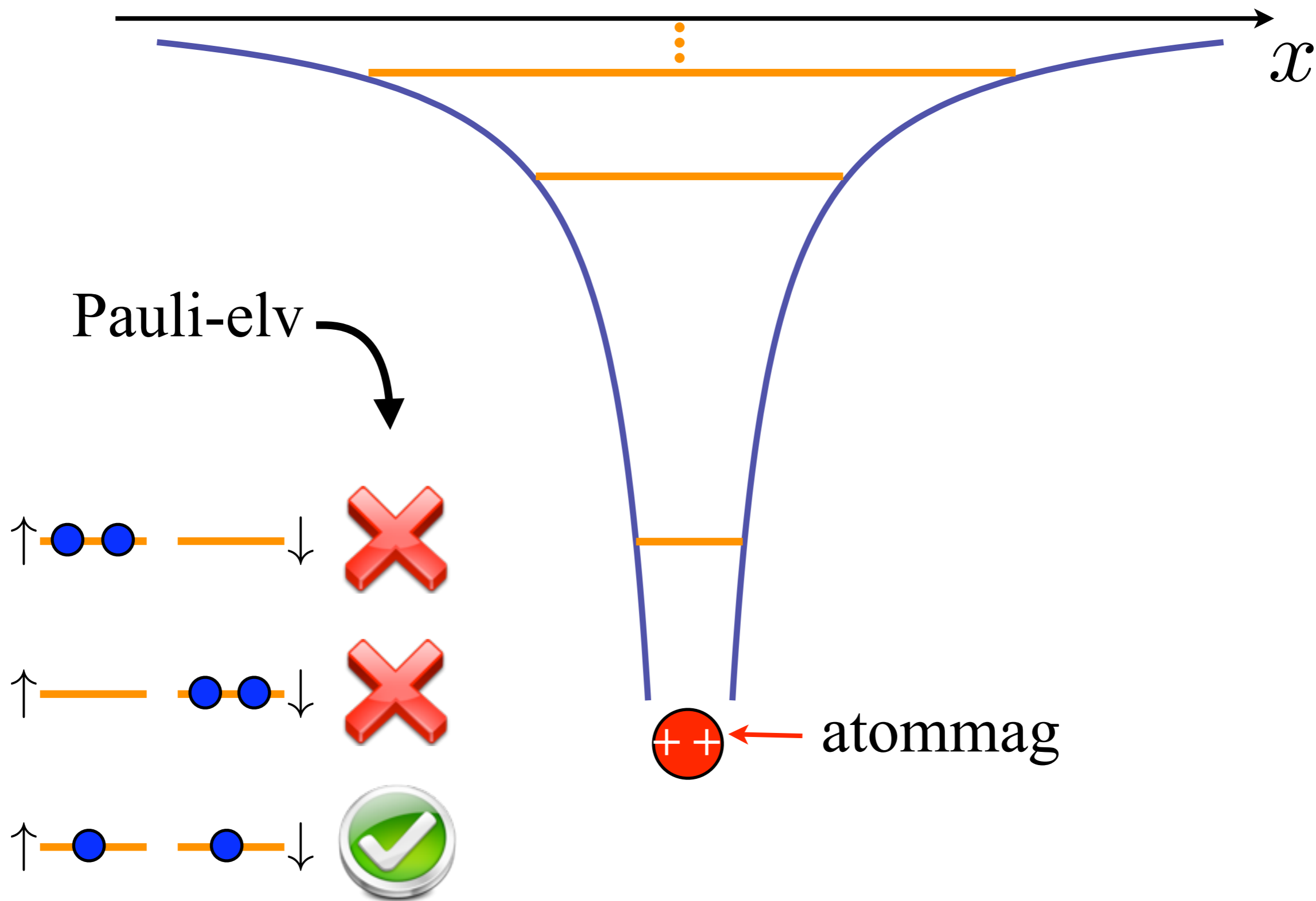
Hidrogénatom: diszkrét energiaszintek



Group → ↓ Period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
1	1 H																		2 He
2	3 Li	4 Be											5 B	6 C	7 N	8 O	9 F	10 Ne	
3	11 Na	12 Mg											13 Al	14 Si	15 P	16 S	17 Cl	18 Ar	
4	19 K	20 Ca	21 Sc	22 Ti	23 V	24 Cr	25 Mn	26 Fe	27 Co	28 Ni	29 Cu	30 Zn	31 Ga	32 Ge	33 As	34 Se	35 Br	36 Kr	
5	37 Rb	38 Sr	39 Y	40 Zr	41 Nb	42 Mo	43 Tc	44 Ru	45 Rh	46 Pd	47 Ag	48 Cd	49 In	50 Sn	51 Sb	52 Te	53 I	54 Xe	
6	55 Cs	56 Ba		72 Hf	73 Ta	74 W	75 Re	76 Os	77 Ir	78 Pt	79 Au	80 Hg	81 Tl	82 Pb	83 Bi	84 Po	85 At	86 Rn	
7	87 Fr	88 Ra		104 Rf	105 Db	106 Sg	107 Bh	108 Hs	109 Mt	110 Ds	111 Rg	112 Cn	113 Uut	114 Uuq	115 Uup	116 Uuh	117 Uus	118 Uuo	

Lanthanides	57 La	58 Ce	59 Pr	60 Nd	61 Pm	62 Sm	63 Eu	64 Gd	65 Tb	66 Dy	67 Ho	68 Er	69 Tm	70 Yb	71 Lu
Actinides	89 Ac	90 Th	91 Pa	92 U	93 Np	94 Pu	95 Am	96 Cm	97 Bk	98 Cf	99 Es	100 Fm	101 Md	102 No	103 Lr

Hélium atom: spin és Pauli-féle kizárási elv (2 elektron)

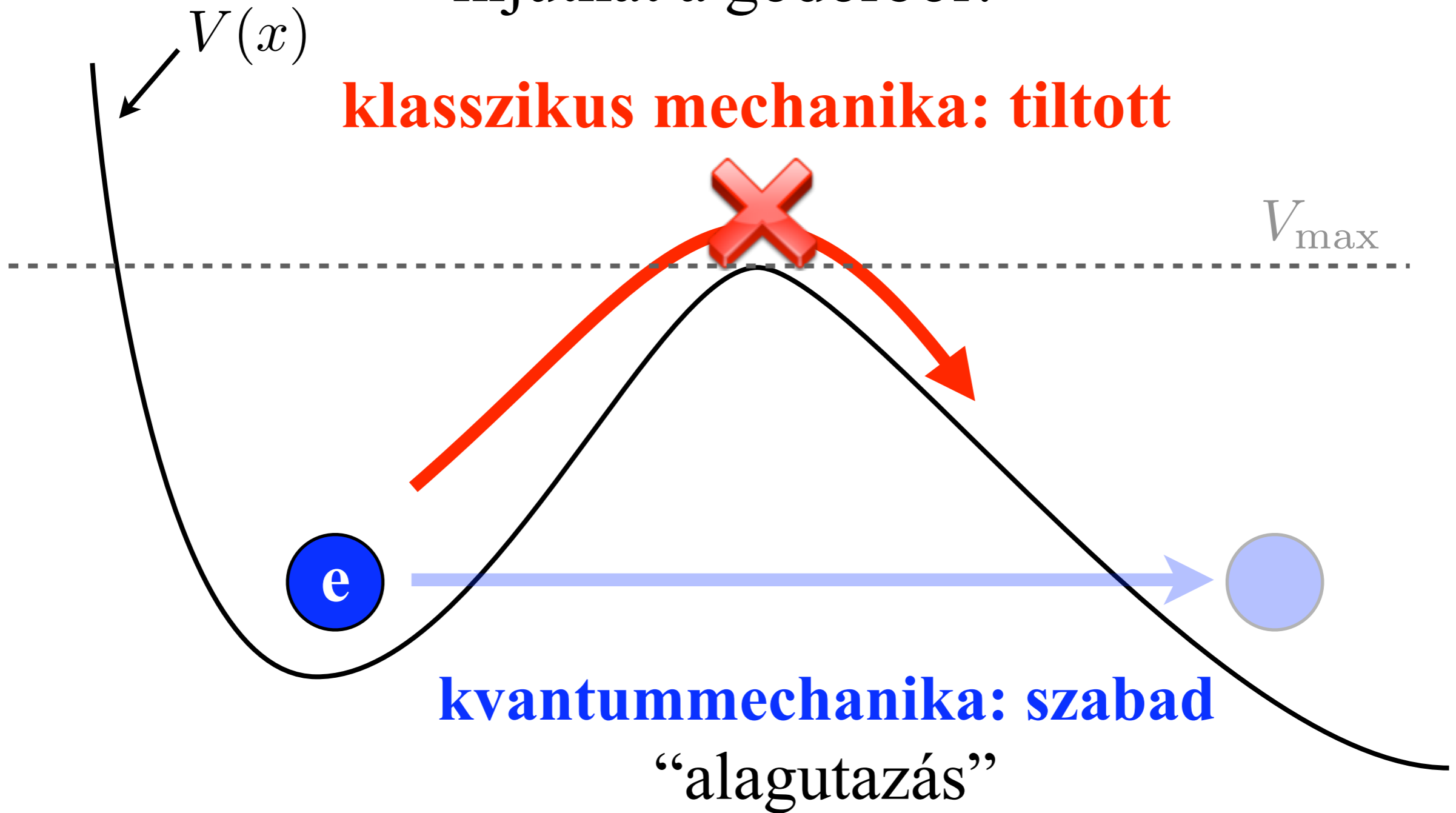


Kvantummechanikai alagút-effektus

$$E < V_{\max}$$

kijuthat a gödörből?

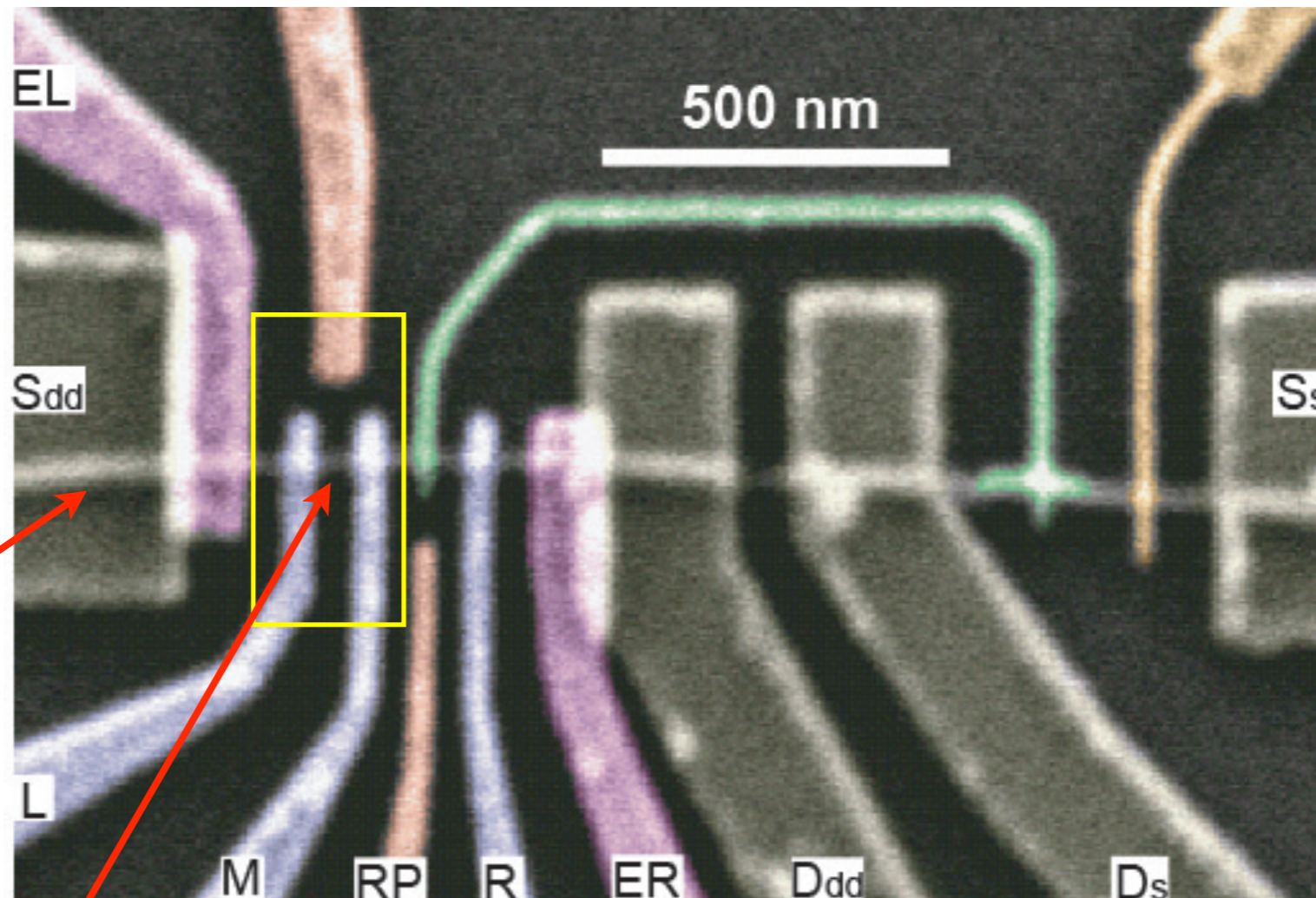
klasszikus mechanika: tiltott



kvantummechanika: szabad
“alagutazás”

2. Mesterséges atomok

Mesterséges atomok nanodrótban

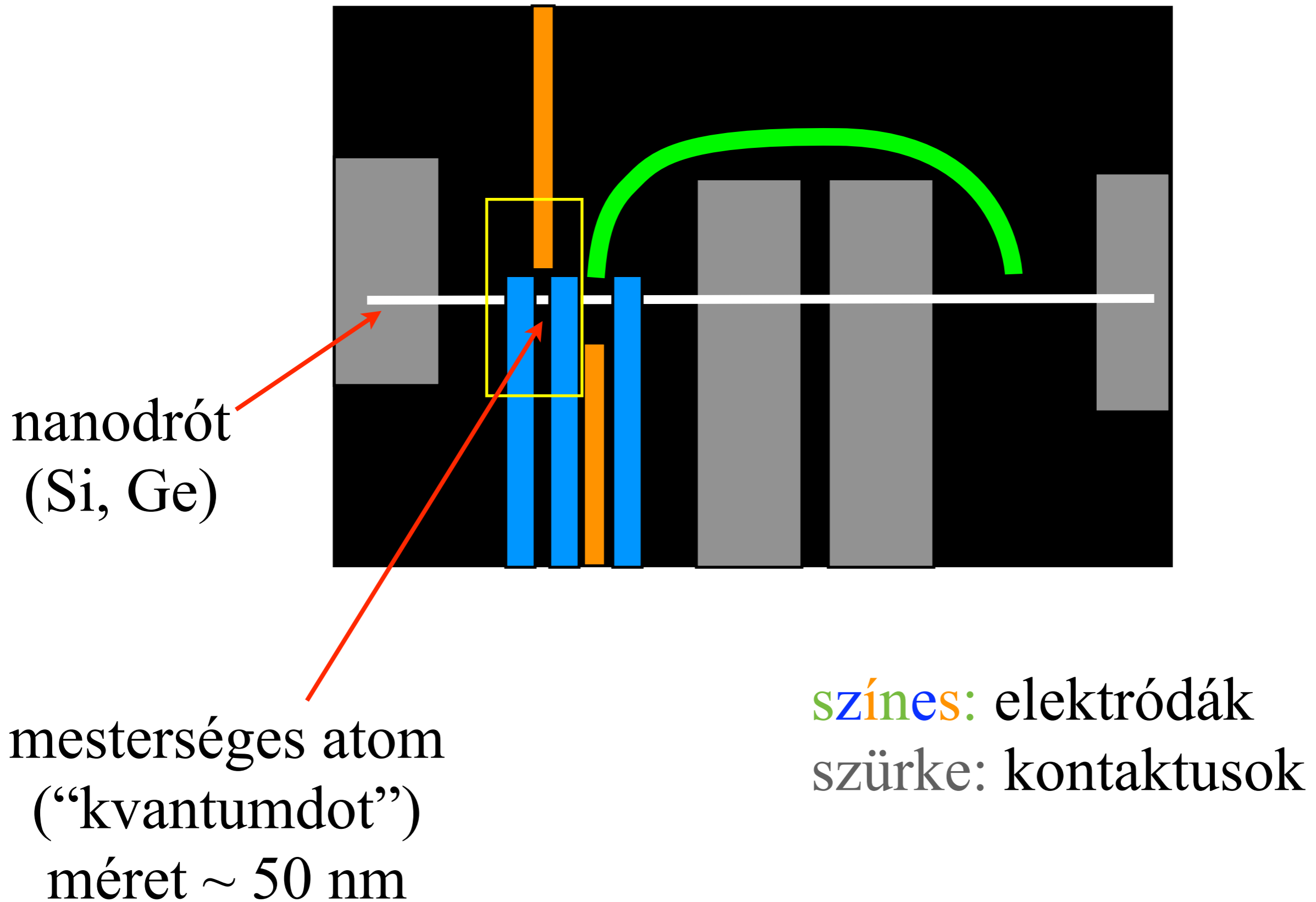


nanodrót
(Si, Ge)

mesterséges atom
("kvantumdot")
méret ~ 50 nm

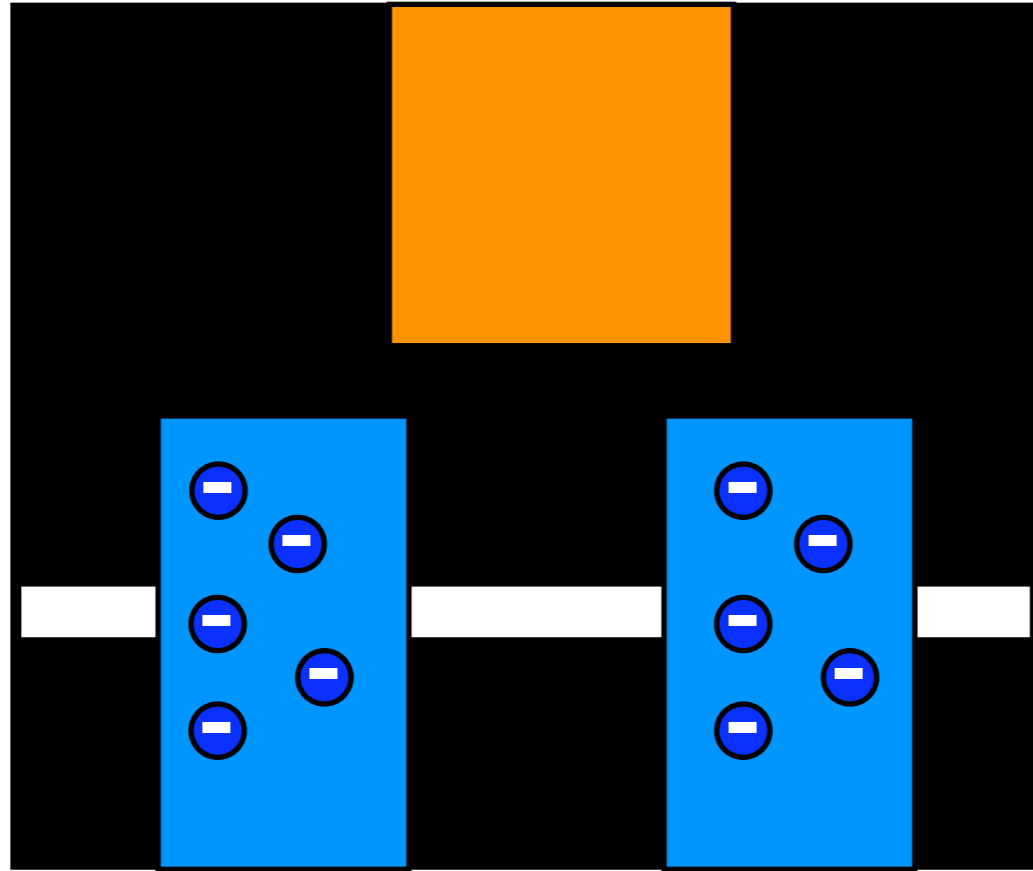
színes: elektródák
szürke: kontaktusok

Mesterséges atomok nanodrótban



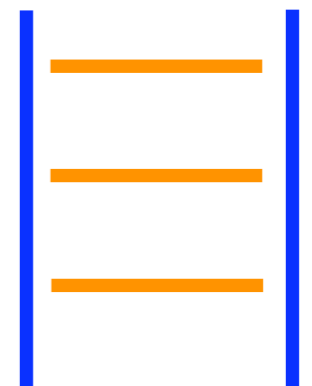
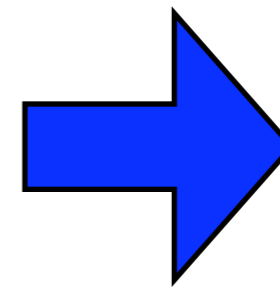
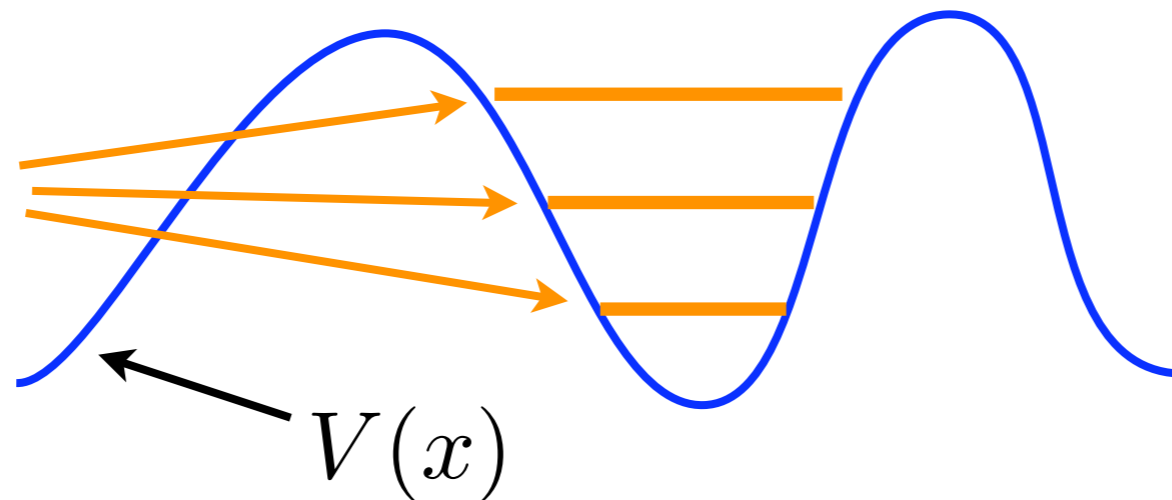
Mesterséges atomok nanodrótban

nanodrót

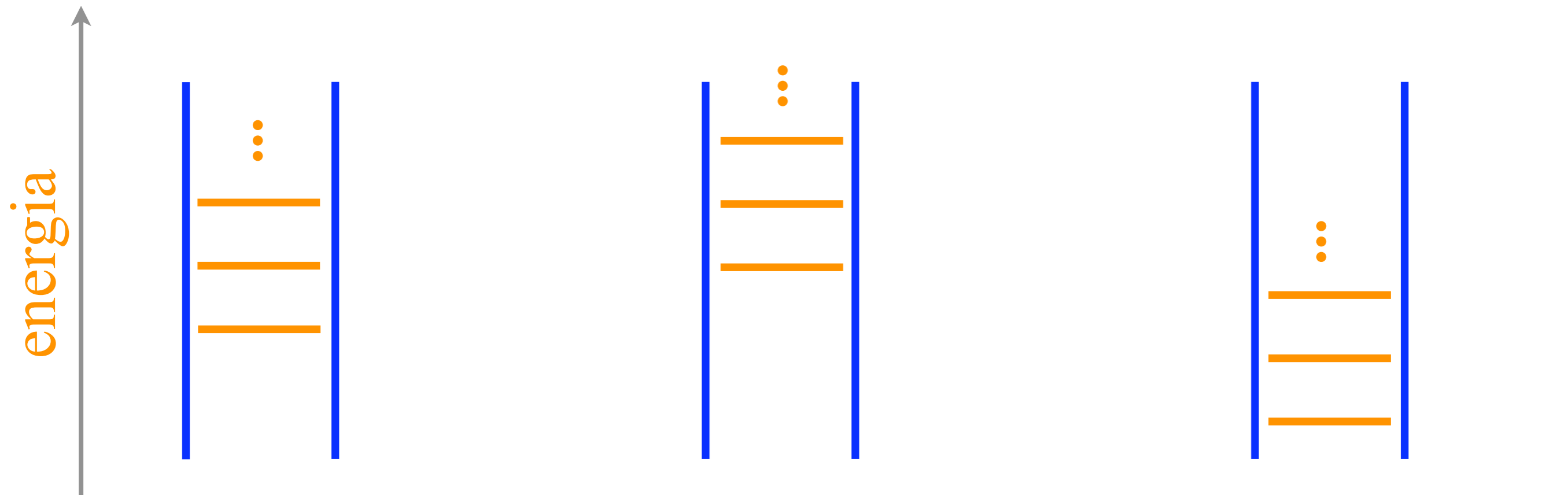
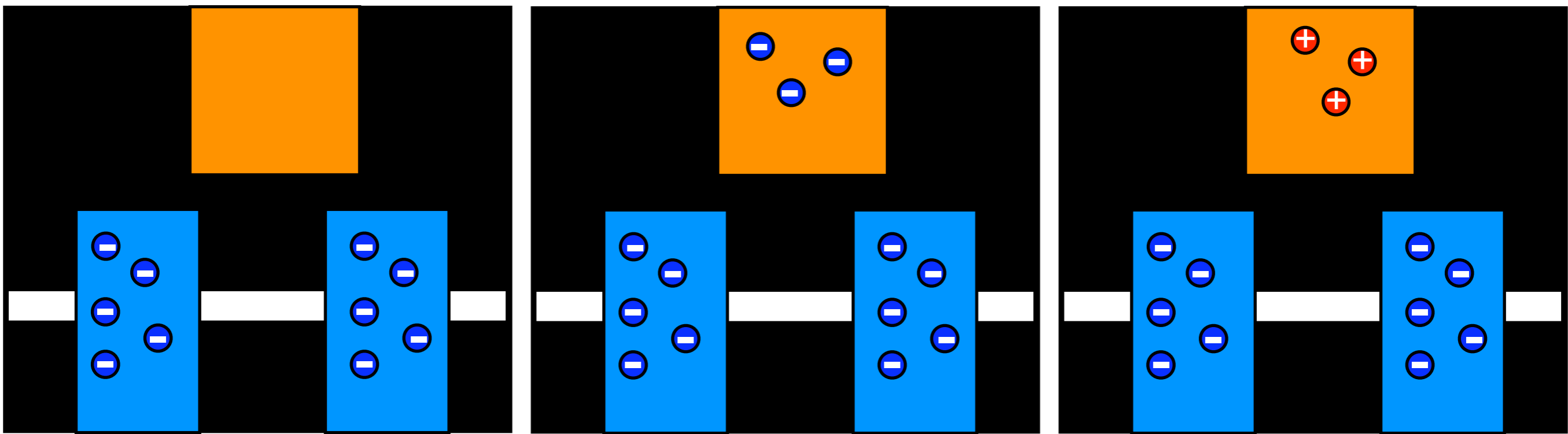


kvantumdot:
egyszerűsített
ábrázolás

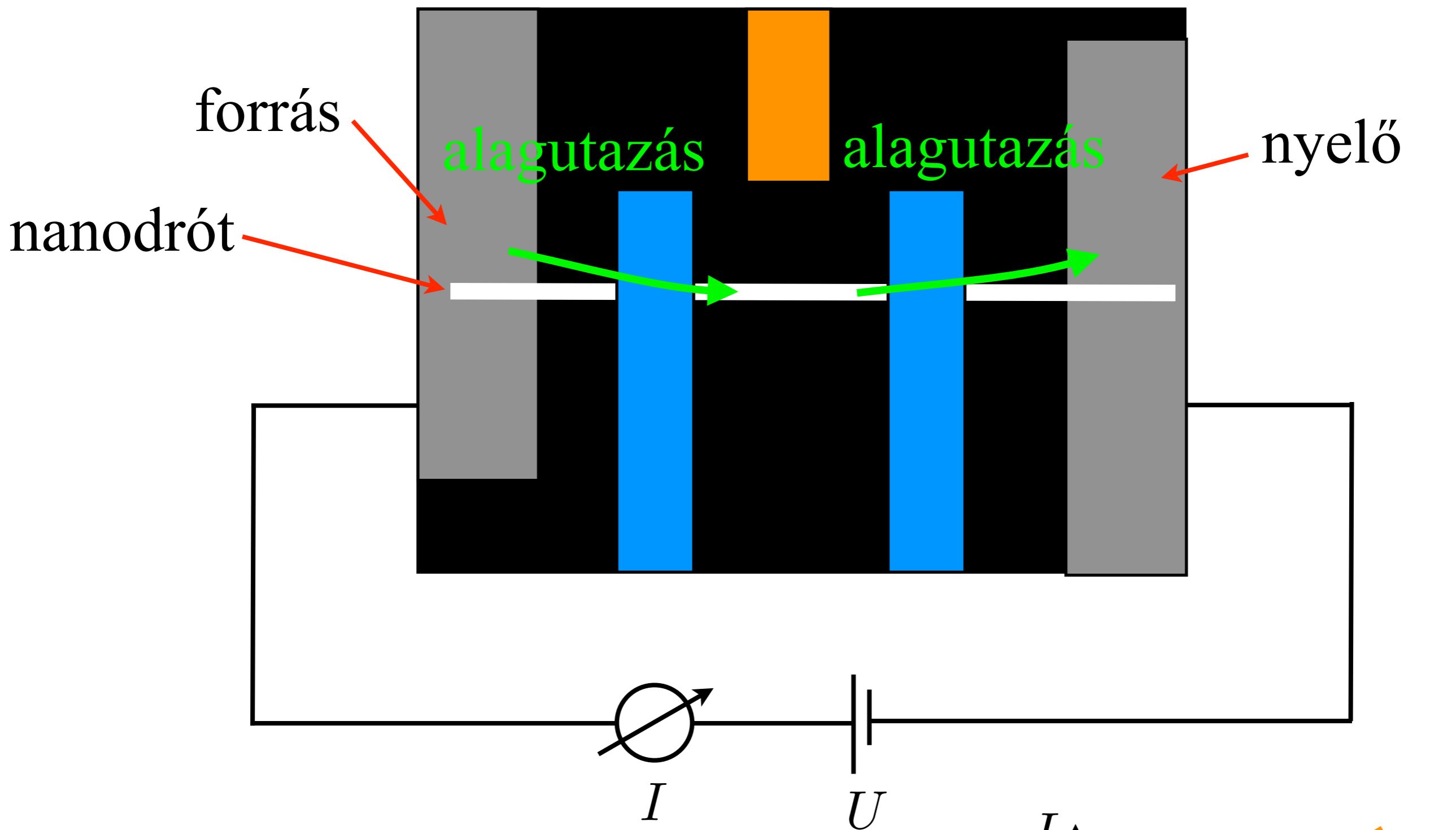
diszkrét
energiaszintek



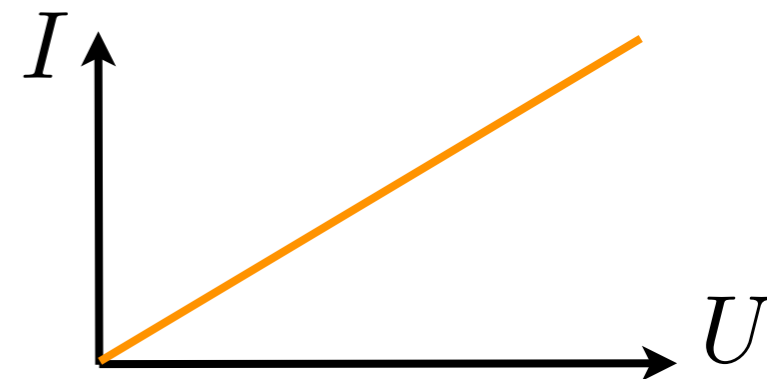
1. Energiaszintek hangolása



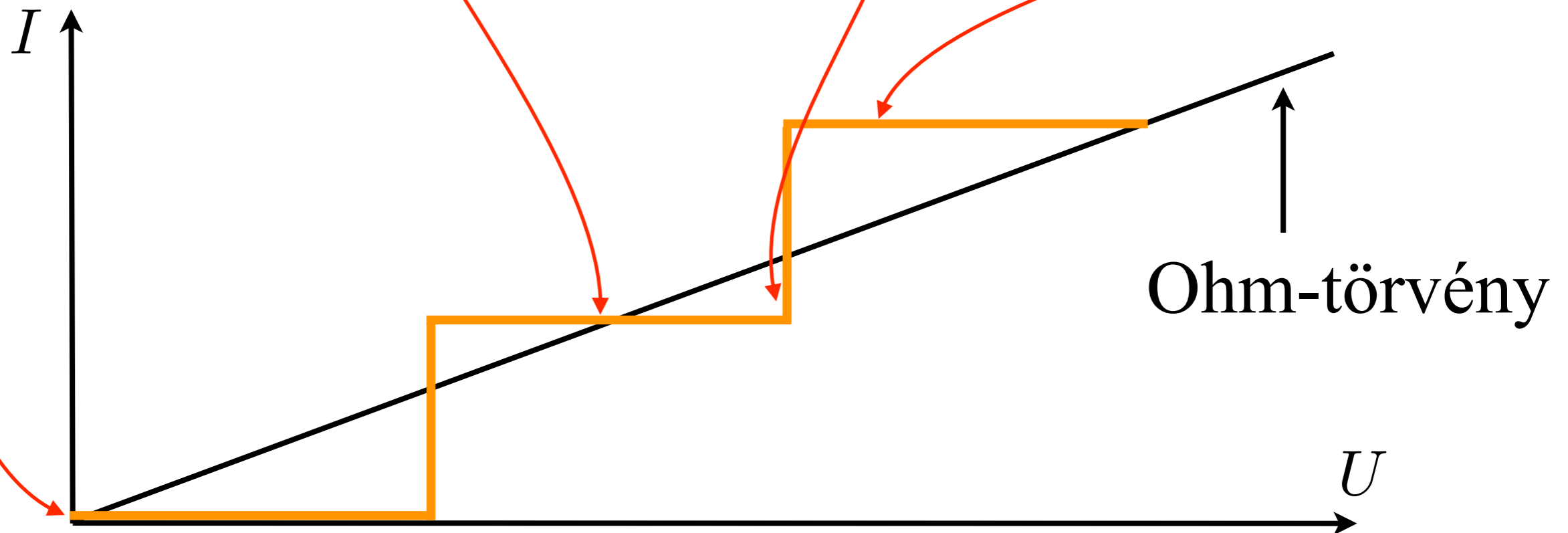
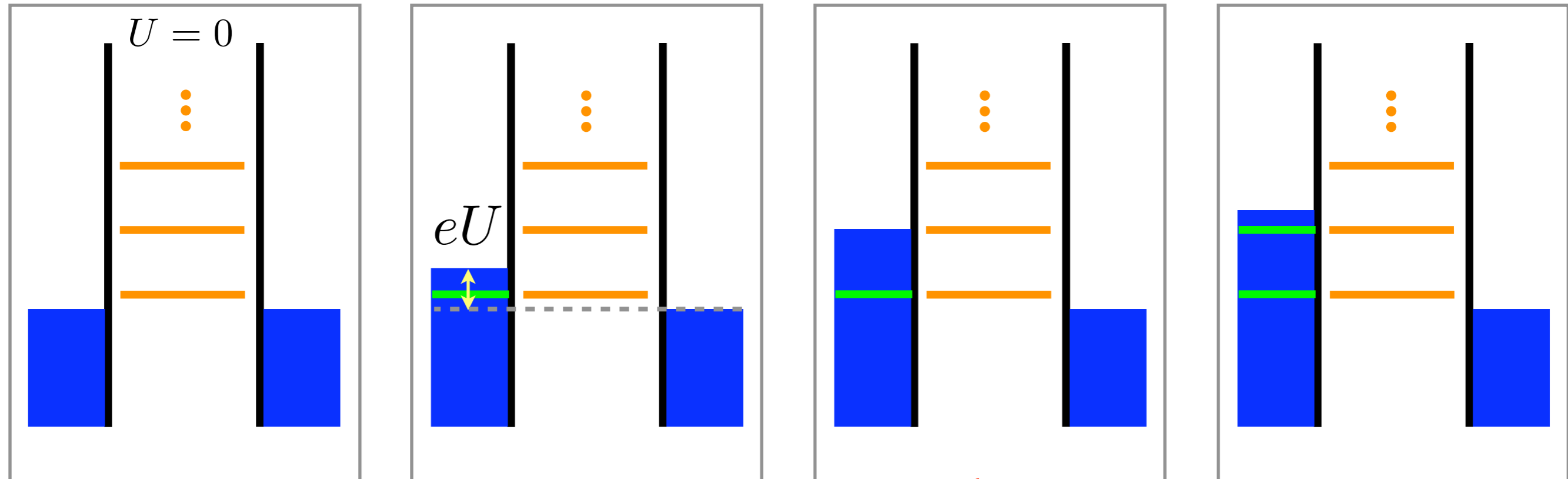
2. Elektromos vezetés kvantumdoton keresztül



Ohm-törvény (itt nem igaz!): $I = \frac{U}{R}$



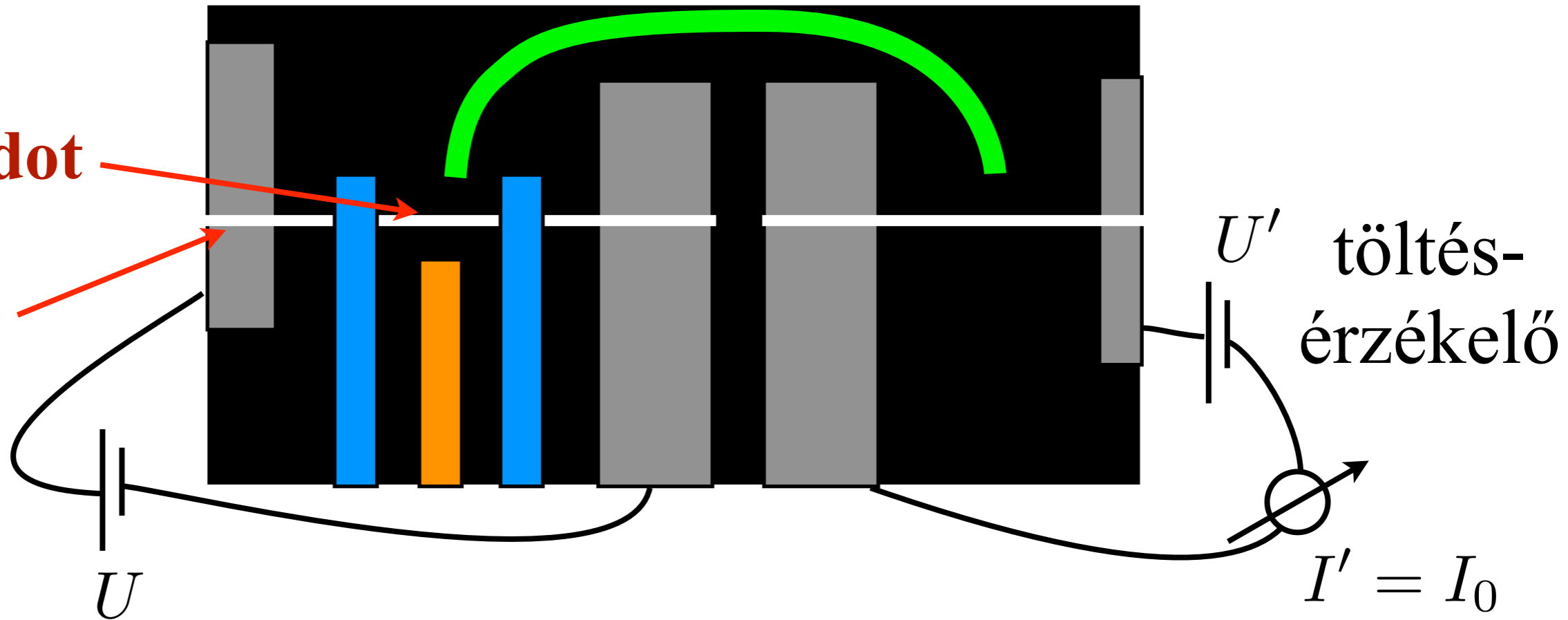
2. Elektromos vezetés kvantumdoton keresztül



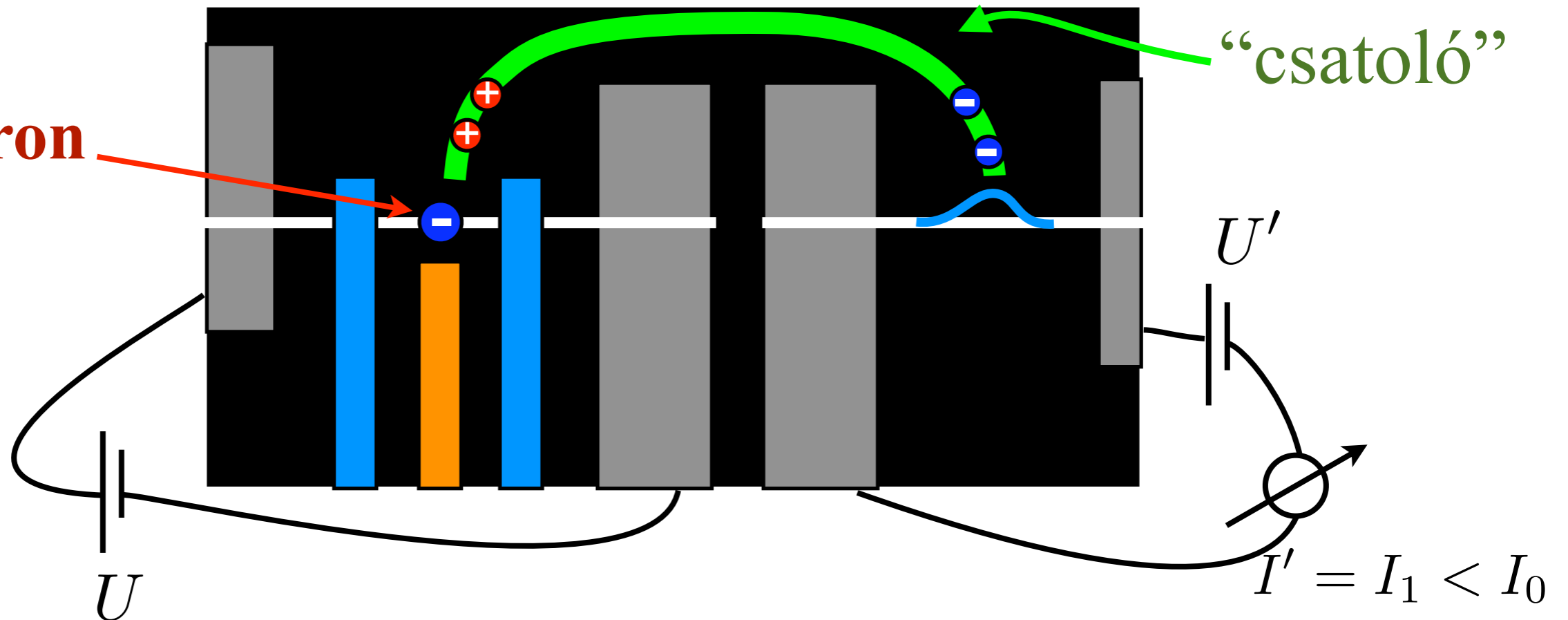
3. Az alagutazás valós idejű megfigyelése

üres
kvantumdot

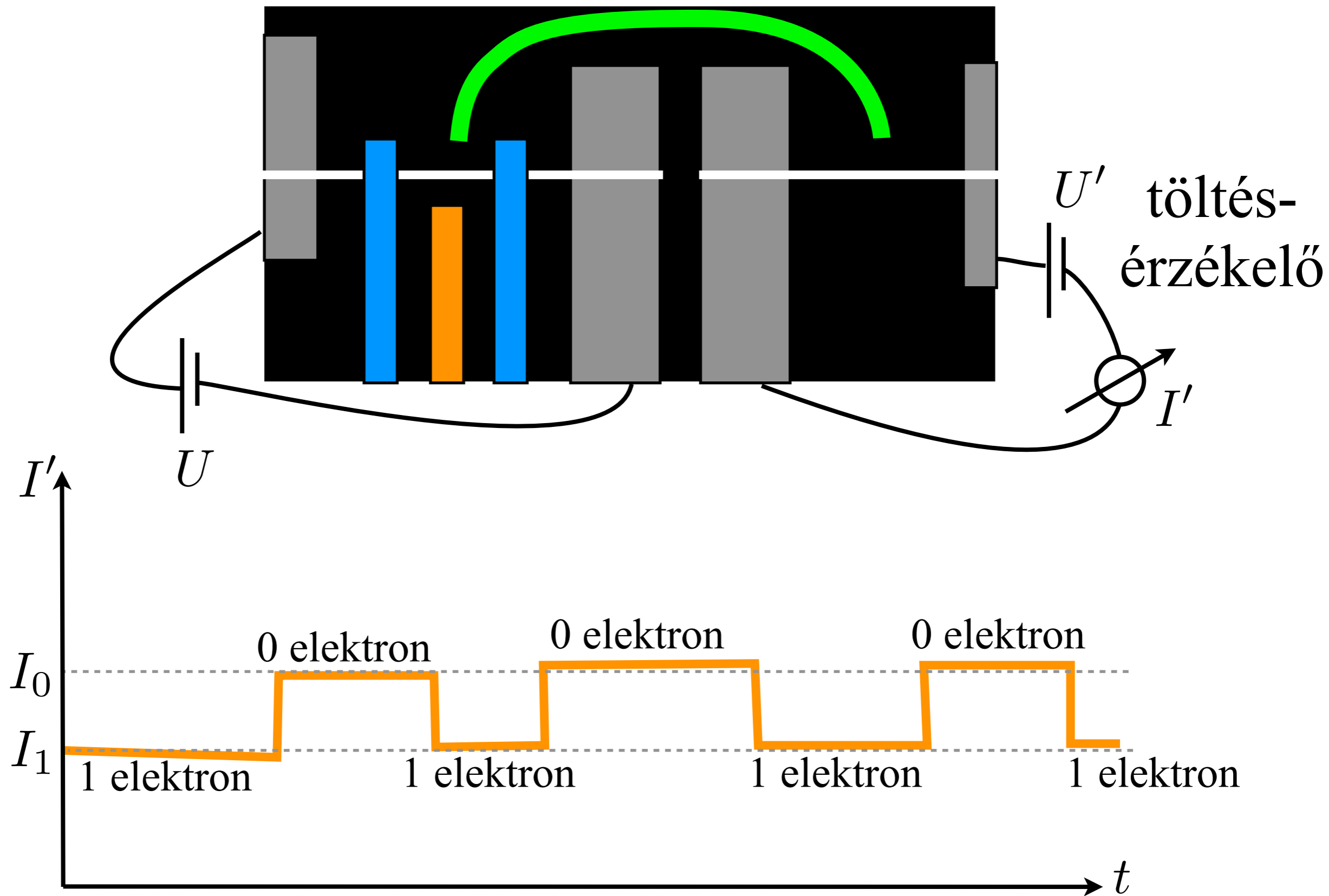
nanodrót



1 elektron

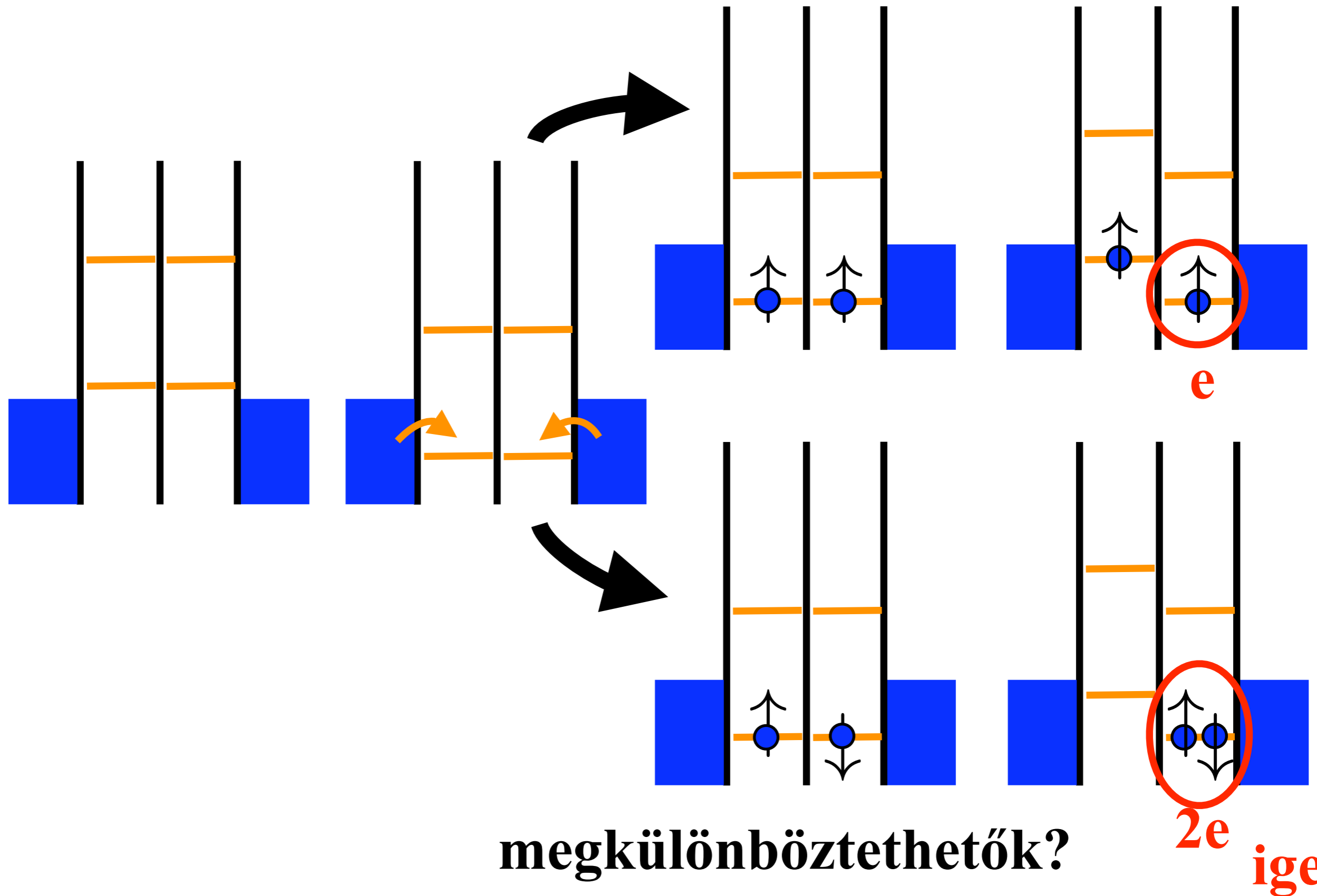


3. Az alagutazás valós idejű megfigyelése



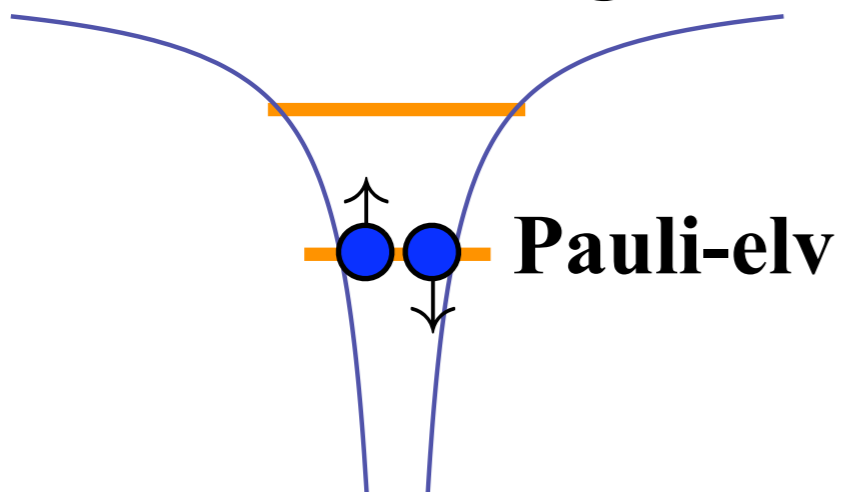
kvantumdot elektronjainak száma mérhető

4. Spin-töltés konverzió kettős kvantumdotban ("Pauli-blokád")

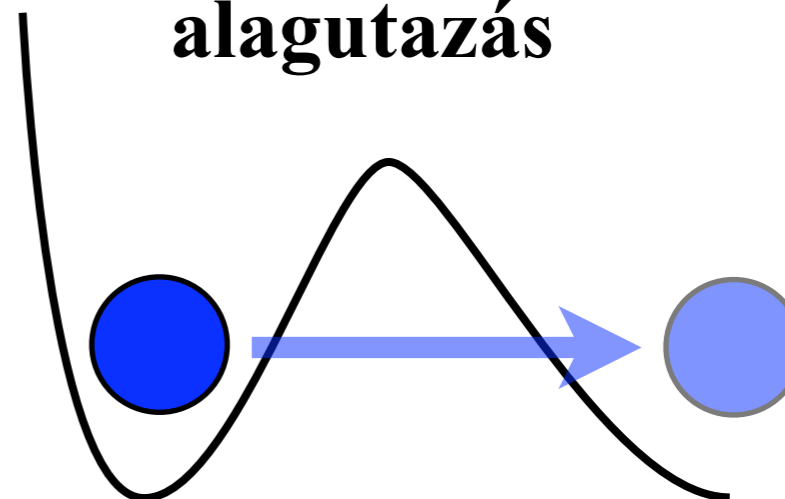


Összefoglalás

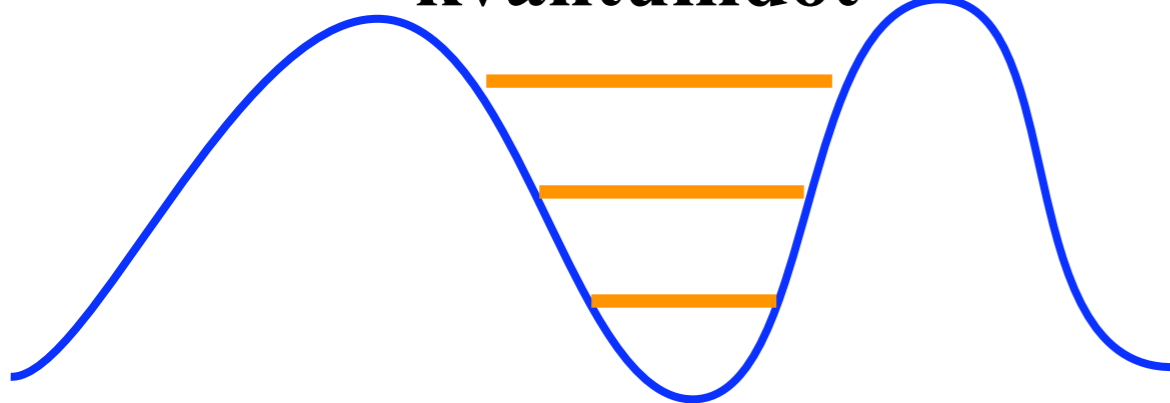
atom diszkrét energiaszintjei



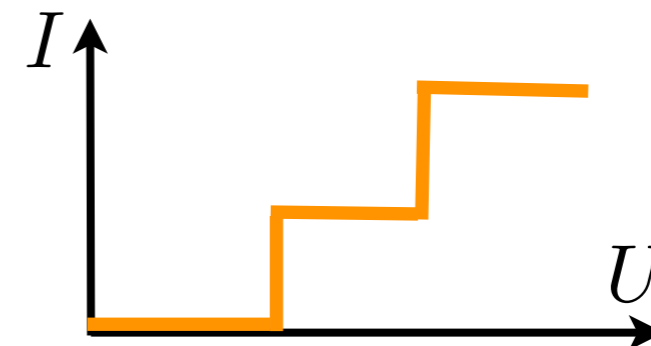
alagutazás



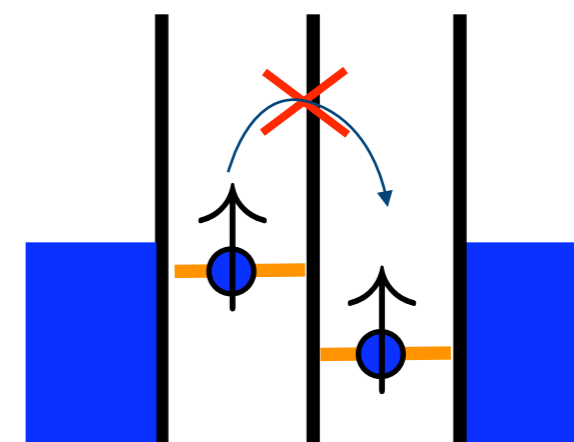
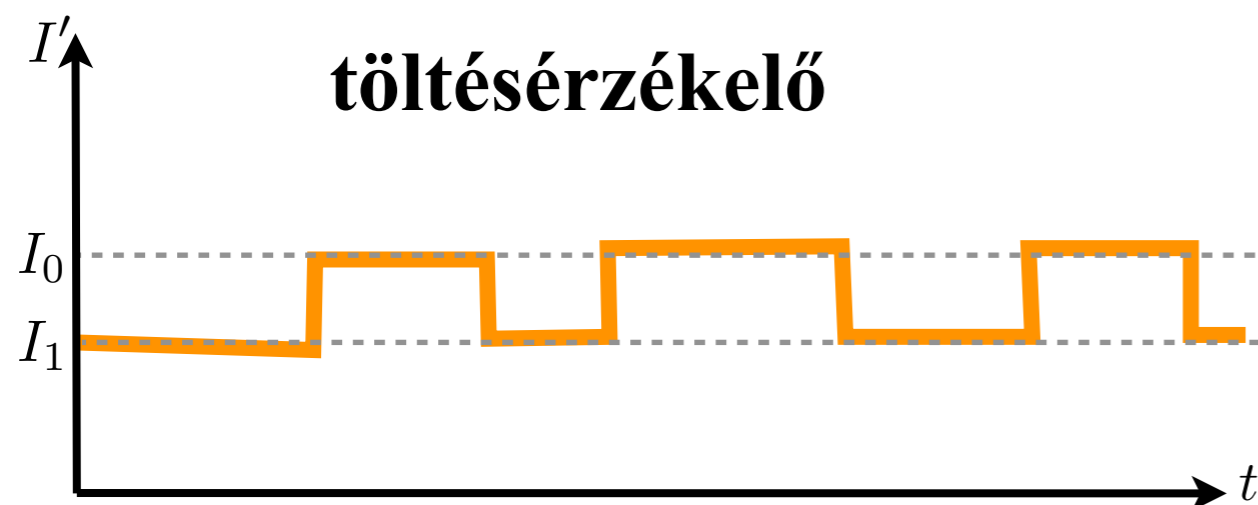
kvantumdot



nem-Ohmikus vezetés



töltésérzékelő



Pauli-blokád