# Experimental Physics 3 - Em-Waves,Optics, Quantum mechanics

Lecture 25

Prof. Dr. Frank Cichos
WS 2022/23

# Some dates in January and February

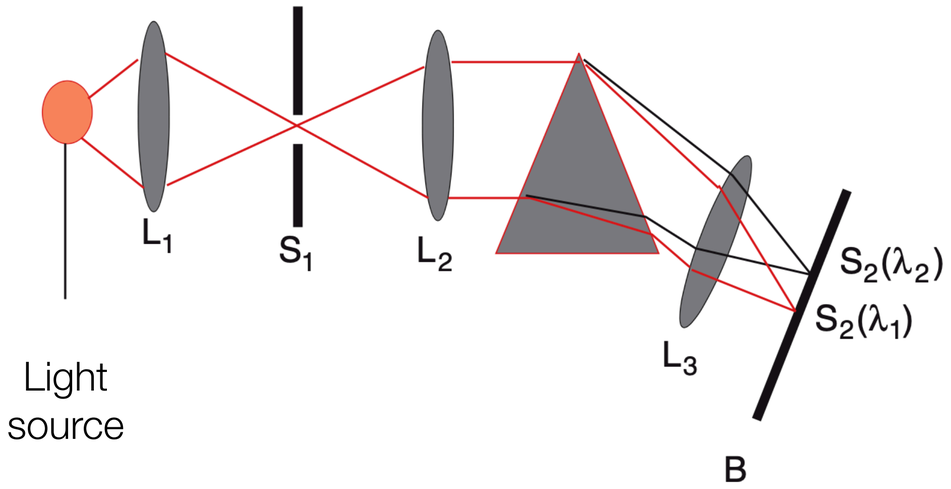
| Mo | Tu | We | Th | Fr | Sa | Su |
|---|---|---|---|---|---|---|
| | | | | | | 1 |
| 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| 9 | 10 | 11 | 12<br>Submission sheet 11 | 13 | 14 | 15 |
| 16 | 17 | 18 | 19<br>Submission mock exam | 20 | 21 | 22 |
| 23 | 24 | 25 | 26<br>Submission sheet 12 | 27 | 28 | 29 |
| 30 | 31<br>Last Tuesday seminar | 1 | 2<br>Last Thursday seminar<br>Last lecture | 3 | | |

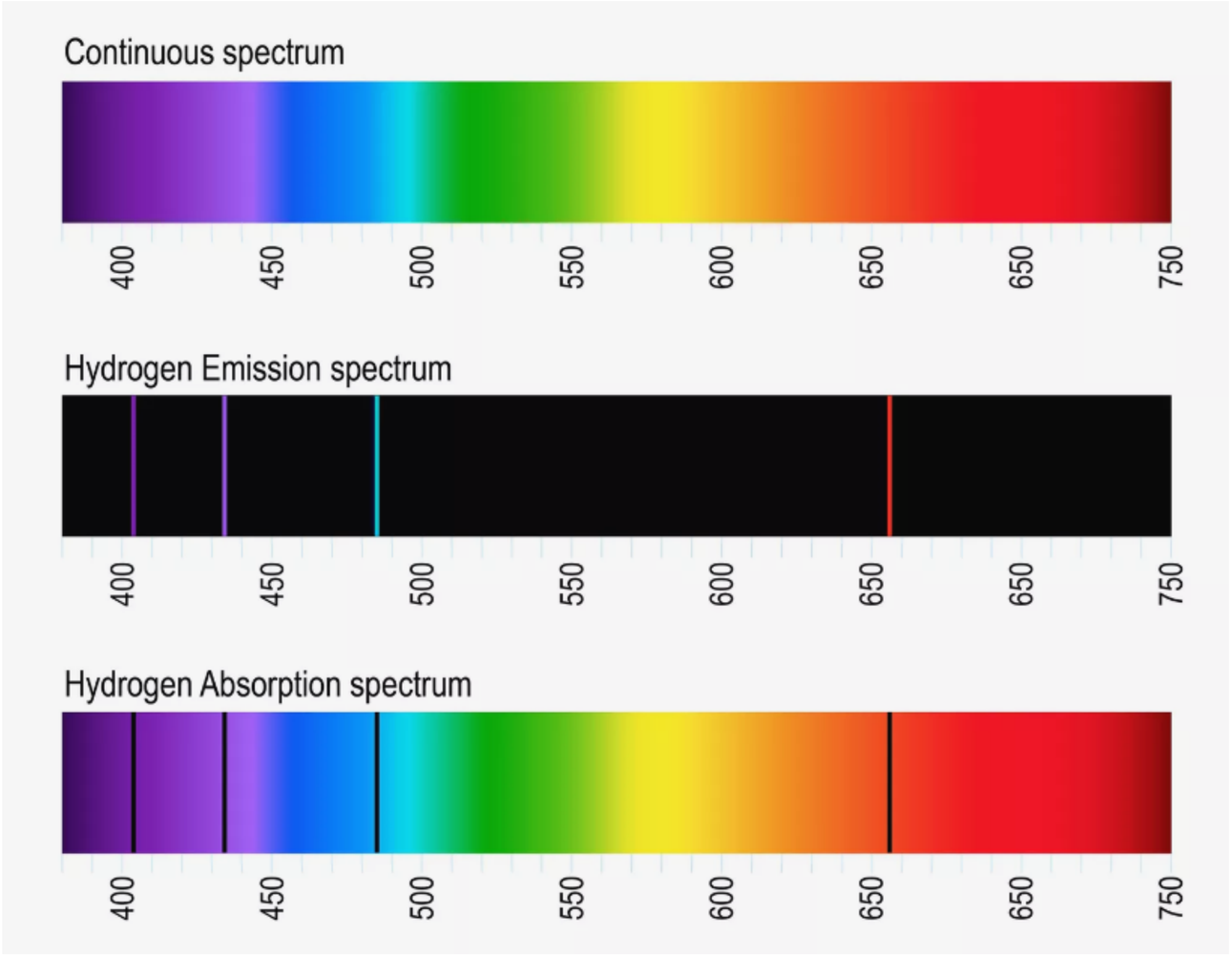
Exam: February 20, 2023, 9 am - 12 pm, 1 (one) DIN A4 page lettered

Re-exam: March 27, 2023, 9 am - 12 pm

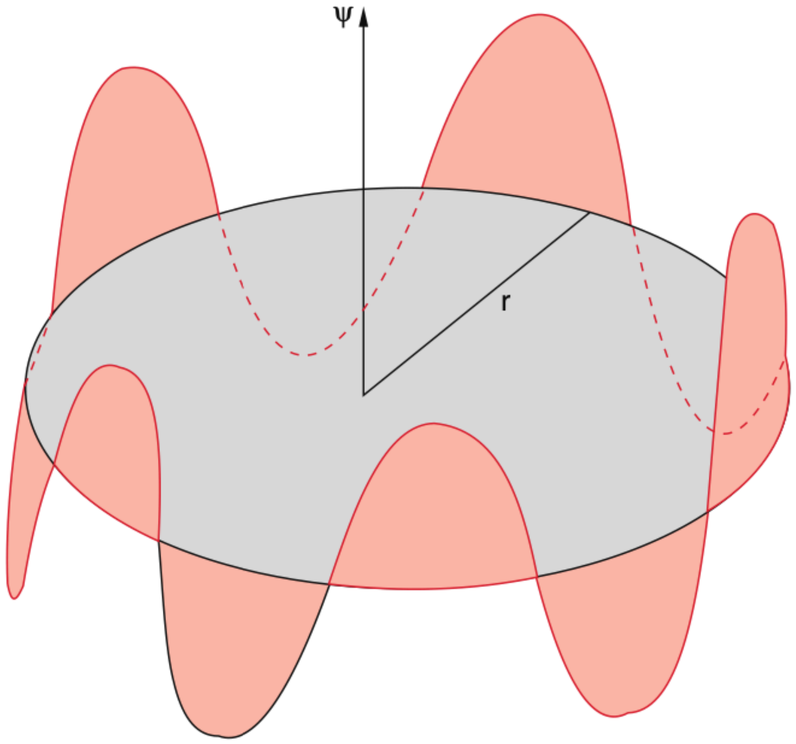
# The Bohr model

# Bohr model - line spectra



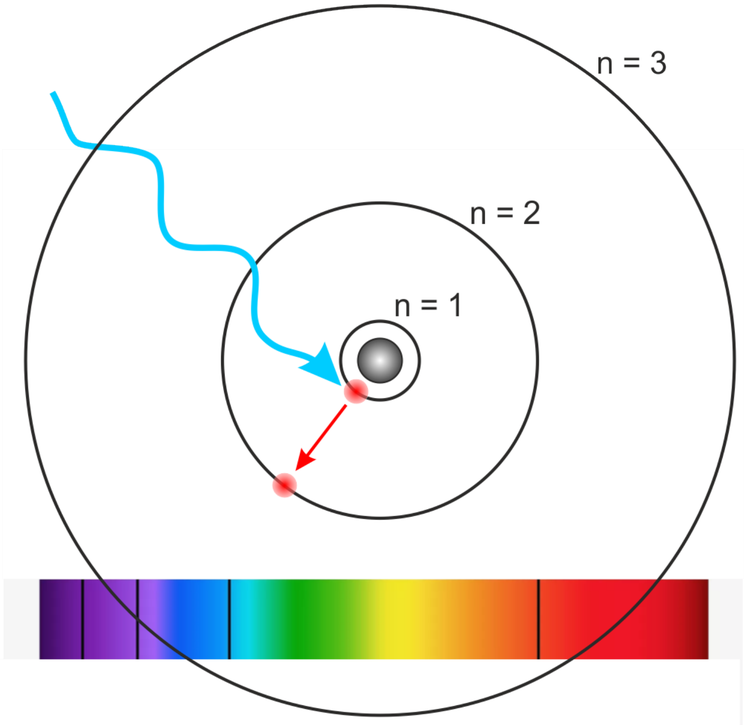
# Bohr model - line spectra due to absorption and emission




Quantization of electron angular momentum

$\Longleftrightarrow$

Constraining orbit circumference




$$E_n = -Ry^* \frac{Z^2}{n^2}$$

$$r_0 = \frac{a_0}{Z} n^2$$

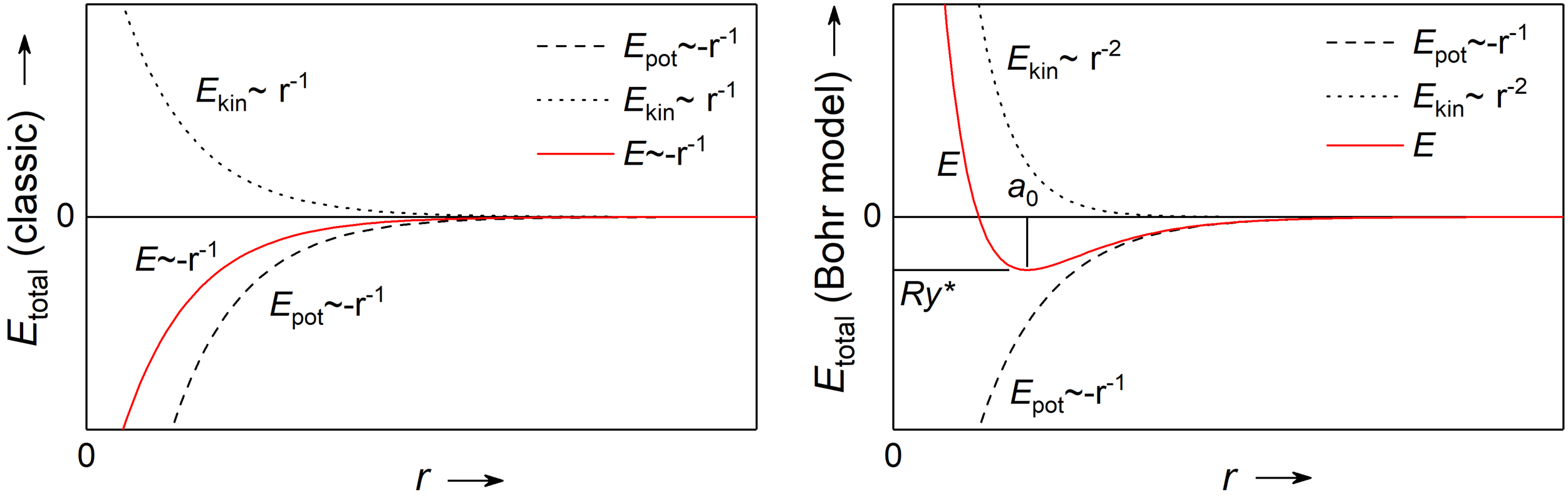
$$E_{min} = -Ry^*$$

$$r_{min} = a_0$$

$$E_k - E_i = Ry^* Z^2 \left( \frac{1}{i^2} - \frac{1}{k^2} \right)$$

$$= \hbar \cdot \omega$$

# Bohr model - stable electron radius



# The Schrödinger equation

# Schrödinger equation

Classical mechanics

- Conservation of energy
- Prospective conditions by Newton's law

$$
\begin{aligned}
E_{\text{kin}} + E_{\text{pot}} &= E \\
T + V &= E \\
\frac{1}{2} m v^2 + E_{\text{pot}} &= E \\
\frac{p^2}{2m} + E_{\text{pot}} &= E
\end{aligned}
$$

$$
\begin{aligned}
x &\longrightarrow x \\
p &\longrightarrow \frac{\hbar}{i}\frac{\partial}{\partial x} \\
H &\longrightarrow -\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2} + E_{\text{pot}}
\end{aligned}
$$

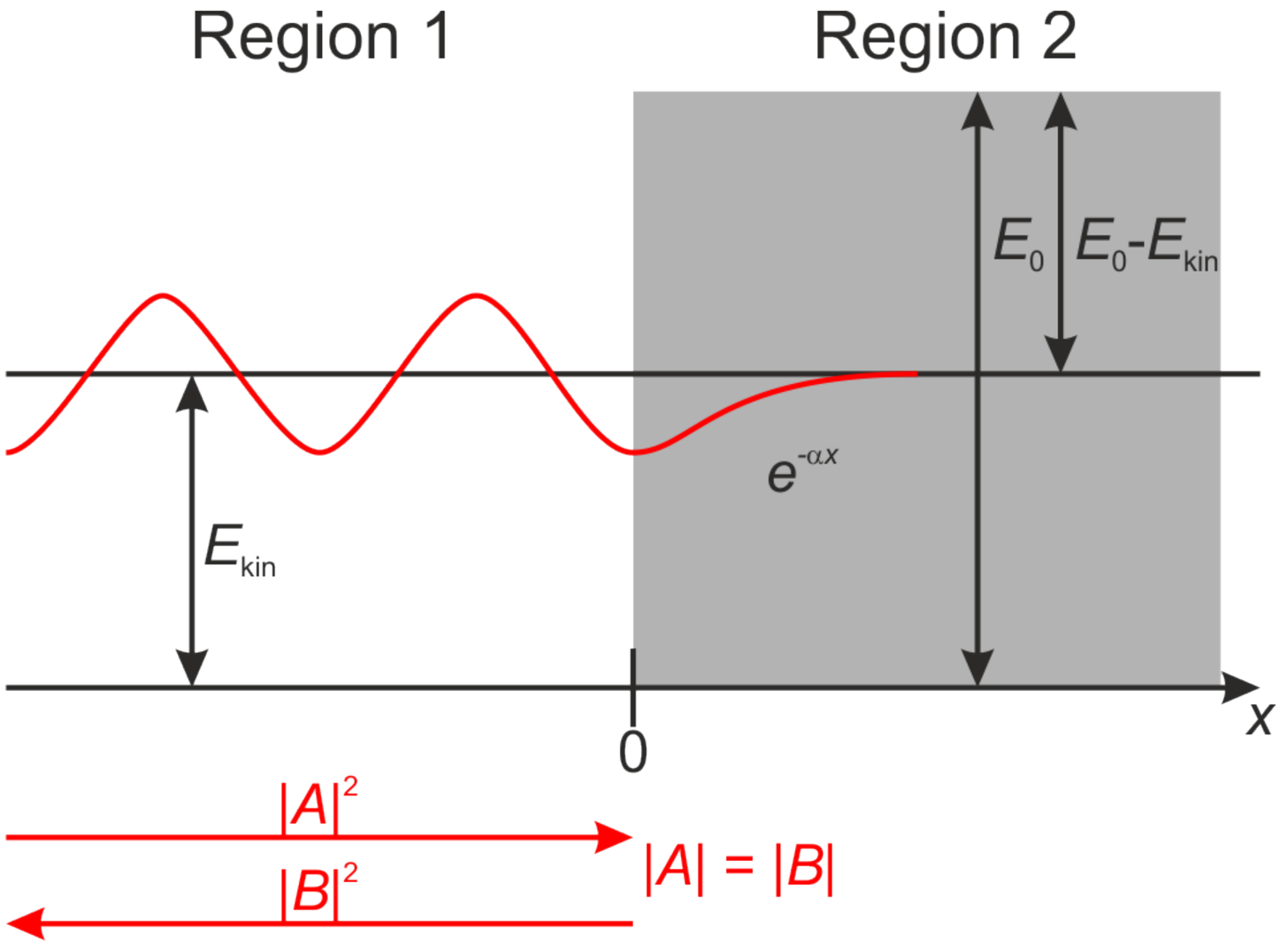
Quantum mechanics

- Conservation of energy
- Prospective conditions by Schrödinger equation
- Physical variables become „operators"
- Observables are operator eigenvalues

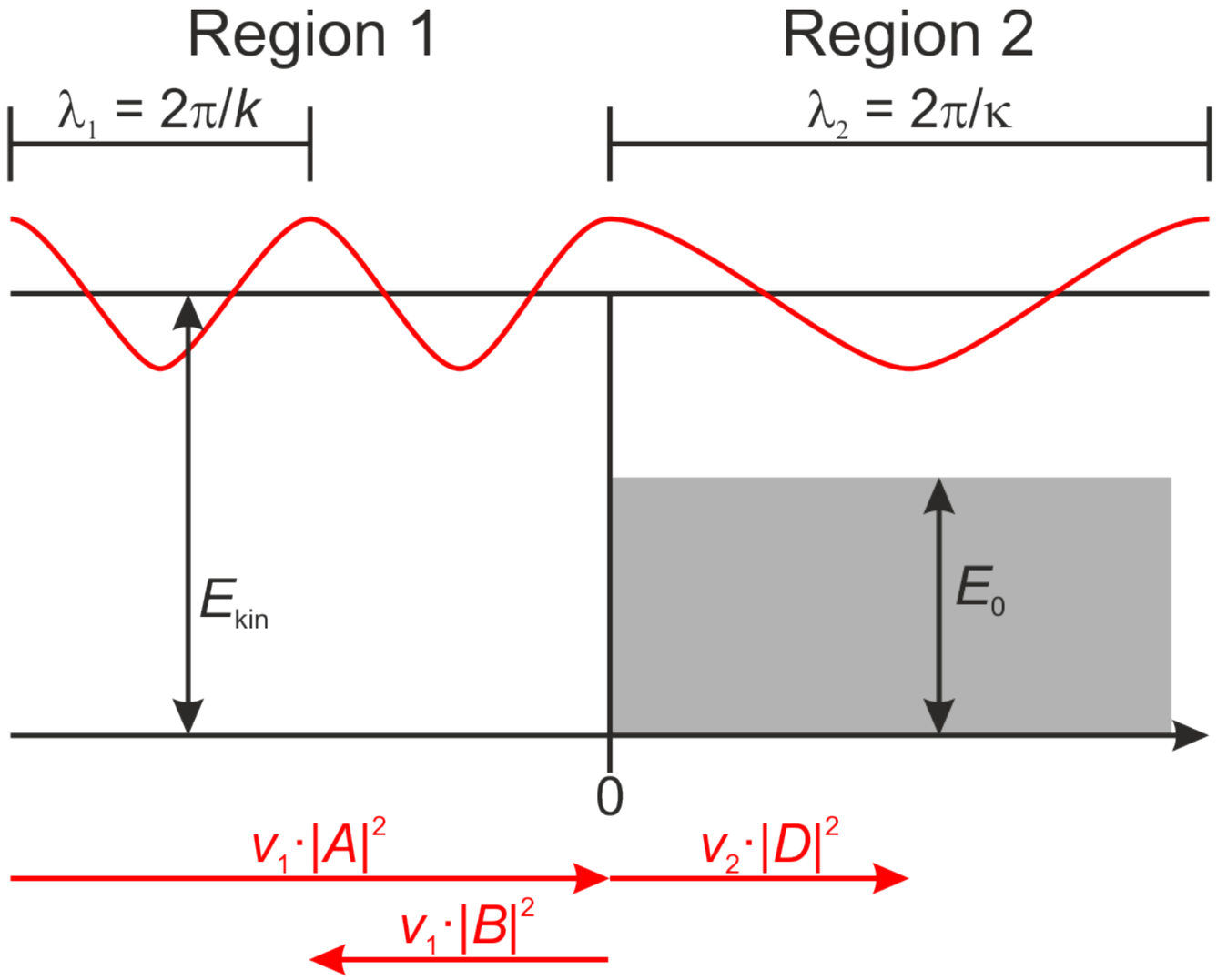
$$H\psi = E\psi$$

$$-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}\psi + E_{\text{pot}}\psi = E\psi$$

# Schrödinger equation - potential barrier $0 < E < E_0$



# Schrödinger equation - potential barrier $0 < E_0 < E$



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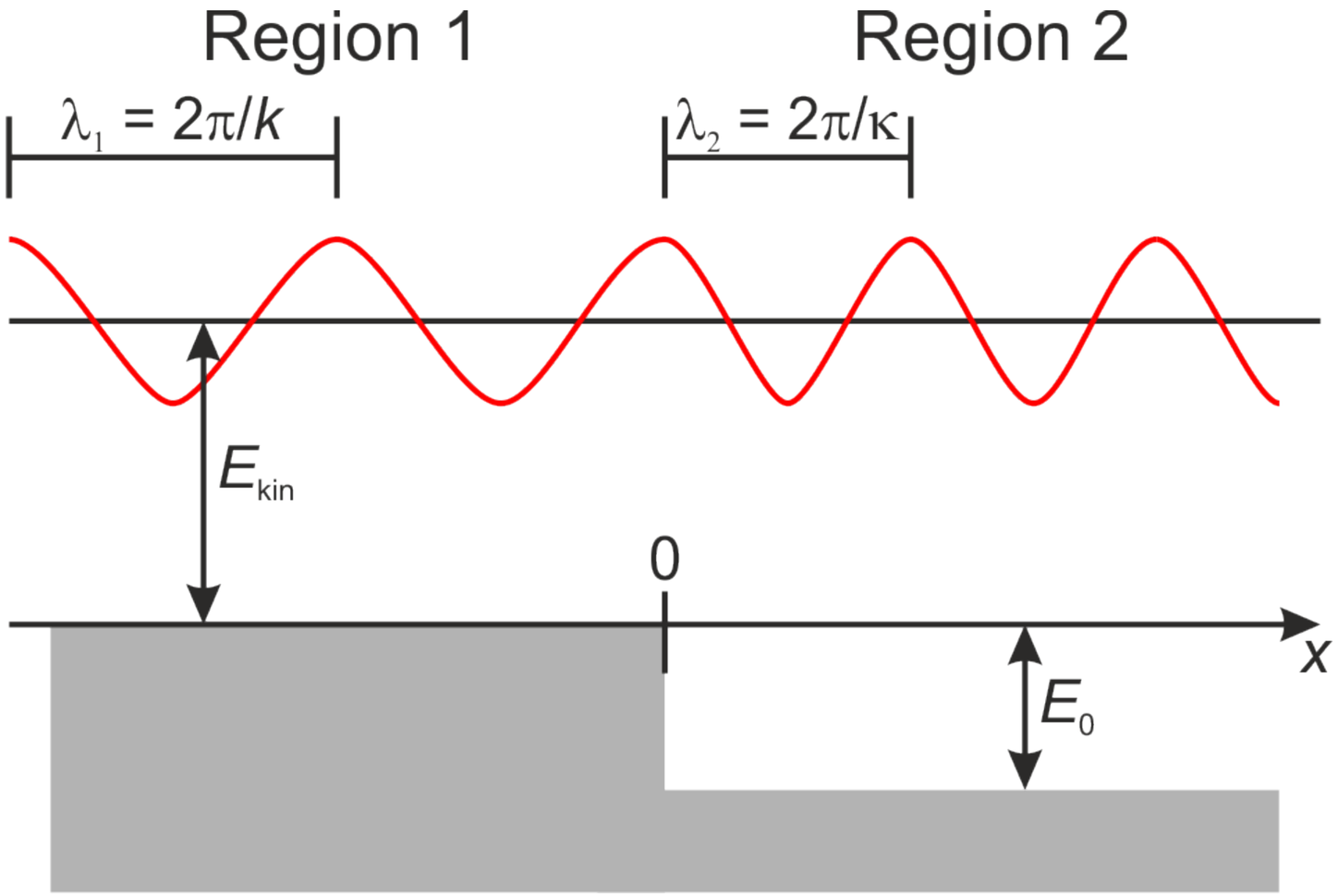

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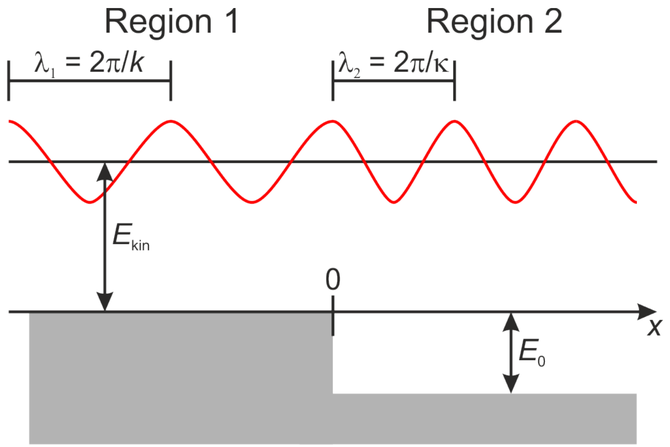


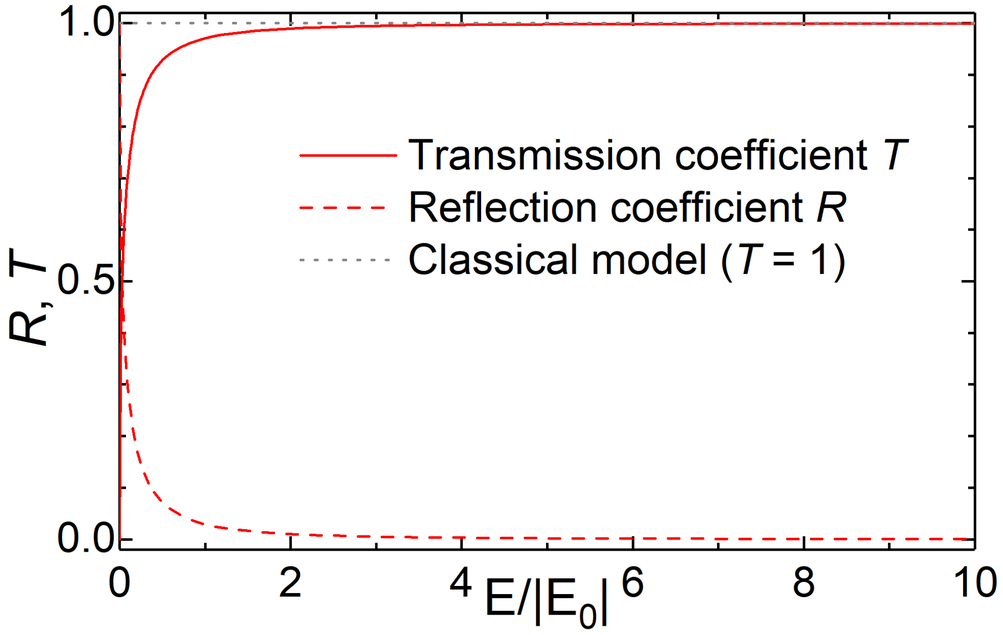


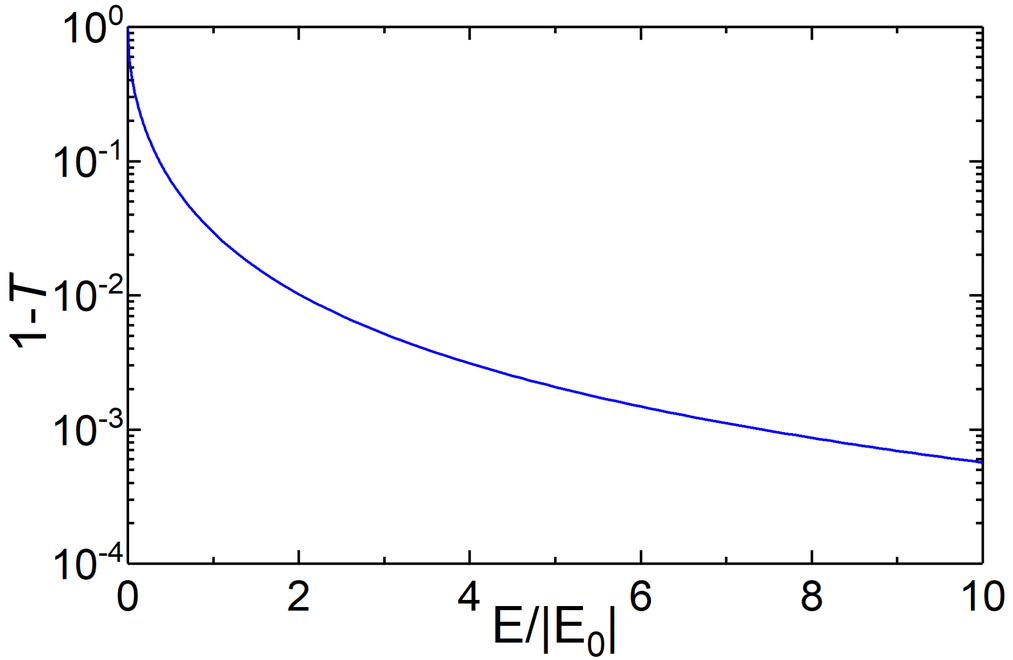

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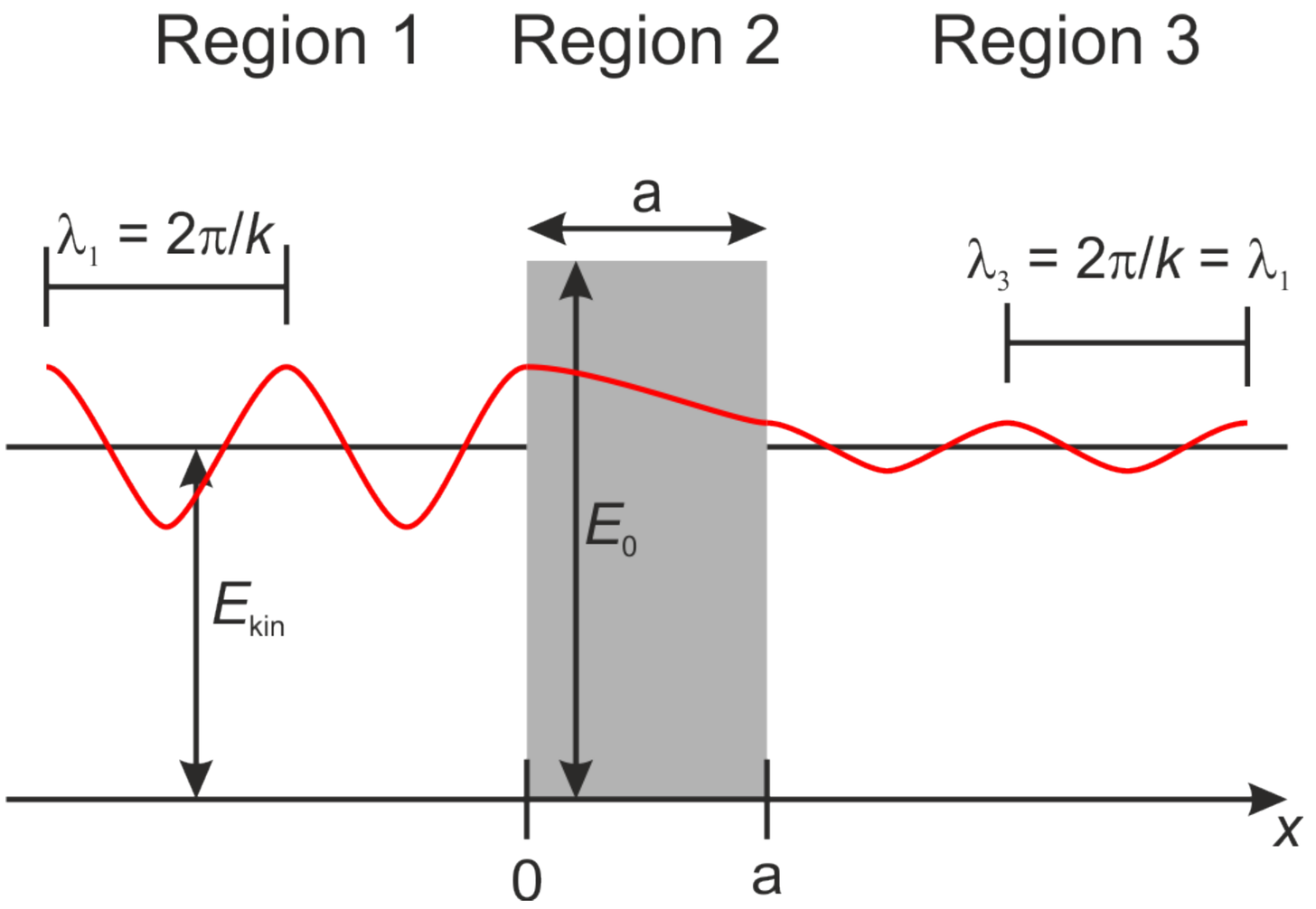

# Schrödinger equation - quantum tunnelling