Exercise Sheet 12 **Theoretische Physik 4: Quantenmechanik**

SoSe 2025 Prof. Dr. C. Gros

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Exercise 1 (9 points)

A particle of mass m is in the ground state of a one-dimentional simple harmonic oscillator, with frequency ω_o. At time $t = 0$ the perturbation

$$V(\hat{x}, t) = V_0 \, \hat{x}^3 \, e^{-t/\tau}$$

is switched on, where τ is a known constant (with units of time).

1. (4/9) Find the probability that the particle is excited to the first excited state, as $t \to +\infty$.
2. (5/9) Find the probability that the particle will be found in an excited state, as $t \to +\infty$.

Exercise 2 (11 points)

A hydrogen atom is in its ground state as $t \to -\infty$. A weak electric field is applied along the z–axis,

$$\mathbf{E}(t) = \frac{E_0 \, \tau}{\tau^2 + t^2} \, \mathbf{e}_z,$$

where τ is a known constant (with units of time).

1. (4/11) Find the selection rules when your initial state is the hydrogen atom ground state.
2. (5/11) Find the probability of finding the atom in the $2p$ state, as $t \to +\infty$.
3. (2/11) What happens to the above probability when $\tau \to 0^+$ and $\tau \to +\infty$? Comment on the result.