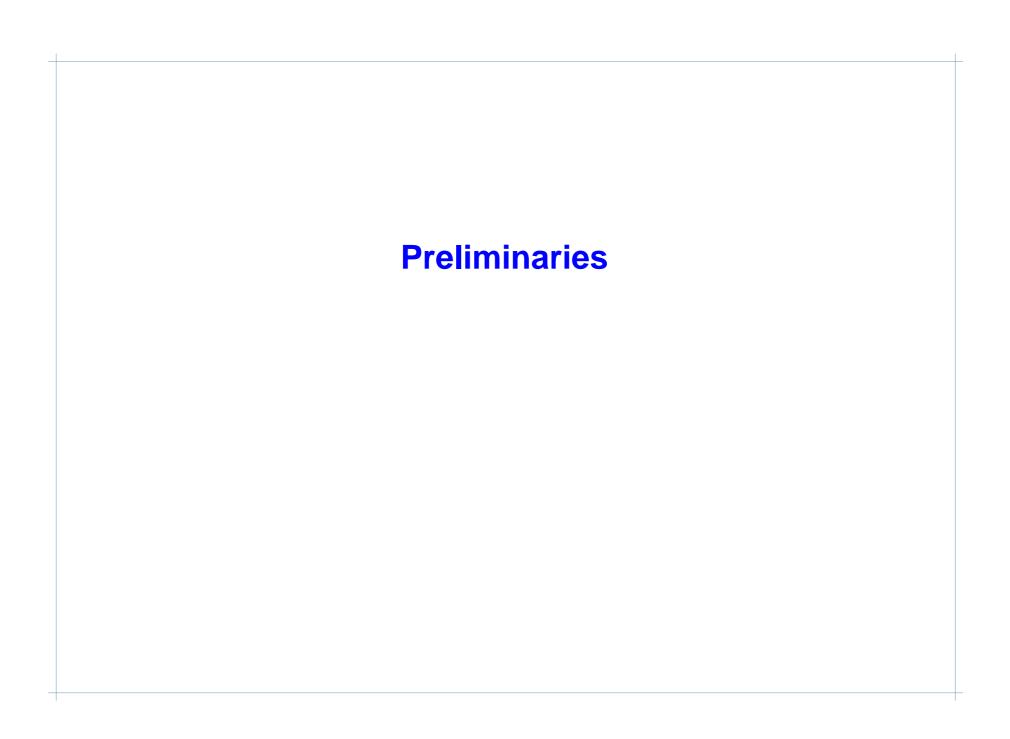


Advanced Quantum Theory

Manfred Salmhofer, Institut für Theoretische Physik

Meisterklasse 2011

Lecture 1, April 15, 2011



Coordinates

Module: MVAMO2, 2L+1T, 4 Credit Points

Lecture days and times:

Fridays, 9-11, großer Hörsaal, Philosophenweg 12

Tutorials: Tuesdays, every second week

Albert-Ueberle-Straße 3-5, Seminarraum I

INF 227, Seminarraum 1.404

please register for the tutorials

Additional lectures on certain Tuesdays: May 24, June 7, July 5

(saves some Fridays)

Credits and Examinations

Homework. Problem sets handed out before lectures;

due one week or ten days later.

Homeworks will be graded; admission to the exam if at least 50 % solved in a meaningful way.

Final: Takes place in exam week.

Contact

e-mail msalmhof@gmail.com

coming up soon:

http://www.thphys.uni-heidelberg.de/~salmhof/AQT11/AQT11.html

Kambis Veschgini (K.Veschgini@thphys.uni-heidelberg.de)

organizes the tutorials

Contents

Modulhandbuch says

Module Contents (selection out of the following topics):

- Quantum theory of matter (Schrodinger equation, bosons and fermion, spin and statistics)
- Time-dependent quantum phenomena (scattering, atoms and molecules in external fields)
- Theory of quantum states (system and environment, pure and mixed states, density operator, entanglement, quantum information)
- Quantum theory of light and matter (quantized fields, interaction with atoms, quantum optics)
- Open quantum systems (matter and radiation, decoherence, non-equilibrium phenomena)
- Relativistic quantum theory (Dirac equation, relativistic light-matter interaction)

Objective: Understanding of fundamental concepts of quantum physics and the relevant theoretical methods

Prerequisites: not just PEP1-4, but also all standard Bachelors' theory courses, in particular Quantum Mechanics

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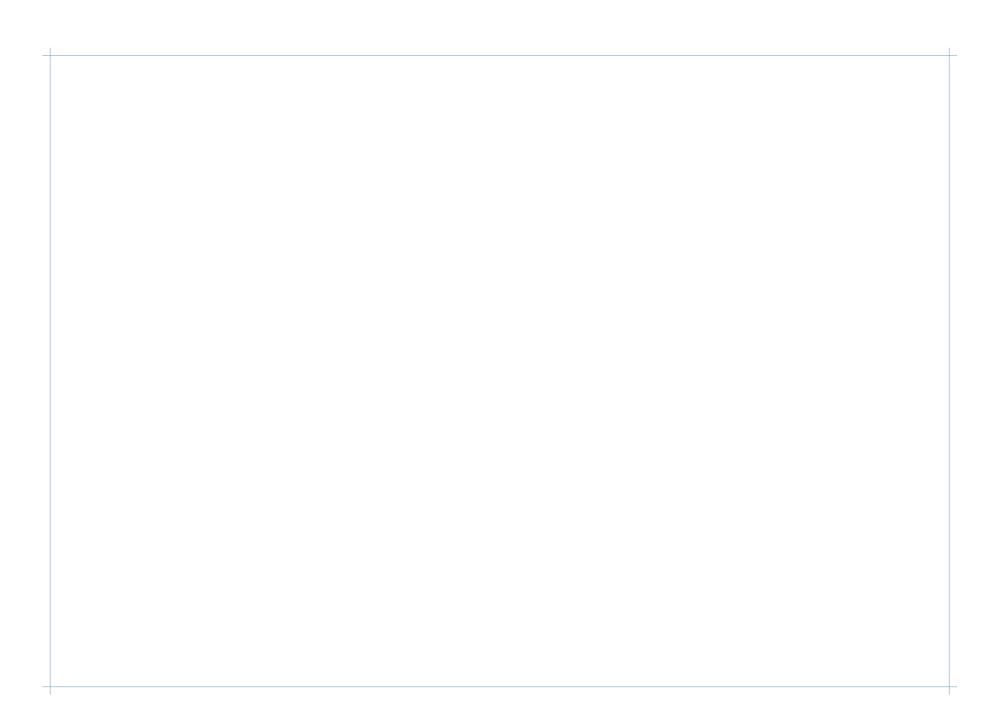
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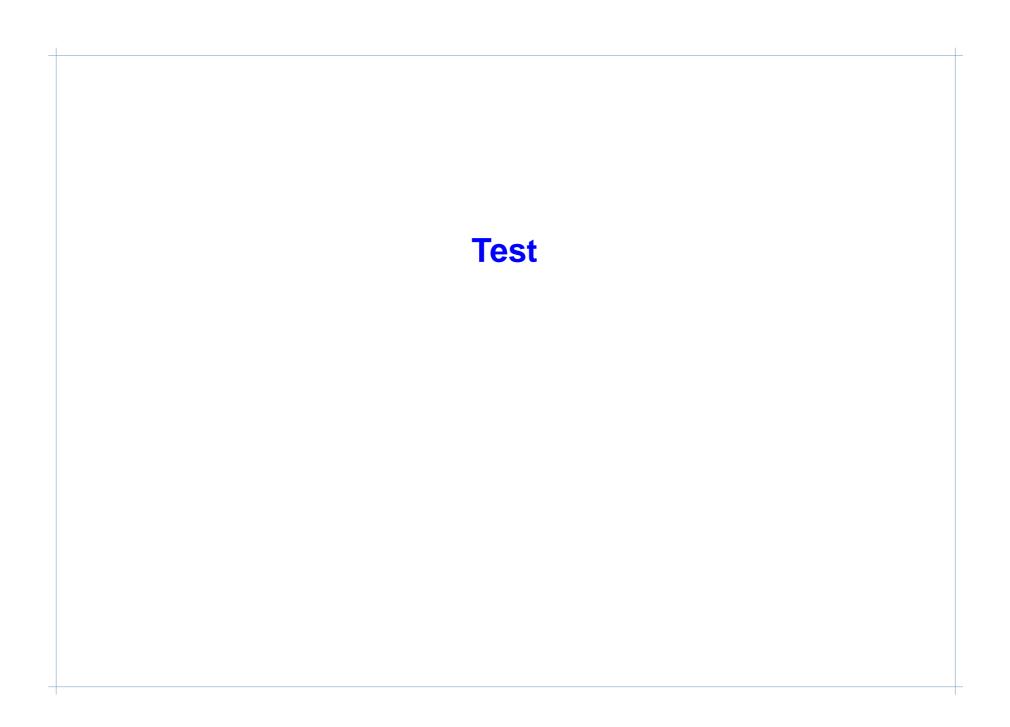
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Carsten Müller offers a course "Fundamentale Wechselwirkungsprozesse zwischen Elektronen und Photonen"





Ten questions about quantum mechanics

- 1. what is a quantum mechanical state
- 2. write down the time-dependent and the stationary Schrödinger equation, and explain the relation between the two
- 3. what is the interpretation of the wave function $\psi(t,x)$, and by which conservation law is it justified
- 4. why does $\psi(t,x)$ not simply define a mass density
- 5. what are quantum mechanical observables
- 6. what are the possible outcomes of experiments for an observable
- 7. what is the expected value and the variance of an obervable
- 8. under what condition are observables jointly measurable
- 9. what is the uncertainty relation and what does it mean
- 10. is time a quantum mechanical observable

Twenty questions about quantum mechanics

- 11. Is $-\frac{d^2}{dx^2}$ a positive or a negative operator on $\mathcal{S}(\mathbb{R})$?
- 12. Find the ground state of $H = \frac{1}{2} \left(-\frac{d^2}{dx^2} + x^2 \right)$.
- 13. what is the spectrum of the H in 12. Why?
- 14. what is the Hamiltonian for the hydrogen atom
- 15. what is the spectrum of the hydrogen atom
- 16. why is there half-integer spin?
- 17. how does spin- $\frac{1}{2}$ couple to a magnetic field
- 18. what is the dimension of the spin- ℓ representation of the angular momentum algebra
- 19. Find $\langle x \mid e^{-\frac{i}{\hbar}tH_0}x' \rangle$ for the free Hamiltonian $H_0 = \frac{P^2}{2m}$.
- 20. what is the Hamiltonian for a spin-0 particle in an electromagnetic field

Some more questions about quantum mechanics

- 21. What is the scattering amplitude
- 22. Write down the Lippmann-Schwinger equation
- 23. The variational principle states that . . .
- 24. The effect of a perturbation H' on the ground state energy is to first order . . .
- 25. The Feynman-Kac formula states that . . .
- 26. What is a mixed state
- 27. Von Neumann's equation reads . . .