Quantum Physics III, 2005 – 2006

Final exam.

The exam will consist of **(1)** one theory question (randomly chosen from the list of topics below), **(2)** one problem (distributed at the exam), and **(3)** possible additional questions on the subject of the course. The problem will be similar to those from the exercises, but technically easier than the average level of the exercises. After the selection of the theory topic and of the problem, you will have about 30 minutes to solve the problem and to prepare the presentation of the theory question. You should aim at a 5-10-minute presentation of the theory topic and a 5-10-minute presentation of the problem. During your preparation, you may use any material you wish, such as books, lecture notes, etc., but you may not use help of others.

List of exam theory topics.

1. Quasiclassical wave function in one dimension. Conditions of applicability of the quasiclassical approximation.

$$\Psi(x) = \frac{1}{\sqrt{p}} e^{i \int p\, dx}$$

2. Bohr–Sommerfeld quantization rule in one dimension.

$$\frac{1}{2\pi\hbar} \oint p\, dx = n + \frac{1}{2}$$

3. Quasiclassical tunneling. Transmission coefficient in the quasiclassical approximation.

$$D = \exp\left(-2 \int_a^b |p|\, dx \right)$$

4. Scattering amplitude and cross-section.

$$\Psi(\mathbf{x}) = e^{ikz} + \frac{f(\theta)}{r} e^{ikr}$$

5. Scattering phase shifts.

$$f(\theta) = \frac{1}{2ik} \sum_{l=0}^{\infty} (2l+1)(e^{2i\delta_l} - 1) P_l(\cos\theta)$$

6. Optical theorem.

$$\operatorname{Im} f(\theta = 0) = \frac{k}{4\pi} \sigma$$

7. Scattering in Born approximation.

$$\frac{d\sigma}{d\Omega} = \left| \frac{m}{2\pi} U(q) \right|^2$$

8. Resonant scattering at low energies.

$$e^{2i\delta_{\rm res}} = \frac{E - E_0 - i\Gamma/2}{E - E_0 + i\Gamma/2}$$

9. Scattering of fast particles (the eikonal approximation).

$$f(\theta) = \frac{k}{2\pi i} \int e^{-iq\rho} \left(e^{2i\delta(\rho)} - 1 \right) d^2\rho$$

10. Thomas-Fermi approximation for many-electron atoms.

$$\nabla^2 \varphi = \frac{8\sqrt{2}}{3\pi} \varphi^{3/2}$$