

International Theoretical Physics Olympiad - 2017

January 28, 2017

You have 24 hours to solve the problems, you can use any textbook and online materials published before the beginning of the contest. You can also use Computer Algebra Systems like Mathematica or Maple. However, in case you want to present solution that relies on these computations please provide a complete description and all supplementary materials including the source code.

You can upload your solutions using your team page. Although we can accept almost all possible formats, the .pdf is the preferred one. Good luck!

1 Quantum to Classical

Even start out initially with quantum fuzziness, a macroscopic object will eventually becomes classical in a very short time due to the loss of quantum entanglement through interactions with the environment. Obtain this time scale, given the mass of the environment particles m (very small compare to that of the macroscopic object), the collision rate Γ between the object and the environment particles, the thermal equilibrium temperature T of the environment and the spatial resolution L .

2 Square Plate

A 2d metallic square $\mathcal{K} = [0, a] \times [0, a]$ has a given resistivity density tensor:

$$\hat{\rho} = \begin{pmatrix} \rho_{xx} & \rho_{xy} \\ -\rho_{xy} & \rho_{xx} \end{pmatrix}, \quad \vec{E} = \hat{\rho} \vec{j}.$$

There is a potential difference between two opposite sides of the square. In this problem you're asked to calculate the full current and the resistivity.

3 Charge Through a Looking Glass

Can you engineer a dielectric permittivity tensor such that a real charge at some distance to an infinite half-space filled with a dielectric will generate an induced (real) point-like charge inside the medium? Note: a medium with such permittivity tensor might be not realizable, at least in a static (equilibrium) setup.

4 Storm in a Bar

There is an elastic magnetized ferromagnetic rod in thermal equilibrium with a medium below the Curie temperature. The rod moves along the symmetry axis and approaches a wall. After the collision, the rod may start rotating around its symmetry axis. Assuming that the collision with the wall happens adiabatically, find the value of the angular momentum after the collision. How does it depend on material parameters and initial parameters of the motion? Does the angular momentum stay constant after the collision?

5 Expanding Universe

Let us investigate the effect of the Universe expansion on the matter. Study the hydrogen atom and for simplicity assume that the expansion is "turned on" at some moment. Treating the time-dependence as a perturbation, calculate the energy radiated by the atom.

6 Gravitating Spins

There is a gravitating cloud of quantum particles of the same type with spin S . They do not interact with electromagnetic field - the charge and all multipole moments are zero. Suggest a method to obtain the spin of one particle if you know their number N , given you can measure and create any external gravitational field (obeying the Einstein equation). Express explicitly the spin value in terms of the quantities measured and describe your procedure.