Zagadnienia na egzamin magisterski z *Physics and Astronomy*

1. Cauchy-Gorsat theorem and its applications to integral formulae.
2. Definition of a group and some examples of subgroups of General Linear group.
3. When an imbedded hypersurface given by some equation f(x)=0 is a differential manifold?
4. What is nonclassical light?
5. Discuss the Hong-Ou-Mandel effect for a pair of single photons impinging at a 4-port 50/50 beam splitter.
6. Discuss the Jaynes Cummings Hamiltonian for light-matter interactions.
7. Curvature and topology of the Universe.
8. Meaning and derivation of the main FLRW distances (radial, tangential, angular diameter, luminosity).
9. Observational strategies for measuring the curvature and the topology of the Universe.
10. Explain Maxwell equations in terms of the Faraday tensor.
11. How electric and magnetic fields transform under the Lorentz transformation?
12. What do you mean by electromagnetic radiation? Discuss the Larmor formula for the radiation power.
13. Kepler's laws and Kepler's orbital elements in the context of the central force problem and qualitative analysis of dynamical models.
14. The N-body problem in the Newtonian framework, first integrals (conservation laws) and the virial theorem; the concept of the inertial reference frame.
15. The restricted three-body problem in the Lagrangian framework and its applications.
16. Explain the difference between hyperfine and fine structures in atoms and molecules.
17. Explain the difference between Schrödinger and Dirac equations (and the properties of their solutions) in the context of atomic structure.
18. What is the difference between ortho and para helium?
19. What is the idea behind the Born-Oppenheimer approximation? Where do we use it in physics?
20. Write down the molecular Hamiltonian and explain each term.
21. Explain the difference between atomic and molecular orbitals using the Hartree-Fock method.
22. What is a semiconductor? What are the types of semiconductors?
23. What is a p-n junction and how can it be made?
24. Construction and principle of operation of a diode.
25. Give the Einstein field equations. Explain the symbols.
26. Give the equations of a geodesic line. What is the role of geodesic lines in the general relativity?
27. Give the Schwarzschild metric. What are physical systems it is related to?
28. Describe the sources of X-rays and gamma-rays that are of stellar origin.
29. Describe ground-based gamma-ray observatories. What technique do they use?
30. What is the first-order Fermi process and where does it occur?
31. Which physical processes participate in and regulate star formation in galaxies.
32. Describe morphological structure of galaxies and characterize their properties across Hubble tuning fork.
33. How supermassive black holes are detected in galactic centers.
34. Internal structure and further evolution of the Sun
35. What are the final stages of stars' evolution depending on their initial mass?
36. List the basic types of planets in the solar system and beyond.

Egzamin dyplomowy składa się z prezentacji pracy (ok. 15 minut), dyskusji z komisją na temat rezultatów pracy oraz odpowiedzi na trzy pytania komisji według powyższej listy zagadnień.

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