

GSC: Example questions on Particle Physics for an Oral exam

1. What the atom is made of?
What is the size of an atom (say H, approximately)?
What is the size of a nucleus (say He, approximately)?
2. What are spins of the electron and proton?
3. What is the spin of an H atom? (Depends on what?)
4. What is an electron made of?
Then why it has a spin? Give a mechanical “interpretation”/puzzle of the electron spin
5. What is nucleus made of?
Why nucleus is not pulled apart (by the Coulomb force)?
What force holds the nucleus together?
Estimate Coulomb vs Gravitational force in, e.g. He nucleus
6. What force holds nucleus together?
(Define) The binding energy
Explain nuclear fission and fusion (reactions)
7. What is a proton made of? What is a neutron made of?
Quarks (*and gluons for exceptional students*)
Which quarks? How many quarks are there in nature? Charge of quarks?
Give proton (neutron) quark structure
8. What are the spins of the proton, neutron, quarks?
Relate the quark structure of the proton, its spin, to the constituents’ spin
9. What force holds quarks together in proton (neutron, ...)
Strong force? What are the carriers of the strong force/interactions?
Gluons? How many gluons are there (*for exceptional students*). Spin of the gluon
What are the carriers of the electromagnetic interactions
Photons? Spin of the photon How many photons are there?
10. (Stable) Matter around us is made of protons and electrons. Protons are made of u and d quarks (*exceptional students: and gluons, plus heavier quarks and antiquarks*).
What the antimatter is made of? For instance, antiproton and antineutron?
Are there other constituents of (anti-)matter?
11. (*For exceptional students?*) Could you describe, schematically, how two electrons repel each other via electromagnetic interactions? (A diagram of the ee scattering)
Same for a qq scattering (qg , gg scattering)
12. What happens, at an underlying process level (like $p \rightarrow n + e^+ + \nu_e$), when a radioactive elements decay. Similar for the neutron decay ($n \rightarrow p + e^- + \text{anti-}\nu_e$).
(*exceptional students: Give examples of β^+ , β^- and γ radioactivity*)
What force is responsible for the $p \rightarrow n + e^+ + \nu_e$ process?
What are the carriers of the weak force?
13. The neutron is heavier than proton. Therefore, the $n \rightarrow p + e^- + \text{anti-}\nu_e$ decay can take place (in a nucleus or free space). However, the $p \rightarrow n + e^+ + \nu_e$ reaction cannot proceed in free space? Then what is the underlying reaction in the β^+ radiation?
14. (*For exceptional students?*). Give the quark-lepton structure of the matter.
Which quark and leptons are (un-)stable?
15. What (How many) forces are there in nature and what are the force carriers?
16. (*For exceptional students?*) Why we need the Higgs mechanism?
When/where the Higgs boson was discovered?
How? (*for exceptional students*)
Was US, UB part of it?