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# EUROPEAN QUANTUM FUTURE ACADEMY 2020

FIRST PROBLEM SET

1) Consider a spin-½ particle in a constant magnetic field of the strength B. Let us denote the initial state of spin degrees of freedom to be described by a density operator ρ.

   a) For the initial state ρ find the orientation of the (ideal) Stern-Gerlach apparatus, for which the probability of observing the positive outcome is maximal. That is, specify the unit vector $\mathbf{m}(\rho)$ associated with the direction of such oriented Stern-Gerlach apparatus. Let us denote this measurement as M_{opt}. and let P_{max} be the value of maximal probability.

   b) Let us denote by T the time when the probability of positive outcome of M_{opt} of the spin evolved in the magnetic field is again maximal (P_{max}). Assume we indeed perform M_{opt} at time t=0 with the positive outcome. Assume the outcome is concluded indirectly based on the fact that the detectors recording the negative outcome have not registered any particle. In other words, the system, after the outcome is registered, is not detected (and destroyed) by any detector, or screen. The measured particle is measured again by M_{opt} at time t=T. The question is: What will be the conditional probability $P_+(\rho)$ of the positive outcome?
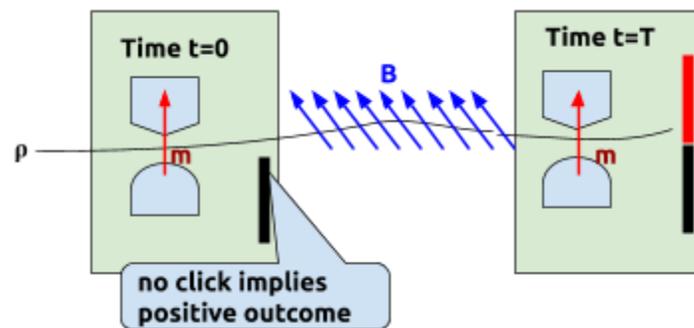
2) How would you measure the value of Planck constant? Describe your favorite experiment, if possible provide also the references and results.

3) Consider a box containing 100 photons of horizontally oriented polarization and 100 photons of vertically oriented photons. Let us denote this box as A-box. Consider another box (B-box) containing 100 photons of left-circular polarisation and 100 photons of right-circular polarisation. Assume you are given one of these boxes and your goal is to identify which box it is (A, or B). How would you proceed and what are your chances to find the answer?

Please send your solutions to mario.ziman@savba.sk before 15/06/2020, but the sooner, the better. Specify your name and faculty. It is recommended to send answers of each problem independently. The second set of problems will appear on 01/06/2020.