

List of material for the MAP final

1. The general framework of Quantum Physics (or: how to model a system in Quantum Physics).

- ortho-projections and the lattice of events,
- probability laws and Gleason's theorem; characterization of mixed and pure probability laws (states),
- physical quantities and self-adjoint operators,
- relations and operations between physical quantities,
- interpretation of the characterization mentioned at (ii); the relation between Gleason's theorem, the "hidden parameter" interpretation of quantum physics, von Neumann's "no hidden parameter" and the concept of statistical sums.

2. The quantum physical model of a system of spin $1/2$ particles.

- physical facts (the Stern-Gerlach experiment), postulates and how they are turned into mathematical requirements,
- the mathematical requirements and their solutions (given in terms of Pauli matrices) in case of 2 particles,
- possibilities regarding the number of solutions (in general),
- the difference between the 2 solutions in the 2 particle case, the existence of a probability law in which the "total spin is zero".

3. The EPR experiment with 2 spin $1/2$ particles.

- the "total spin zero" probab. law is unique and is infact a (pure) state,
- probabilities and correlations in this state,
- classical "strategies" and classical inequalities regarding correlations,
- the arising "paradox" and its interpretations.

4. Physical operations as (completely) positive maps.
 - physical operations as $\mathcal{S}(\mathcal{H}) \rightarrow \mathcal{S}(\mathcal{H})$ maps that preserve convex combinations,
 - $\mathcal{S}(\mathcal{H}) \rightarrow \mathcal{S}(\mathcal{H})$ convex combination preserving maps and positive maps,
 - symmetry operations and Wigner's theorem,
 - rotations of spin 1/2 particles,

5. Composite systems.
 - the 2 spin 1/2 particle as a bipartite system,
 - bipartite systems in general,
 - product states and entanglement,
 - physical operations and composite (bipartite) systems: completely positive maps,
 - the “no clone” (or: “no quantum copy”) theorem.

6. Dense coding and quantum cryptography.
 - distinguishing between states by measurement,
 - the procedure of dense coding,
 - dense coding, entanglement and interpretations,
 - the quantum cryptography protocol of Bennett and Brassard.