Master's thesis – track Theoretical Physics

'An attempt to simultaneously measure two non-commuting observables'

Abstract:
Standard quantum mechanics states that an ideal simultaneous measurement of two observables can only be done if those observables commute. Recently, a model for a measurement of a spin-1/2 system has been suggested, where the measurement process is seen as a physical interaction between a spin and a magnetic memory, the apparatus. It is then allowed to let the spin interact with two such apparatuses simultaneously, each of them measuring a different (non-commuting) spin component, and to study the dynamics of the process. In this thesis we want to answer the following questions: (i) will both apparatuses yield results? (ii) are these results faithful? (iii) how much information can we extract from them? (iv) what is the final state of the measured spin? Question (i) is answered affirmatively, and the minimum strength of the coupling spinapparatus is found. Regarding question (ii), we find that the process is non-ideal: the apparatuses can yield false indications. This is quantified by an efficiency parameter, for which we find an upper bound and numerical results. Nevertheless, we will show that the process is completely informative: we can determine the expected value of both spin components after many runs of the experiment. Regarding question (iv), we find that at the end of the process the spin has collapsed in neither of the eigenstates of the two measured observables, but in a linear combination of them.