Study program : Physics
Type and level of studies: Doctoral studies
Course unit: Quantum decoherence theory
Teacher in charge : professor Miroljub Dugić
Language of instruction English
ECTS: 15
Prerequisites: Set semester
Semester II (Summer semester first year course)
Course unit objective The students will be familiarized with the basic concepts and fundamentals of modern decoherence theory as well as basic models. Ubiquity of quantum correlations (entanglement in closed systems) and decoherence for open quantum systems are the main qualitative objectives of the course. Universal applicability of decoherence in quantum theory, quantum information and computation as well as in all basic applications is particularly emphasized. The course is set so as to ease introductio to the more general open quantum ssytems theory.
Learning outcomes of Course unit The students will be able to work independently in research and in critical assessment of the others' research results in the foundations and some basic applications of the decoherence theory. The students will be prepared for studying the more general open quantum systems theory.
Course unit contents *Theoretical classes* Quantum measurement scheme of von Neumann (projective measurements). The Kraus operations formalism. POVM measurements. Dynamical formation of entanglement in closed systems. Reduced (open system) dynamics. Schmidt canonical form. Environment-induced superselection rules, robustness of the pointer basis states and the pointer observable. 'Predictability sieve' method. Simple models: Scattering of particles; von Neumann's model of position measurement; decoherence and measurement of a single qubit by a qubits-environment; Walls–Collet–Milburn measurement model. Approximate descriptions: a master equation for scattering and the position measurement. Ehrenfest theorems. Outlook: molecular structure.
Literature 1. M. A. Nielsen, I. L. Chuang, "Quantum computation and quantum information", Cambridge University Press, Cambridge, 2000. 2. D. Giulini, E. Joos, C. Kiefer, J. Kupsch, I.-O. Stamatescu, H. D. Zeh, "Decoherence and the appearance of a classical world in quantum theory", Springer, Berlin 1996. 3. M. Schlosshauer, "Decoherence, the measurement problem, and interpretations of quantum mechanics", *Reviews of Modern Physics* **76**, 1267 (2005); also available at http://arxiv.org/abs/quant-ph/0312059 . *Additional literature*: 4. W. H. Zurek, "Environment-induced superselection rules", *Physical Review D* **26**, 1862 (1982). 5. D. F. Walls, M. J. Collet, G. J. Milburn, "Analysis of a quantum measurement", *Physical Review D* **32**, 3208 (1985). 6. J. Jeknić-Dugić, "The environment-induced-superselection model of the large-molecules conformational stability and transitions", *European Physical Journal D* **51**, 193 (2009).

Number of active teaching hours				**Other classes**
Lectures:	Practice:	Other forms of classes: mentoring 5	Independent work: 2	

Teaching methods

Examination methods (maximum 100 points)			
Exam prerequisites	**No. of points:**	**Final exam**	**No. of points:**
Student's activity during lectures		oral examination	40
practical classes/tests		written examination	

Seminars/homework	**60**	....	
Project			
Other			

Grading system		
Grade	**No. of points**	**Description**
10	**91-100**	Excellent
9	**81-90**	Exceptionally good
8	**71-80**	Very good
7	**61-70**	Good
6	**51-60**	Passing
5	**<51**	Failing

(Table 5.2) Course unit description