**Final exam program**

on discipline **“Additional chapters of scattering theory”** for 1st course doctoral students for specialty “6D060500 – Nuclear Physics”

The proposed program for the discipline **“Additional chapters of scattering theory”** is made according to the discipline's syllabus. The program determines the requirements for the levels of mastering the academic discipline, to which the student should be capable of learning: describe acquired knowledge (specifically) and it’s understanding; interpret an understanding of the overall structure of the study field and the relations between its elements (specifically); generalize new knowledge in the context of basic knowledge, interpret its contents; create educational and social interaction and cooperation in the group; explain the solution of the problem, its importance; classify criticism and to criticize; decide to work in a team; combine the role of taken course in the implementation of individual learning paths. The system of descriptor verbs must be used during the formation of competences; design active and interactive methods which are recommended to ensure deeper understanding and learning of educational material and to achieve learning outcomes of the course.

**The aim of the course:** learning the modern physics of atomic nuclei and quantum mechanics for systems consisting of few-particles and clusters.

At the exam, students will be asked three theoretical questions (the first two are 33 points each and the third are 34 points each).

**Exam questions:**

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|  | Give definition and describe formulation of scattering theory in terms of representation theory | Lecture № 1 |
|  | Describe the type of scattering matrix | Lecture № 1 |
|  | Give definition of the discrete spectrum | Lecture № 2 |
|  | Explain the virial theorem | Lecture № 2 |
|  | Describe same particles | Lecture № 2 |
|  | Give definition of statistical physics | Lecture № 3 |
|  | Explain S-matrix | Lecture № 4 |
|  | Give definition and describe continuous spectrum | Lecture № 4 |
|  | Describe the scattering operator in the continuous case | Lecture № 3 |
|  | Explain representation theory | Lecture № 3 |
|  | Characterize analytic properties of the wave function | Lecture № 4 |
|  | Give definition of spectral theory | Lecture № 5 |
|  | Describe the Green's function | Lecture № 5 |
|  | Explain perturbation theory | Lecture № 5 |
|  | Characterize applications of spectral theory | Lecture № 6 |
|  | Describe operator algebra | Lecture № 6 |
|  | Give definition of the time Green's function | Lecture № 5 |
|  | Explain translational representation for the solution of the wave equation in free space | Lecture № 7 |
|  | Characterize the wave function in the semiclassical approximation | Lecture № 7 |
|  | Describe translational representation for the solution of the wave equation in free space | Lecture № 7 |
|  | Explain quantum oscillator under the influence of an external force | Lecture № 8 |
|  | Give definition and describe parametric excitation of a quantum oscillator | Lecture № 8 |
|  | Explain the scattering matrix | Lecture № 9 |
|  | Describe heisenberg representation | Lecture № 9 |
|  | Give definition of canonical transformations | Lecture № 9 |
|  | Describe generalization of the normalization | Lecture № 9 |
|  | Analyze quantum oscillator under the influence of an external force | Lecture № 8 |
|  | Give definition and describe perturbation theory for quasistationary states | Lecture № 9 |
|  | Analyze wave function of a multichannel system | Lecture № 10 |
|  | Explain the motion of two particles in an external potential field | Lecture № 13 |
|  | Explain section and unitarity of the S matrix | Lecture № 10 |
|  | Describe symmetry of the S matrix | Lecture № 10 |
|  | Give definition of S matrix and its relation to the R-matrix | Lecture № 11 |
|  | Explain threshold phenomena | Lecture № 11 |
|  | Characterize energy dependence of the scattering cross section near the threshold of reactions | Lecture № 11 |
|  | Describe generalization to the case of particles with spin | Lecture № 11 |
|  | Give definition and describe the Faddeev equations | Lecture № 12 |
|  | Describe general formulas for scattering cross sections | Lecture № 12 |
|  | Explain the motion of two particles in an external potential field | Lecture № 13 |
|  | Analyze the formula for determining the amplitudes of various processes | Lecture № 13 |
|  | Explain asymptotics of the wave function at large distances | Lecture № 13 |
|  | Explain and describe theory of weak interactions | Lecture № 14 |
|  | Analyze reactions with neutrino emission | Lecture № 14 |
|  | Describe quasienergy of a system subjected to periodic action | Lecture № 15 |
|  | Characterize multiplication in the case of several channels | Lecture № 15 |

***Evaluation and attestation policy***

**Criteria-based evaluation:**

Assessment of learning outcomes in correlation withdescriptors (verification of competence formation during midterm control andexaminations).

**Summative evaluation:**

evaluation of the presence and activity of the work in the classroom; assessment of the assignment, independent work of students, (project/casestudy/ program/...)

The formula for calculating the final grade.

Below are the minimum estimates in percentage terms:

95% - 100%: А 90% - 94%: А- 85 % - 89%: В

80% - 84%: В 75% - 79%: В- 70% - 74%: С+

65% - 69%: С 60% - 64%: С- 55% - 59%: D+ 50% - 54%: D- 0% -49%: F

**LITERATURES**

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2. E. Koelink, Lectures on scattering theory, Delft the Netherlands 200
3. H.Friedrich, Scattering Theory, Fachbereich Physik T 30aTU München Garching Germany, 2015
4. John R. Taylor  Scattering Theory: The Quantum Theory of Nonrelativistic Collisions, 512 pages, Dover Publications, May 26, 2006
5. Ta-you Wu, Takashi Ohmura, Quantum Theory of Scattering, 528 pages,  Dover Publications, July 19, 2011
6. D.S. Sivia, Elementary Scattering Theory: For X-ray and Neutron Users, 216 pages, Oxford University Press; 1 edition,January 29, 2011
7. Roger G. Newton, Scattering Theory of Waves and Particles: Second Edition, 768 pages, Dover Publications; Second edition, June 19, 2013
8. R.Blumenhagen, D.Lüst, S.Theisen, Basic Concepts of String Theory, 784 pages, Springer; 2013 edition, October 4, 2012