AL FARABI KAZAKH NATIONAL UNIVERSITY

Approved at the meeting
Academic Committee (NMS)
KazNU named after al-Farabi
Vice Rector for Academic Affairs
_____A.K. Hikmetov
Protocol No. 6 dated June 22, 2020

PROGRAM OF ENTRANCE EXAM FOR DOCTORS PhD IN EDUCATIONAL PROGRAM "8D05307- PHYSICS AND ASTRONOMY"

ALMATY 2020

The program is compiled in accordance with the State educational standard in the educational program "6D061100 - Physics and Astronomy". The program was compiled by Prof. Z.Zh. Zhanabaev.

The program was considered at a meeting of the Department of Solid State Physics and Nonlinear Physics

Protocol №____ from «____»_____2020 г.

Head chair _____ M.K. Ibraimov

The method of the bureau of the Faculty of Physics and Technology was approved at the meeting

Protocol №____ from «____»_____2020 г.

Chair Method Bureau _____ A.T. Gabdullina

Approved at the meeting of the Scientific Council
Protocol №____ from «____»_____2020 г.

Chairman of the Scientific Council
Dean of the Faculty _____ A.E. Davletov

Scientific Secretary _____R.U. Masheeva

CONTENT

1. Goals and objectives of the entrance exam in the educational program

The purpose of the entrance exam program is to identify the level of theoretical training entering the doctoral program and formulate a personal recommendation for admission on the basis of competitive participation.

At the entrance exam, applicants for doctoral studies should show the depth of knowledge in the main disciplines of the previous training, research potential, which are sufficient and necessary for the successful development of the educational program of doctoral training and the defense of a doctoral dissertation on the subject of the specialty.

An applicant must show the ability to work independently with modern literature, demonstrate his achievements in the field of modern astrophysics in the form of author publications, diplomas, certificates, etc.

The entrance exam form is a combined written and oral exam. Examiners write down their answers to questions of the examination ticket on the answer sheets, answer the examination committee verbally. In the event of an appeal, the basis for consideration is the written entries in the answer sheet.

2. Requirements for the level of training of people entering PhD doctoral studies

Specialties of the previous level of education:

- 061100– “Physics and Astronomy”
- 060400 - “Physics”
- 072300 - “Technical Physics”
- 011000 - “Physics”
- 074000-Nanomater. and nanotechnology.
- 071000-Materials. and tech. new materials
- 071700 – Thermal power engineering
- 060500- Nuclear physics
- 071800- Power industry
- 071900 – Radio engineering,
- electronics and telecommunications
- 6M073200 - Standardization and certification
- 050110 - Physics Hydroaerodynamics
- 110240-Engineering and physics of low temperatures
- 110640 - Hydroaerodynamics Information systems, Mechanics

3. Prerequisites for the educational program

1. Nonlinear processes
2. Experimental methods of astrophysics
3. Physics of stars
4. Information technology in astrophysics

4. Exam Topics

Discipline "Fundamentals of Astrophysics"

1. Definition of astrophysics. Fundamental concepts of astrophysics. Information about the universe. Basic astrophysical instruments. Telescope functions. Aberration. Chromatic and spherical aberration. The main types of reflectors. Solar telescopes.
2. Receivers of electromagnetic radiation. Photocathode. PMT. Bolometers CCD array configuration. Transforming coordinates on the celestial sphere. The technique of astrophysical observations. Photographic photometry. Photoelectric photometry. All-wave astronomy (UV, IR, radio, X-ray, gamma).
3. The technique of spectroscopic observations. The sun. Photospheric formations. The solar spectrum. Chromosphere and crown. Interstellar medium. Different observable states of interstellar gas. Interstellar magnetic field. Cosmic rays.
4. The conditions of gravitational compression of the cloud and its fragmentation. Gas and dust disks. Potential energy and virial theorem.
5. Basic concepts of astrophotometry. Magnitude. Degenerate stars. The relationship between mass and radius, the ultimate mass of stars. The basics of spectral analysis. Spectral classification of stars. Hertzsprung-Russell diagram. Main sequence.
6. The theory of the evolution of stars. Sources of star energy. Formation of heavy elements. Jeans instability. Composition and structure of various types of galaxies. Standard starburst scenario. Dynamic equilibrium of stars. Normal stars, white dwarfs and neutron stars. Black holes.
7. Neutron stars. Pulsars Supernova stars. Remains of Supernovae and their observations. The sun is like a star. Elements of stellar astronomy. Galaxy structure. Classification of galaxies. Clusters of galaxies.
8. Spiral branches and star formation. Non-stationary and double stars. New stars. Elements of stellar dynamics. The evolution of galaxies. Active nuclei of galaxies. Quasars.
9. Observations of objects with high redshift and the evolution of galaxies. Quasars. Elements of cosmology. Hubble Law. Friedman's decision. Critical density. Standard cosmological scenario. Relict radiation. The cellular structure of the universe.

Discipline "Nonlinear Astrophysical Processes"

1. Nonlinear systems. Properties of nonlinear systems. Mappings.
2. Methods of the theory of dynamic chaos in astrophysics. Examples of time series in astrophysics.
3. Dynamic systems. Dynamic system and its mathematical model. State space.
4. Description of oscillatory processes in phase space. Phase space. Phase portrait.
5. Phase trajectory. Attractor. Strange attractor.
6. Large-scale Invariance in the Universe, Observations and Scaling Patterns
7. Algorithms for determining the main characteristics of chaotic astrophysical signals
8. Hierarchical processes in the Universe, their large-scale invariance
9. Statistical characteristics of dynamic chaos

Discipline "Observational and digital methods of astrophysics"

1. Analysis of astrophysical signals. Stages of development of the theory of digital signal processing. Time Series Analysis. Phase Time Series Expansion
2. The essence of linear discrete processing. Statistical signal processing methods. Characteristics of stochastic and chaotic processes.
3. Fractal and multifractal analysis of signals. The fractal nature of chaotic signals.
4. Determination of fractal, multifractal characteristics of interleaved signals.
5. Multifractal properties of astrophysical signals. Hilbert Discrete Transformation for Signal Frequency
6. Random processes. Classification of random processes. Probabilistic characteristics of random processes. Parseval equality.
7. Correlation analysis. Mutual correlation function of deterministic signals. Autocorrelation function of deterministic signals. The relationship between correlation functions and signal spectra. Correlation interval, white noise

8. Information-entropy analysis of signals. The concepts of information and entropy, criteria for the degree of self-organization of open systems.
9. Mutual, conditional information of the astrophysical time series
10. Signal-to-noise ratio and information / entropy in astrophysics
11. Physics of modern gravitational wave detectors
12. Physical characteristics of stars by spectral, photometric observations
13. The main parameters of modern radio telescopes, their advantage compared with optical telescopes

5. References

Main literature:

1. Постнов К.А. Лекции по общей астрофизике для физиков – М., МГУ, 2001г.
2. Постнов К.А., Засов А.В., Курс общей астрофизики, -М., МГУ, 2005
3. Иванов В.В. Астрофизика звезд,- Санкт-Петербург, 2006г.
4. Вихлинин А. Избранные лекции по курсу «Введение в астрофизику», М., Наука,2002г.
5. Ландау Л.Д., Лифшиц Е.М. Механика. Т. 1. М., 2004
6. Ландау Л.Д., Лифшиц Е.М. Теория поля. Т. 2. М., 2003
7. Ландау Л.Д., Лифшиц Е.М. Статистическая физика. Т. 5. М., 2002
8. Николис Дж. Динамика иерархических систем. М.: Мир, 1989. – 488с. Жаров В.Е. Сферическая астрономия – М., 2002.
9. Ковалевский Ж. Современная астрометрия – М. Век-2, 2004. – 480 с.
10. Машонкин Л.И., Сулейманов В.Ф. Задачи и упражнения по общей астрономии – Казань, КГУ, 2002.
11. Kovalevsky J. Modern Astrometry - Berlin: Springer, 1995.
12. ESA. The HIPPARCOS and TYCHO catalogues-VI. Introduction and Guide to data, 1997.
13. Кононович Э.В., Мороз В.И. Общий курс астрономии - М. ,УРСС, 2001. – 544с.
14. Иванов В.В., Кривов А.В., Денисенков П.А. Парадоксальная Вселенная. 175 задач по астрономии - С-Пб., СПбГУ, 1997.
15. Монтенбрук О., Пфлегер Т. Астрономия на персональном компьютере - С-Пб., Питер, 2002. – 320с.
16. Ранцини Ж. Космос. Сверхновый атлас Вселенной / – М., Эксмо, 2005.-216с
17. Хакен Г. Информация и самоорганизация: макроскопический подход к сложным системам. - М.: Мир.- 1991.- 240с.
18. Климонтович Ю.Л. Статистическая теория открытых систем. Т. 3. - М.: Янус.- 2000. - 624с.

additional literature:

1. Николис Дж. Динамика иерархических систем. М.: Мир, 1989. – 488с.
2. Аленицын А.Г., Бутиков Е.И., Кондратьев А.С. Краткий физико-математический справочник. М., "Наука", 1990, 368 с.
3. Кортнев А.В. и др. Практикум по общей физике. М. 1965.
4. Шишловский А.А. Прикладная физическая оптика. М. 1965.
5. Фейнман Р., Лейтон Р., Сэнде М. Фейнмановские лекции по физике. Т.5. – М.: Мир, 1976.
6. http://www.sai.msu.ru
7. www.astronet.ru
8. http://astra.prao.psu.ru

6. Graduation scale for exam results in doctoral studies
«8D05307- PHYSICS AND ASTRONOMY»

Letter Grade	The digital equivalent of points	% content	Traditional system assessment	Competency Scale
A	4,0	95-100	Excellent	"Excellent" mark - deep comprehensive knowledge of all program material, understanding of the essence and interconnection of the processes and phenomena under consideration, solid knowledge of the main provisions of the disciplines: logically consistent, informative, complete correct and specific answers to all questions of the examination ticket and additional questions of members of the examination committee; use, to the extent possible, in answering questions of materials from all the recommended literature.
A-	3,67	90-94		
B+	3,33	85-89	Good	Evaluation of "good" - solid and fairly complete knowledge of all program material, a correct understanding of the nature and relationship of the processes and phenomena under consideration; consistent, correct, specific answers to the questions posed with the free elimination of comments on individual issues.
B	3,0	80-84		
B-	2,67	75-79		
C	2,00	50-74	satisfactorily	Assessment "satisfactory" - a solid knowledge and understanding of the main questions of the program, correct and specific answers, without gross errors, to the questions posed when eliminating inaccuracies and insignificant errors in highlighting certain provisions in leading questions of examiners, when answering questions the main recommended literature is not used enough.
		0-50	unsatisfactory	The rating "unsatisfactory" is an incorrect answer to at least one of the main questions, gross errors in the answer, a misunderstanding of the essence of the questions posed; uncertain and inaccurate answers to additional questions