Review

the official reviewer for a doctoral thesis of Khassanov Manas on the topic « Generation and propagation of gamma rays in the magnetosphere of neutron stars», submitted for the degree of Doctor of Philosophy (PhD) is the specialty «6D060500 – Nuclear Physics»

1. The relevance of the research topic and its connection with general scientific and national programs (the requirements of practice and the development of science and technology).

Neutron star formed as a result of a supernova explosion. A neutron star is an object of study not only of astronomy, but also is of great interest to nuclear physics due to nuclear processes occurring inside and on its surface, and therefore an object of study of nuclear physics. Currently, the available data do not yet allow us to draw certain conclusions about the mechanism of pulsar radiation in the gamma ranges, so for this reason theoretical studies of nuclear reactions occurring at these objects are intensively carried out. The cyclic nuclear reaction Pb-Bi plays an important role in explaining the nucleosynthesis of heavy elements, explosions of novae and supernovae. Therefore, detailed calculations related to the nuclear reaction of Pb-Bi cycle and all its sub-cycles, as well as calculations of the intensity of gamma radiation by Pb-Bi cycle, are relevant today in explaining the mechanism of pulsed radiation in the gamma ranges. Magnetars are the same neutron stars but only with magnetic fields close to B_q and even higher and reach approximately 10^{15}G. In the vicinity of such objects, there is strong magnetization, which creates favorable conditions for performing nonlinear electrodynamic effects. These effects affect the propagation of radiation from these objects and carry important information about them.

Considering doctoral thesis of the applicant Khassanov M.K is aimed to study of gamma generation by Pb-Bi cyclic reaction on the surface of neutron stars and its further propagation.

2. Scientific results in the framework of the requirements for dissertations (paragraphs 2, 5, 6 of the "Rules for the award of scientific degrees").

In the thesis of Khassanov M.K the following new scientific results were obtained:

– Isotopic composition and Pb-Bi complete cycle was determined.

– The intensity of the gamma radiation of the Pb-Bi cycle on the surface of the ns was calculated.

– The dependence the relative time delay between two normal modes from the gamma radiation passed through magnetic field of neutron star was calculated.

3. The degree of validity and reliability of each scientific result (scientific provision), conclusions of the applicant, formulated in the thesis.

The reliability of the scientific provisions submitted for defense, the results and conclusions of the applicant is not in doubt. The candidate used well-known physical models, mathematical methods, as well as computer simulation methods to obtain the results of the dissertation and conclusions. The research results were reviewed in highly rated international scientific journals and journals of recommended by Control Committee of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan and were presented and defended at international scientific conferences.

4. The degree of novelty of each scientific results (scientific provision), conclusions of the applicant, formulated in the thesis.

The scientific novelty of the dissertation results done by Khassanov M.K no doubt and consists in the following:

– The total isotopic composition of the Pb-Bi cycle was determined for a $10^{13} - 10^{18}$ neutron/cm^2 neutron flux, arising when interstellar matter falls on the surface of a neutron stars.

– The gamma radiation intensity occurring on the surface of a neutron star and generating by Pb-Bi cycle at $10^{13} - 10^{18}$ neutron/cm^2 neutron flux was calculated.

– Using the equations of nonlinear quantum electrodynamics, the dependence the relative time delay between two normal modes from the gamma radiation passed through magnetic field of neutron star was calculated.

5. The focus of the results obtained by the applicant on the solution of the relevant actual, theoretical or applied problem.

The scientific results obtained in the thesis have the following practical significance:

– Consideration of cyclic Pb-Bi reactions on the surface of a neutron stars occurring during the accretion of interstellar matter allows to understand one of the mechanisms of generation of gamma radiation by neutron stars.

– The results of the thesis can be applied in measuring the polarizations of gamma rays emanating by neutron stars.

– The results obtained in the work expands the fundamental knowledge about the physics of neutron stars with strong magnetic fields.

6. Confirmation of sufficient completeness of publications of the main provisions, results and the conclusion of the thesis.

On the topic of the dissertation 9 works have been published in total. 1 papers were published in the international journals indexed in Scopus (Elsevier,

Netherlands) and Web of Science (Clarivate Analytics, USA). 3 papers were published in journals recommended by Control Committee of Education and Science of the Ministry of Education and Science of the Republic of Kazakhstan. 5 abstracts and papers were published in the materials of local and foreign international scientific conferences.

7. Disadvantages on the content and design of the thesis.

In the dissertation work devoted to such a complex object as a neutron star, of course, can be found many comments, questions and suggestions for improvement.

1. The main disadvantage of the dissertation work is absence a comparison of the obtained simulation results for gamma radiation intensity with an observational data.

2. The text of the dissertation paid little attention to the discussion of drawings. For example, in figures 16 and 17.

3. On pages 43-46 where the simulation results made by the candidate are illustrated and the results of the calculations by other authors should be illustrated together in the same drawing, not separately.

4. The proposed Schwarzschild metric on page 60 needed to be written in a different form.

5. In the text of the dissertation there are a number of misprints.

8. Compliance of the dissertation with the requirements of section 2 of the «Rules for the award of scientific degrees».

Based on the foregoing, I believe that the dissertation work of Khassanov M.K. on topic «Generation and propagation of gamma rays in the maghetosphere of neutron stars», submitted for the degree of Doctor of Philosophy (PhD) in the specialty "6D060500 - Nuclear Physics", meets the requirements for works of this kind, both in content and volume, and the applicant Khassanov M.K. deserves the award of a degree in the specified specialty.

Official reviewer,
Candidate of physic-mathematical
sciences, PhD, associate Professor

Yerzhanov K.K.
Date: