

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 stars are one of the most interesting stars in the universe. These stars are sources of electromagnetic radiation in all wavelength ranges from radio to hard gamma radiation. Neutron stars have a relatively thin crust of matter in the form of heavy atomic nuclei and electrons. The surface of a neutron star may consist of elements of the iron group formed at the stage of birth of the star, or of various elements formed as a result of their accretion. Super strong magnetic fields of some neutron stars of the so-called magnetars can lead to nonlinear quantum electrodynamic effects (such as vacuum polarization), which are important for irradiative processes. Therefore, all these various properties of a neutron star are of great interest for theoretical astrophysics of non-ideal plasma physics and nuclear physics. In recent decades, astrophysical nucleosynthesis, the formation of heavy elements, in particular, the s-process and r-process, is enormous for the scientific picture of the world. The cyclic nuclear reaction Pb-Bi plays a special role both in the s-process and in the r-process. An important condition for the occurrence of these processes in stars is a neutron source. For this reason, the processes occurring in the depths of a neutron star, as well as on its surface, are relevant today.

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 results of the work performed by the author are compared, where it is possible, with the available data from other authors in the literature. The reliability of the scientific provisions submitted for defense, the results and conclusions of the applicant is not in doubt. 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 results obtained in the thesis of Khassanov M.K., are new and are as follows:

- All possible nuclear reaction channels were carefully considered for Pb-Bi cyclic nuclear reactions and its isotopic composition were determined for a neutron flux $10^{13} - 10^{18}$ neutron/cm².
- Based on the energy released during Pb-Bi cyclic reactions, the intensity of gamma radiation was calculated as a function of the neutron flux.
- Based on the equations of nonlinear quantum electrodynamics, the relative time delay between two normal modes of the gamma radiation 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:

- The considered cyclic Pb-Bi reaction, which is the termination point of the s-process, is not important only in fundamental problems, but also has a practical importance. For example, it is important in lead-bismuth reactors.
- The results obtained in Chapter 2 make it possible to take into account the corrections for polarization in the registration of gamma rays emitted by neutron stars.
- The results obtained in the thesis allows to obtain new knowledge in the field of neutron star physics.

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.

First of all, I want to note that the candidate has completed a large amount of theoretical work. At the same time, the dissertation contains many typos and inaccuracies in the formulations and terms. I will note some of them:

1. The main disadvantage of the work is the methodology of presenting the material. For example, in figures 16 and 17 there are no dimensions, although they are indicated in the text.

2. In Drawing 6 the illustration of cyclic reactions is decorated not clear enough.

3. In Drawings 8-11 not enough attention is paid to compare the results obtained by the candidate and other authors.

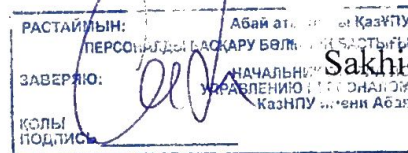
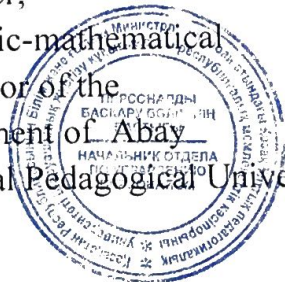
4. In the dissertation work, there is no comparison of the results of simulation the intensity of gamma radiation arising when interstellar matter falls on the surface of a neutron star with observation data.

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 magnetosphere 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,

Doctor of physic-mathematical
sciences, Director of the
Science department of Abay
Kazakh National Pedagogical University



Sakhiev S.K.
Date: