REVIEW
of the official reviewer for dissertation work
Yeleusheva Badigul Maratovna on the theme «Radiative capture reactions on light nuclei in stellar and interstellar plasma» presented for the degree of Doctor of Philosophy (PhD) of the educational program «8D05308 - Nuclear Physics»

№	Criteria	Eligibility (one of the options must be checked)	Justification of the position of the official reviewer
1.	The topic of the thesis (as of the date of its approval) corresponds to the directions of development of science and/or state programs	1.1 Compliance with priority areas of science development or government programs:	The dissertation work of Yeleusheva B.M. corresponds to the priority areas of scientific development and government programs of the Republic of Kazakhstan in the field of natural sciences.
		1) The thesis was completed within the framework of a project or target program financed from the state budget (indicate the name and number of the project or program) 2) The thesis was completed within the framework of another state program (indicate the name of the program) 3) The dissertation corresponds to the priority direction of the development of science, approved by the Higher Scientific and Technical Commission under the Government of the Republic of Kazakhstan (indicate the direction)	The research work was completed within the framework of a project financed from the state budget on the topics: 1."Study of the rates of some thermonuclear reactions in solar cycles and BBN" (IRN: AP09259021-OT-23, 2021-2023); 2."Study of the processes of thermonuclear hydrogen combustion in the CNO cycle on the Sun and in stars" (IRN: AP19676483, 2023-2025);
2.	Importance for science	The work **makes**/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	The dissertation work included a full study of the model calculations of the reaction rates of radiative neutron capture on ^{8}Li, ^{9}Be, and ^{13}B nuclei and protons on isotope ^{15}N for evaluation of light elements evolution scenarios in stellar and interstellar plasma.
3.	The principle of independence	Self-reliance level: **1) High;**	The level of independence of the dissertation work is high, as evidenced by the work done

		2) Medium; 3) Low; 4) No independence	by the applicant, which includes: performing numerical and analytical calculations, analysis of the obtained results, plotting graphs and reviewing of literature, which were completed by the applicant independently.
4.	The principle of inner unity	4.1 Justification of the relevance of the thesis: **1) Justified;** 2) Partially justified; 3) Not justified.	The relevance of the dissertation work is justified and disclosed.
		4.2 The content of the thesis reflects the topic of the thesis: **1) Reflects;** 2) Partially reflects; 3) Does not reflect	The content of the dissertation fully reflects the topic of the dissertation. The Introduction provides an overview of the dissertation, the purpose and objectives of the research, scientific novelty, and theoretical and practical significance of the presented studies. Section 1 presents the modified potential cluster model approach and elements of formalism for radiative capture processes. Astrophysical processes of $^{8}Li(n,\gamma)^{9}Li$, $^{9}Be(n,\gamma_{0+1+2+3+4+5})^{10}Be$, $^{13}B(n,\gamma_{0+1})^{14}B$, and $^{15}N(p,\gamma)^{16}O$ are considered in Sections 2, 3, 4 and 5, respectively. At the end of dissertation, the general conclusions of the performed research were described, and research beyond this dissertation is discussed.
		4.3. The purpose and objectives correspond to the topic of the thesis: **1) correspond;** 2) partially correspond; 3) do not correspond	In the dissertation work, the author gave a clear and precise formulation of the goals and objectives of the research, which fully corresponds to the stated topic of the dissertation.
		4.4 All sections and provisions of the thesis are logically interconnected: **1) completely interconnected;**	All sections and provisions of the dissertation have a close logical connection and are completely interconnected with each other,

		2) the interconnection is partial; 3) there is no interconnection	smoothly revealing the methods and results obtained within the framework of MPCM.
		4.5 The new solutions (principles, methods) proposed by the author are reasoned and evaluated in comparison with the known solutions: **1) there is a critical analysis;** 2) partial analysis; 3) the analysis does not represent one's own opinions, but quotes from other authors; 4) no analysis	In the dissertation the author has shown detailed review of previous works of other authors confirmed by references and compare it with the present results.
5.	Scientific novelty principle	5.1 Are the scientific results and provisions new? **1) completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The scientific results and provisions submitted for defense are completely new. Total cross sections for radiative n^8Li capture at energies were obtained, generally agreeing with experimental measurements. Partial and total cross-sections for the $^9Be(n,\gamma)^{10}Be$ reaction were calculated from 10^{-5} to 5 MeV. The expanded energy range allows for considering five resonances, with the resonance at $E_x = 0.730$ MeV identified. The impact of asymptotic constants on cross-sections and reaction rates was demonstrated. Total cross sections for the $^{13}B(n,\gamma)^{14}B$ reaction were calculated for the first time from 10^{-2} eV to 5 MeV, with thermal cross-sections in the range of 5.1–8.9 mb. Reaction rates were calculated over a temperature range of 0.01 to 10^9 K, with ignition T_9 values determined based on neutron number density.
		5.2 Are the dissertation findings new? **1) completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The findings of the dissertation are completely new. The novelty of the scientific work lies in the fact that for the first time: 1. For the first time, a model-free criterion for

			evaluating the reliability of the calculated reaction rates is proposed due to the binding energy in the nucleon channels $^{6}Li(n,\gamma)^{7}Li$, $^{7}Li(n,\gamma)^{8}Li$, and $^{8}Li(n,\gamma)^{9}Li$. 2. The partial and total cross-sections of the $^{9}Be(n,\gamma)^{10}Be$ reaction calculated in the energy range from 10 eV to 5 MeV allows to consider five resonances and estimate their signature in the total cross-section. 3. The calculations of the total cross sections of $^{13}B(n,\gamma_{0+1})^{14}B$ reaction performed in MPCM from 10^{-2} eV to 5 MeV provide the proposal for new experimental measurements ISOLDE. 4. The $^{15}N(p,\gamma)^{16}O$ reaction rate has negligible dependence on the variation of asymptotic constant, but shows a strong impact of the interference. 5. The regularity "the higher the channel threshold, the higher the reaction rate" is new and same for neighbouring isotopes Li, B and, N is formulated.
		5.3 Technical, technological, economic or management decisions are new and reasonable: **1) completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	The solutions obtained by the doctoral student are completely new. It is confirmed by recent articles in peer-reviewed journals.
6.	The validity of the main findings	All main conclusions **are**/are not based on scientifically significant evidence or well-grounded (for qualitative research and areas of training in the arts and humanities)	The theoretical research conducted by the dissertation has led to results that demonstrate both scientific and practical innovativeness. The main conclusions are confirmed and proven, since the author relies on previously analyzed scientific documentation and factual

			data confirmed by methods and theories.
7.	The main provisions for the defense	It is necessary to answer the following questions for each provision separately: 7.1 Is the provition proven? **1) proven;** 2) rather proven; 3) rather not proven; 4) not proven; 5) in the current formulation, it is impossible to verify the proof of the position 7.2 Is it trivial? 1) yes; **2) no;** 3) in the current formulation, it is impossible to verify the triviality of the position 7.3 Is it new? **1) yes;** 2) no; 3) in the current formulation it is impossible to verify the novelty of the provision 7.4 Application level: 1) narrow; 2) medium; **3) wide;** 4) in the current formulation, it is not possible to verify the level of application of the provision 7.5 Is it proven in the article? **1) yes;** 2) no; 3) in the current formulation, it is impossible to verify the	**Defense of provision #1** - Two criteria found for the evaluation of $^{8}Li(n,\gamma_{0+1})^{9}Li$ reaction rate allow to *narrow down* the range of reaction rates and *constrain* the choice of asymptotic constants: the values of thermal cross sections and *correlation* between the energy thresholds and order of reaction rates at low temperatures on lithium isotopes $^{6,7,8}Li$. **Defense of provision #2** – The partial and total cross-sections of $^{9}Be(n,\gamma_{0+1+2+3+4+5})^{10}Be$ reaction calculated in the energy range from 10^{-5} to 5 MeV *allows to consider* five resonances and *estimate* their signature in the total cross-section. The inclusion of resonances shows their impact on the reaction rate within the factor 4-5 rising at T_9 >1, comparing the modern results of Wallner *et al.*, 2019 and Mohr *et al.*, 2019. **Defense of provision #3** - The calculations of the total cross sections of $^{13}B(n,\gamma_{0+1})^{14}B$ reaction performed in MPCM from 10^{-2} eV to 5 MeV provide the proposal for new experimental measurements ISOLDE. The presented data on the reaction rates substantiate the role of $^{13}B(n,\gamma_{0+1})^{14}B$ reaction in the Boron-Carbon-Nitrogen chains, this is not the *break-point* of the Boron sequence. 7.1 All defense of provisions are proven in dissertation work

		evidence of the position in the article	7.2 All defense of provisions are not trivial 7.3 All defense of provisions are completely new 7.4 The application level of all defense of provisions are wide 7.5 All defense of provisions are proven in article
8.	The principle of reliability Reliability of sources and information provided	8.1 Choice of methodology - is justified or the methodology is described in sufficient detail **1) yes;** 2) no	The modified potential cluster model used in the dissertation are described in detail in the dissertation work with all the features of the mathematical apparatus used in the calculations. The choice of methodology is justified and supported by references to proven scientific sources and the results obtained given in the dissertation.
		8.2 The results of the thesis were obtained using modern methods of scientific research and methods of processing and interpreting data using computer technologies: **1) yes;** 2) no	In the dissertation research, modified potential cluster model was used. This approach allowed the author to obtain both new results in this direction and to analyze proposing a modern approach to its solution.
		8.3 Theoretical conclusions, models, identified relationships and patterns have been proven and confirmed by experimental research (for areas of training in pedagogical sciences, the results have been proven on the basis of a pedagogical experiment): **1) yes;** 2) no	All results of the dissertation research were compared with the available experimental data, as well as with the results of studies of previous works from other authors. The models used in the study are based on the built and proven theoretical foundation of the cluster model.
		8.4 Important statements are **confirmed** / partially confirmed / not confirmed by references to current and reliable scientific literature	The theoretical results and important statements of the dissertation research were confirmed by experimental data, the sources of which were referenced in the text of the dissertation in the list of sources used.

		8.5 Used literature sources are **sufficient**/not sufficient for a literature review	The author of the dissertation used a sufficient number of literary sources to construct a logically structured literary review.
9	Practical value principle	9.1 The thesis has theoretical value: **1) yes;** 2) no	The dissertation has high theoretical vas and offers both new approaches and new knowledge in the theoretical study of the processes of interaction in light nuclei: n^8Li, n^9Be, $n^{13}B$, $p^{15}N$
		9.2 The thesis is of practical importance and there is a high probability of applying the results obtained in practice: **1) yes;** 2) no	The thesis has the practical importance and there is a high probability of applying the results obtained in practice.
		9.3 Are the practice suggestions new? **1) completely new;** 2) partially new (25-75% are new); 3) not new (less than 25% are new)	All suggestions in dissertation are completely new, it is confirmed by new articles in peer-reviewed journals.
10.	The quality of writing and design	Academic writing quality: **1) high;** 2) average; 3) below average; 4) low.	The dissertation is distinguished by the high quality of academic writing, which is manifested in the clarity and accuracy of presentation, logical structure, argumentation and evidence, as well as compliance with scientific style and language.
11.	Notes on a thesis	There are no notes.	
12.	Scientific level of the doctoral student's articles on the topic of research (in case of defense of the dissertation in the form of a series of articles, the official reviewers comment on the scientific level of each article of the doctoral student on the topic	The applicant has published 4 articles on the topic of the dissertation research: **Publications in scientific journals included and indexed in the Scopus\Web of Science database:** 1) The reaction rate of radiative n^8Li capture in the range from 0.01 to $10T_9$ // Frontiers in Astronomy and Space Sciences. – 2023. – Vol. 10. – 1251743. 2) Estimation of radiative capture $^{13}B(n,\gamma_{0+1})^{14}B$ reaction rate in the modified potential cluster model // Chinese Physics C. – 2023. – Vol. 47. – 104103. 3) Radiative $^9Be(n,\gamma_{0+1+2+3+4+5})^{10}Be$ reaction rate in the potential cluster model // Chinese Physics C. – 2023. – Vol. 47. – 084105.	

	of research)	4) Astrophysical S-factor and reaction rate for $^{15}N(p,\gamma)^{16}O$ within the modified potential cluster model·// Chinese Physics C. – 2024. – Vol. 48. – 044104.
13.	Decision of the official reviewer	The dissertation work of Yeleusheva Badigul Maratovna on the theme " Radiative capture reactions on light nuclei in stellar and interstellar plasma " submitted for the degree of Doctor of Philosophy (PhD) in the educational program "8D05308 - Nuclear Physics" is performed at a high level and represents a good research work. The methods and defense of provisions proposed in the dissertation work are relevant, new and can be applied in further research in this scientific area. The quality of the dissertation, the quality of published publications meet all the requirements of the rules for awarding the degree of Doctor of Philosophy (PhD). Yeleusheva Badigul Maratovna is fully deserving of being awarded the academic degree of Doctor of Philosophy (PhD) in the educational program "8D05308 - Nuclear Physics".

In reviews, official reviewers indicate one of the following solutions:

1) to award the degree of Doctor of Philosophy (PhD) or Doctor of Specialization;

2) send the thesis for revision (except for cases of thesis defense in the form of a series of articles);

3) refuse to award the degree of Doctor of Philosophy (PhD) or Doctor of Specialization.

Copies of the reviews of the official reviewers are handed over to the doctoral student no later than 5 (five) working days before the defense of the thesis.

Official Reviewer:
PhD in Physics
Postdoctoral scholar
"Energetic Cosmos Laboratory" Project Group
AOE "Nazarbayev University__
place of work, academic title)

(signature) __Aliya Nurmukhanbetova
(FULL NAME)