REVIEW

of the official reviewer for dissertation work (series of articles)

by Gabitova Ilfa Azamatovna on the topic «Structure and evolution of circumstellar matter in Be stars» presented for the degree of Doctor of Philosophy (PhD) in the educational program 8D05307 – Physics and Astronomy.

№	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: 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)	Gabitova Ilfa's dissertation work (series of articles) entitled «Structure and evolution of circumstellar matter in Be stars» was prepared in alignment with the plans for fundamental scientific research projects. The dissertation topic is aligned with the plans of fundamental research works of the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan «Grant financing of scientific research» within the framework of project AP23484898 – «Development of a modern technique for determining the fundamental parameters of Galactic hot supergiants».
2.	Importance for science	The work makes/does not make a significant contribution to science, and its importance is well disclosed/not disclosed	The work makes a significant contribution to science in the field of stellar astrophysics. Its importance is disclosed through the novel application of Doppler tomography to decretional circumstellar disks

			analysis and empirical characterization of disk–companion interaction in Be stars.
3.	The principle of independence	Self-reliance level: 1) High; 2) Medium; 3) Low; 4) No independence	The PhD candidate's level of independence is high. The candidate personally processed the data, performed spectroscopic analysis and tomographic reconstructions, and is the first author of 2 out of 3 articles composing the dissertation work.
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 is justified by the open status of the problem of Be phenomenon. The work addresses an important question in stellar astrophysics about the dynamical evolution of decretion disks in binaries.
		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 thesis, presented as 3 articles, including all plots, tables and datasets therein completely reflects the topic of the thesis.
		4.3. The purpose and objectives correspond to the topic of the thesis: 1) correspond; 2) partially correspond; 3) do not correspond	The objectives (radial velocities, RV, analysis, violet-to-red, V/R, monitoring, tomography), and the main goal of diagnosing companion-disk interaction correspond directly to the topic "Structure and evolution of circumstellar matter in Be stars". Each objective contributes measurable input to the final conclusions.
		4.4 All sections and provisions of the thesis are logically	Methodology, analysis and

		interconnected: 1) completely interconnected; 2) the interconnection is partial; 3) there is no interconnection	interpretation form an interconnected chain. The results on V/R analysis and Doppler tomography as well the resulting dominant period in V/R and RV datasets are obtained independently from each other and form a self-consistent final interpretation.
		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	The author evaluates tomography results against known Be-disk behavior and compares findings with previous studies on Doppler tomography (i.e. Zharikov et al. 2013) and with theoretical models of Be systems. Discussion is focused on how the new results extend existing frameworks rather than repeat them.
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 results and provisions drawn from them are completely new. Mapping of the full Be disk dissipation event has not previously been achieved. The masses of both components in HD 698 are found for the first time, which reveals a true nature of the companion star in the system. The velocity mapping of HD 698 introduces new diagnostics of emission tied not to a circumstellar disk around the Be star, but to a stripped companion.
		5.2 Are the dissertation findings new? 1) completely new; 2) partially new (25-75% are new);	The findings within dissertation are completely new. The work shifts HD 698 from a suspected black-hole

		3) not new (less than 25% are new)	system to an interacting Be+stripped-companion binary. Other findings revise earlier interpretations and provide quantitative support for binary-modulated disk asymmetry.
		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 work demonstrates that long-time spectroscopic monitoring in the optical range alone can recover companion-locked emission via Doppler tomography, without model-dependent simulations or harder to obtain X-ray observations. This expands available methodology for Be-star studies.
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)	All conclusions rely on real observational material, phase-resolved spectroscopy, and proven Doppler reconstruction algorithms. The agreement between RV curves, V/R cycles, and tomographic features confirms internal consistency and physical reliability of the findings.
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 7.2 Is it trivial? 1) yes; 2) no 7.3 Is it new?	1. In the object κ Draconis, the phase synchronization of the Hα line peak ratio (V/R) with the orbital period is caused by the companion star's influence on the circumstellar disk throughout the entire disk dissipation period, from maximum intensity to complete disappearance. The provision is proven. The phase-resolved data show that V/R

		1) yes; 2) no 7.4 Application level: 1) narrow; 2) medium; 3) wide 7.5 Is it proven in the article? 1) yes; 2) no	modulation matches the orbital period across multiple years and states of disk evolution. The provision is not trivial. This finding is a part of bigger study, confirming V/R modulation by the companion star in dozens of known Be binaries, allowing to use V/R monitoring as an instrument of binarity search in Be stars. Application level is wide within the class of Be stars and possibly other binaries with disks and no active mass-transfer. The provision is proven in the article by Miroshnichenko et al. 2023 where the candidate is a co-author. 2. According to Doppler tomography results, this phase-synchronized peak ratio originates in a bright emitting region in the outer disk, always facing the companion star. This region exists due to the tidal or radiative influence of the companion star and does not disappear even at the late stages of disk dissipation, as the disk radius contracts from ~64 $R_\odot$ to ~30 $R_\odot$. The provision is proven. Tomograms consistently reveal an emission enhancement at stable velocity coordinates, always companion-facing. Its presence during disk

			contraction demonstrates that the modulation is maintained either gravitationally or radiationally. The provision is not trivial. No similar study was done on this system. Application is medium, since within Be class the number of systems with dissipating disks is little and required spectroscopic coverage is hard to obtain. The provision is proven in the article by Gabitova et al. 2024 where the candidate is the first author. 3. In the object HD 698, the central emission peak in the Hα line profile is not associated with the circumstellar disk but with an additional source of radiation moving at velocities close to those of the companion star, which has a dynamical mass of 1.1±0.2 $M_\odot$. The provision is proven. Tomographic reconstruction of the disk reveals a companion-velocity component not belonging to the disk's Keplerian field. The velocity amplitude and phasing match the secondary star's motion. Masses of both stars are obtained with clear and transparent methodology. The provision is non-trivial. It challenges the black hole hypothesis, that has been dominant for this system and it

			shows presence of additional source of emission beside expected circumstellar disk. The application is wide despite the very rare nature of the object. The study can help identify new strcuctures such as circumsecondary disks in systems that are observed in evolutionary transient stages, offering a new angle of study on the Be phenomenon as a whole. The provision is proven in article by Gabitova et al. 2025 where the candidate is the first author.
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	Spectral reduction, RV extraction, tomography reconstruction, and Gaussian decomposition are described transparently. Computer packages used (IRAF, dopmap) are standard in observational astrophysics and are publicly available.
		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	All aspects of the work from spectroscopic analysis to tomographic reconstructions are realized numerically, using modern computer technologies.
		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	Theoretical conclusions and the model used in the study (spatial distribution of emmiting matter in κ Dra) are directly constricted by results of experimental research, which in the field of astrophysics is observations.

		8.4 Important statements are confirmed / partially confirmed / not confirmed by references to current and reliable scientific literature	The findings from Doppler tomography are backed by citations of results from SPH simulations, physical parameters of the systems obtained are backed by citations on matching previous studies or on studies of similar systems Citations are appropriate and demonstrate awareness of the scientific context.
		8.5 Used literature sources are sufficient/not sufficient for a literature review	The bibliography is sufficient as it includes both foundational and modern works on Be disks, one/two-armed oscillations, tidal dynamics, tomography and SPH simulations.
9	Practical value principle	9.1 The thesis has theoretical value: 1) yes; 2) no	The results refine understanding of disk dynamics in Be binaries and provide constraints for future radiative transfer and hydrodynamic modelling. The work strengthens theoretical frameworks linking binarity to V/R behaviour.
		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 tomography workflow can be reproduced for other objects with sufficient spectroscopic monitoring. It is applicable to companion-search methods, mass determination, and disk morphology tracking.
		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)	While Doppler tomography itself is established, applying it to Be systems with high-mass stars, decretion disks, tracking disk dissipation and companion-linked emmision is a new implementation.

			The practice can be widely adopted in Be-star surveys and binary confirmation programs.
10.	The quality of writing and design	Academic writing quality: 1) high; 2) average; 3) below average; 4) low.	The level of academic writing presented in the articles that compose the dissertation work is high. The text is structured logically, terminology is precise, and results are clearly presented.
11.	Notes on a thesis	The work could benefit from more advanced modeling, such as hydrodynamical simulations.	
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 of research)	1. **Gabitova I. A.**, Zharikov S. V., Miroshnichenko A. S., Carciofi A., Khokhlov A. A., Agishev A., and Prendergast P. Doppler Tomography of the Be Star HD 698 //Galaxies. – 2025. – Vol. 13. – № 4. DOI: 10.3390/galaxies13040080. (**Journal Impact Factor – 3.8, WoS – Q2, Scopus – 74**) This study offers the most novel result, identifying companion-linked emission and refining the physical model of an object previously suspected to host a black hole. While the paper is a first step, setting up grounds for detailed modeling of the system, the results presented are of genuine astrophysical importance. 2. **Gabitova I. A.**, Miroshnichenko A. S., Zharikov S. V., Amantayeva A., and Khokhlov S. A. Doppler Tomography of the Circumstellar Disk of the Be Star κ Draconis //Galaxies. – 2024. – Vol.12. – №3. DOI: 10.3390/galaxies12030023. (**Journal Impact Factor – 3.8, WoS – Q2, Scopus – 74**) This work presents a creative application of Doppler tomography and delivers the first velocity-space mapping of the Be disk dissipation. The paper is of high quality. It is compact and focused on the clarity of methodology and interpretation. 3. Miroshnichenko A. S., Chari R., Danford S., Prendergast P., Aarnio A. N., Andronov I. L., Chinarova L. L., Lytle A., Amantayeva A., **Gabitova I. A.**, Vaidman N. L., Baktybayev S. S., and Khokhlov S. A. Searching for Phase-Locked Variations of the Emission-Line Profiles in Binary Be Stars //Galaxies. – 2023. – Vol.11. – №4. DOI: 10.3390/galaxies11040083. (**Journal Impact Factor – 3.2, WoS – Q2, Scopus – 66**) This publication establishes observational baseline for V/R variability across a broad sample of Be stars and demonstrates scrupulous methodology in long-term spectroscopic monitoring. The article is well-structured, scientifically useful, and contributes valuable classification and period confirmation relevant to	

		binary-driven disk dynamics.
13.	Decision of the official reviewer (pursuant to paragraph 28 of the present Model Regulations)	The dissertation work of Gabitova Ilfa entitled "Structure and evolution of circumstellar matter in Be stars" meets the requirements of the Committee for Quality Assurance in Science and Higher Education for dissertations for the degree of Doctor of Philosophy (PhD). The candidate deserves to be awarded the academic degree of Doctor of Philosophy (PhD) in the educational program 8D05307 – Physics and Astronomy.

Official Reviewer:

Dr. Dana Alina, Assistant Professor,
Physics Department,
School of Sciences and Humanities
Nazarbayev University,
Astana, Kazakhstan

(signature) D. Alina

Signature certification:

Dr. Gonzalo Hap Hortelano, Dean,
School of Sciences and Humanities,
Nazarbayev University,
Astana, Kazakhstan

(signature) G. Hap Hortelano

ЖӘГҒМ
SSH