MERIT
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PROJECT PROPOSAL
TECHNICAL DESCRIPTION

This page is for information only and should not be included in the proposal!

Proposals must address each of the award criteria as outlined in the relevant sections and respect the following minimum standards:

- 10 pages limit
- a minimum font size of 11 points (text inside tables 9 points)
- single line spacing
- margins (top, bottom, left, right) of at least 15 mm (not including any footer or headers),
- recommended font Times New Roman
- hyperlinks in the core text will not be open by the evaluators (avoid using them)
- footnotes are to be used exclusively for literature reference, min. font size 8. They will count towards the page limit
- tables are only to be used for illustrating the core text of the proposal; they cannot be used to contain the core text itself

Language:

- avoid jargon
- write in a style that is accessible using figures/tables/charts/diagrams to illustrate where appropriate.
- explain any abbreviations the first time you use them.
- use simple clear text, make sure that it ‘reads well’.
- avoid long sentences. Avoid too much repetition.
- do not copy and paste information from other documents/websites. Instead, tailor information to fit with your proposal. Try to make it relevant to your proposed fellowship.
- be consistent with terms used (for example, you can talk in 1st person (me), 3rd person (the researcher, the fellow), use the same term throughout.

Since the technical proposal template is based on the MSCA PF we strongly suggest to the applicants to go over the Handbook MSCA PF 2022 to find useful recommendations and what are the strengths and weaknesses of an application. But pay attention that some of the award criteria are different!

ISEMA (Impact of Self-consistent Stellar Evolution Models in Astrophysics)

---------- **Start page count – (max 10 pages)** ----------

1. EXCELLENCE

1.1 Quality and pertinence of the project's research and innovation objectives (and the extent to which they are ambitious, and go beyond the state-of-the-art).

In this project research, to be developed at the Ondrejov Observatory (OO) as the host institution, we revisit the evolution, structure, and properties of massive stars, plus their implications for Stellar Astrophysics and beyond. This will be made through a combination between state-of-the-art theoretical models and the most recent astronomical observations.

Stellar evolution is a relevant topic in Stellar Astrophysics, because it allows to elucidate questions such as the lifetime of stars as a function of their initial masses, their distribution of population at given interstellar environment, the final fate of the stars at the end of their lives, among other features. Evolution of the massive stars, i.e., born with masses 10 or more times than the mass of the Sun, is particularly interesting because they are the major contributors to the chemical enrichment of the interstellar media, and they are progenitors of compact objects such as neutron stars (NS) and black holes (BH). These compact objects have attracted a particular interest for astronomical research since the detection of the first gravitational waves (GW) in 2015, thus reconfirming one of the oldest theories about General Relativity from Albert Einstein. One of the most important sources of GW in the Universe is the merging of two compact objects in a binary system. Because these compact objects are stellar remnants of massive stars, and because we currently know that roughly the 70% of massive stars live of have lived in a binary system (i.e., with a secondary star as a companion, Sana et al. 2013), **the study of the evolution of massive stars is crucial to calculate the frequency of the mentioned merger events producing gravitational waves**. With the upcoming releases of the LIGO/Virgo/KAGRA (LVK) collaboration for the detection of gravitational waves, we urgently need new theories from stellar astrophysics to explain the new results.

Massive stars release a great amount of matter from their outer envelopes outwards, due to their strong outflows named **stellar winds**. Given the strength of these winds, a massive star loses so much mass that it is disrupting itself, thus heavily altering its evolution. In that line, one of the most important challenges is the evolution of the so-called **very massive stars** (VMS, born with more than ~100 solar masses), because they are the ideal candidates to produce the most massive stellar black holes but their mass-loss rates are very sensitive to the implemented theoretical prescription. In particular, we know that very massive stars switch from optically thin (O-type) to optically thick (WNh-type) winds during their H-core burning evolutionary stage (main sequence), but the moment when this transition from thin to thick winds takes place is still a matter of debate. As a consequence, **we require an accurate physical understanding of the outflows of massive stars in order to calculate the amount of mass lost by the wind (hereafter mass-loss rate), and therefore accurately describe the stellar evolution from their initial to their final stages.**

Stellar winds from massive stars also enrich the interstellar medium with the new chemical elements produced by nucleosynthesis, and this enrichment is directly proportional to the strength of such outflows. Moreover, the Galactic Centre (GC) of the Milky Way is populated by a large proportion of massive stars feeding the supermassive black hole Sgr A* by means of their strong stellar winds ([redacted] et al. 2007; [redacted] et al. 2017). The rate of this accretion over Sgr A* depends on the temperature reached by the gas formed by the collision of the winds of these massive stars at the GC, which in turn depends on the parameters (mass-loss rate and velocity profile) of such winds ([redacted] et al. 2005,2008; [redacted] et al. 2020a,b). Therefore, massive stars produce not only sources for gravitational waves but also impacts chemically and dynamically their local and Galactic environment.

In the last decades, both theoretical and observational diagnostics have demonstrated that the values for mass-loss rate commonly adopted to perform evolutionary models have been overestimated. This, because currently we know that winds of massive stars do not have a smooth density structure, but it contains overdense inhomogeneities called **clumping**, which overestimates the spectral measurements of mass-loss rate ([redacted] et al. 2005; [redacted] et al. 2012,2013). Hence, new theoretical studies modelling the wind of massive stars incorporate clumping, but still assuming many conditions a-priori for the inhomogeneities. Regardless of these limitations, the new found values for mass-loss rate are in the order of ~2 to 3 times less than previously assumed, and thus their impact in the stellar evolution becomes relevant. **This has been corroborated by the most recently developed models for the evolution of massive stars, which remark important discrepancies with respect to previous studies ([redacted] et al. 2022; [redacted] et al. 2022b,2023a)**. In particular, our mentioned evolution models are based on the calculations for the wind of massive stars presented in [redacted] et al. (2019,2021,2022a), where the obtained mass-loss rates are the result of a simultaneous calculation of the radiative acceleration of the wind and its hydrodynamics (for that reason, we call these results **self-consistent wind solutions**). Such new models are the state-of-the-art in the framework of stellar evolution, and they have adequately described some features observed for massive stars. This is shown in the attached Fig.1, where we compare the theoretical stellar evolution based on our new self-consistent models ([redacted] et al. 2023a) against evolution models adopting old recipes for mass-loss rate: left panel shows that stars should evolve towards cooler temperatures and right panel shows that the expected rotation velocities are in agreement with the most recent stellar surveys.

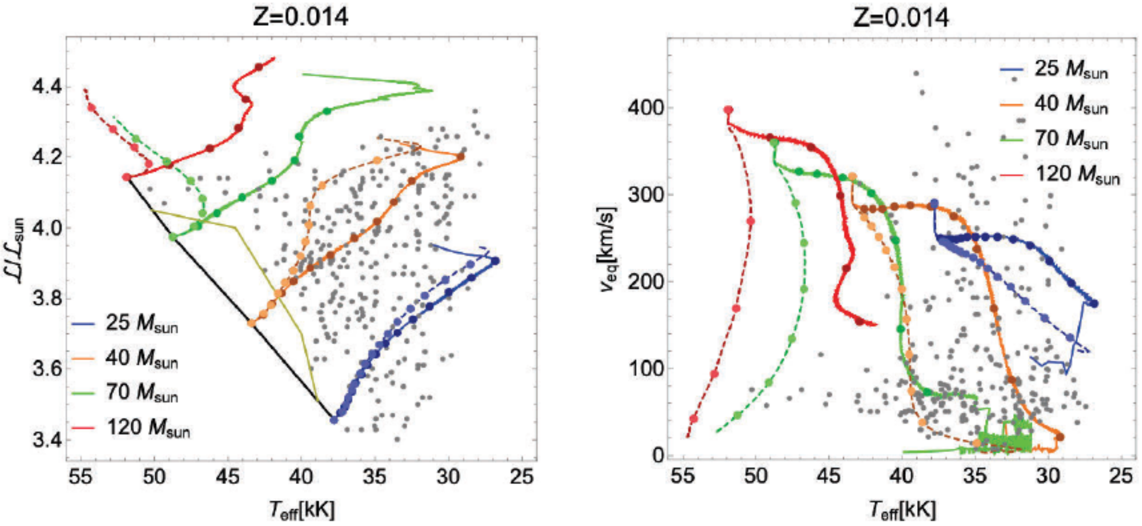

Fig. 1: Comparison between old evolutionary tracks (dashed lines) and new self-consistent evolutionary tracks (solid lines). Left panel shows the spectroscopic Hertzsprung-Russel diagram, whereas right panel shows the rotational velocity as a function of the effective stellar temperature. Grey dots represent the observational values obtained from the Galactic survey from [redacted] et al. (2020,2022). See Section 5 of [redacted] et al. (2023) for details.

Certainly these are encouraging results, but there is still a lot of work to do in terms of testing our evolution models with observational diagnostics, especially if we consider the observational projects for the years to come. For instance, results introduced by [redacted] et al. (2022b,2023a) are still limited to the local environment formed by our Milky Way and the Magellanic Clouds, and then we still need to explore environments with at more distant galaxies, where due to the low metallicity the stellar evolution is considerably different ([redacted] et al. 2015; [redacted] et al. 2019). Development of new technologies for the observational Astronomy have produced more astronomical data with better resolution, and therefore it is now possible to measure the parameters of massive stars (e.g., temperature, size, or mass-loss rate) with higher precision than before. A good example of this is the Hubble UV Legacy Library of Young Stars as Essential Standards (ULLYSES) program, which is a collaboration between different researchers to observe and calibrate the data for a large sample of stars. In the case of massive stars, the XShootU project (part of ULLYSES) includes the high resolution spectra of roughly 250 stars in the Magellanic Clouds and other galaxies where the metallicity (i.e., the fraction of the stellar chemical composition of elements heavier than helium) is very low, and whose parameters are being studied by spectral fitting. These environments at low metallicity are important because they resemble the conditions of the early Universe, and therefore we can have hints about how the evolution of stellar populations was in the past. Therefore, **the study of the stellar and wind parameters by spectral fitting, plus the incorporation of the most updated evolution models, are the perfect symbiosis towards a more accomplished understanding about massive stars and their impact beyond the field of Stellar Astrophysics.**

All these are hot topics in Astrophysics research nowadays, some of them we have already started to explore, and therefore we are confident that this proposal will be a huge contribution to our knowledge about the Universe. Besides, **the mentioned research in these paragraphs have involved a significant demand for computational resources such as new software and large data storage.** And in that line, we expect our proposal will support technological development in these areas.

In synthesis, our research objectives (RO) are:

- Study the inhomogeneities (clumping) in the wind structure, based on our state-of-the-art velocity profiles ([redacted] et al. 2019; 2021; 2022a), and the impact of clumping in the mass-loss rate of massive stars.
- Understand the evolution of massive stars in different environments (Milky Way, Magellanic Clouds, and galaxies at low metallicities) by evaluating our state-of-the-art evolution models with respect to observational diagnostics. This means, understand how stellar parameters such as the temperature, mass, size, rotation or mass-loss rate change over time, and what future we can elucidate for massive stars based on our analysis.
- Study the impact of our new evolution models over the remnant mass of compact objects (neutron stars and black holes), with particular focus on the evolutionary track of the VMS, and how these new masses affect the predictions of double compact objects (DCO) mergers as progenitors of gravitational waves.
- Study the impact of our new evolution models over the properties of the massive stars at the Galactic Centre, whether these stars are expected to exhibit weaker or stronger winds, and how these changes alter the accretion over the supermassive Galactic black hole Sgr A*.

1.2 Soundness of the proposed methodology (including interdisciplinary approaches, consideration of the gender dimension and other diversity aspects if relevant for the research project).

The methodology for our scientific project consists in a combination of running computational programs to develop theoretical models for stellar structure and evolution, together with the analysis of astronomical data (observations). The methodology is also based on the following pillars:

- For the **study of the wind structure and its inhomogeneities**, we will analyse the different clumping configurations (i.e., how big/small are these inhomogeneities and how they are distributed over the full density structure) and how these impact over the self-consistent solution for the wind hydrodynamics and the wind acceleration. In parallel, we evaluate how the self-consistent velocity profiles for the wind affects the clumping configuration in comparison with the original velocity law (namely beta-law) assumed a priori for the wind hydrodynamics. To achieve these analyses, we employ computational resources to develop our own programmes, as we formerly did in [redacted] et al. (2019).

  These two approaches are going to be developed simultaneously in order to derive a self-consistent prescription for the clumping, complementing the already obtained self-consistent solution for the mass-loss rate.
  - First, we parametrise our velocity profiles coming from [redacted] et al. (2019,2021,2022a) as Legendre polynomials, analogous to [redacted] (2011). A first *ansatz* of this procedure has already been explored, taking advantage of my former visit to the OO as a visitor (see Fig.2).

- ➢ Second, we incorporate this formula based on Legendre polynomials as an input for the 3D Monte Carlo clumping code developed by [redacted] et al. (2013), then replacing the old velocity profile based on beta-law.
- ➢ Then we evaluate the different resulting clumping configurations, looking for the structure of inhomogeneities which suits better the observational diagnostics (see, e.g., Fig.3 where we compare an observed spectrum with a synthetic model based on clumping parametrisation).

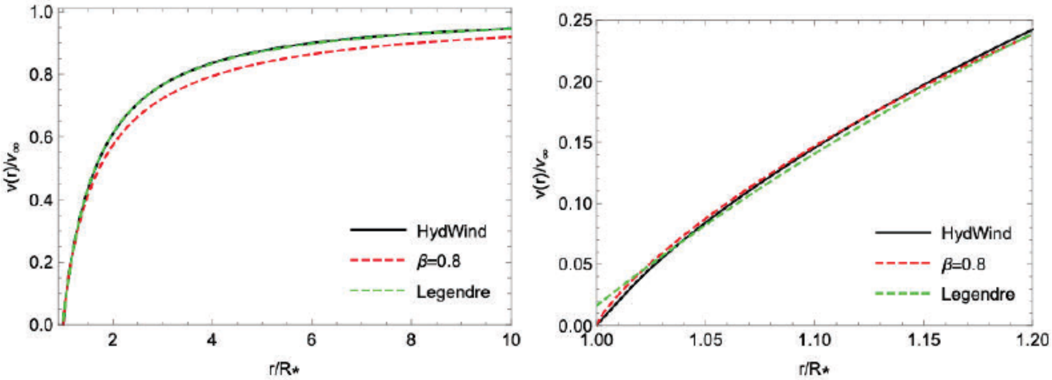

Figure 2: Fit with a serie of Legendre polynomials.

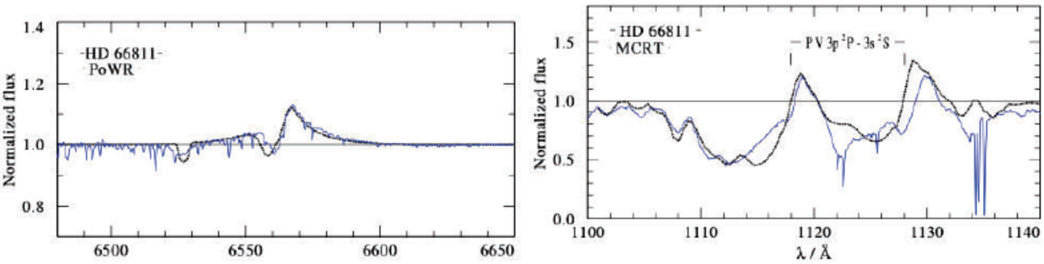

Figure 3: Spectral fitting for Hα (left panel) and the ultraviolet P V doublet (right panel) for ζ-Puppis (HD 66811) from the 3D Monte-Carlo calculations done by [redacted] et al. (2013). Final adjusted mass-loss rate was $2.51 \times 10^{-6}\ M_\odot\ \mathrm{yr}^{-1}$ and clumping factor $D = 10$.

- ❖ From our **stellar evolution models**, we develop a grid of tracks (i.e., plots showing the changes in temperature, luminosity, among other required parameters, at different timesteps, such as in Fig.1) following the evolution of stars born at different initial masses and different metallicities. The stellar metallicity is important for the evolution of massive stars because it is directly proportional to the mass-loss rate (see review from Vink 2021). For that purpose, I use the computational Geneva Evolution Code (GENEC, [redacted] et al. 2008), which simulates the evolution of a single star from its birth to its collapse, based on state-of-the-art physical assumptions concerning energy transport, mass loss, etc. Results derived from stellar evolution models are varied, but we will focus on the most relevant scenarios related to our original work plan:
  - ➢ We develop new tracks adopting the state-of-the-art recipes for mass-loss rate. Not only the recipe from [redacted] et al. (2022b,2023), which is valid for the beginning of the lifetime of stars, but also the mass-loss recipes for stars at advanced stages such as WNh ([redacted] et al. 2020; [redacted] et al. 2022) and WR stars ([redacted] 2020; [redacted] et al. 2023). For this, we modify the scripts of GENEC (which are written in *Fortran*) according to our requirements, and then we run the evolution models taking advantage of the computational resources at our disposal.
  - ➢ We extend the range of validity of our evolution models, covering the mass range of the mentioned very massive stars (VMS) and also covering environments at very low metallicity.

- We analyse the results related with the expected values for the evolution of stellar properties during their lifetimes (radius, temperature, luminosity, abundances, rotational velocity), comparing with old evolution models and with more modern astronomical observations.
- We analyse the **initial-remnant mass relation** (a plot showing what should be the mass of a star given its initial mass at birth, see Fig. 4), and evaluate how the implementation of new wind recipes impacts on the predictions of masses for stellar black holes, either in the Milky Way as close extragalactic environments. Our analysis also includes the mass-loss from eruptive processes such as Luminous Blue Variables (LBV). Subsequently, based on these new initial-remnant mass relations, we can infer the expected number of double compact objects (DCO) merging events in the local Universe.

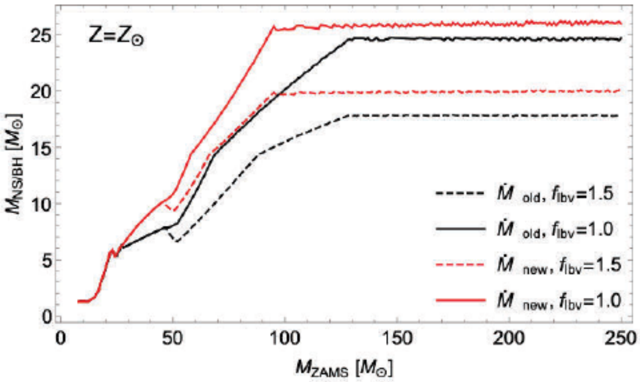

Fig. 4: Upper panel: Initial-remnant mass relations, comparing old and new (self-consistent) wind prescriptions, and testing $f_{\rm lbv}$ for LBV winds being either 1.0 or 1.5. Figure taken from [redacted] (2023b, in preparation).

- For the **astronomical data**, we collect the information analysed by the XShooter project, plus any other sources under agreement with the respective researchers. Data required for us include stellar parameters (temperature, mass, radius, metallicity, rotation velocity) and wind parameters (mass-loss rate, terminal velocity, clumping), which are obtained by spectral fitting with computational codes such as FASTWIND or CMFGEN. If the data of parameters is incomplete, or under discussion, the fitting will be developed by this project thanks to the expertise of the researcher and the host team.

Important to mention, that the section of wind structure and inhomogeneities will be performed in close collaboration with [redacted] from the host institute (OO), with [redacted] from Masaryk University (Brno, Czech Republic) and with [redacted] and [redacted] from Chile. The section of stellar evolution models will be performed in collaboration with [redacted] and [redacted] from Geneva Observatory (Switzerland), [redacted] from Keele University (United Kingdom), with [redacted] from Universidad Adolfo Ibáñez (Chile) and with Dr. [redacted] from Nicolaus Copernicus Astronomical Centre (Warsaw, Poland). And the section of astronomical data will be performed in close collaboration with [redacted] and [redacted] (OO), plus the international team participating in the XShooter project. In summary, we possess a powerful international network, with high level researchers in the field of Stellar Astrophysics, to achieve our goals. Moreover, we have at our disposal supercomputers in Chile, Poland and the Czech Republic to run the mentioned codes such as CMFGEN and GENEC; however, we have the intention of doing our 9-months secondment in the Berlin Institute of Technology (BIT) to expand our computational power and then to accelerate the running of all our structural and evolutionary models.

Concerning the structure of the scientific results, we aim to publish a desirable number of 4 academic papers in Open Access journals, one per each one of our scientific goals, or Work Packages (WP):

- One paper about the clumping in the wind structure of massive stars, based on a velocity profile beyond the beta-law.

- One paper about the impact of new self-consistent evolution tracks for different sets of stellar populations at low metallicity, using the observational data from the XShooter project.
- One paper about the evolution of very massive stars adopting the state-of-the-art prescriptions mass-loss for mass-loss rate at all their evolutionary stages (O, WNh and WR type), and calculating the predicted total mass for the remnant stellar black hole. We add the impact on the predictions of DCO mergers as sources of future gravitational waves.
- One paper about the impact of new self-consistent evolution tracks for the population of massive stars (O and WR type) at the Galactic Centre, in a supersolar metallicity environment, and the effect of their colliding winds for the accretion over the supermassive black hole Sgr A* at the centre of the Milky Way.

More publications, based on our potential future collaborations, are also expected. However, due to potential delays (see assessment of risks), we propose a minimum of 3 published papers at the end of this MERIT project. In addition, other activities about dissemination of our academic work contemplates the attendance to international conferences and seminars.

About the gender dimension, it is important to remark that this introduced methodology has no gender biases, because all the related work requires only technical and academic skills which are independent of the gender of the participants. Also, the Stellar Department of the Czech Academy of Sciences is headed by [redacted]; and besides her, our community of collaboration is adequately represented by an important number of female researchers, thus ensuring a representative work group.

1.3 Quality of the two-way transfer of knowledge between the researcher and the host.

The Stellar Physics Department of the Astronomical Institute of the Czech Academy of Sciences (ASU), headed by Dr. [redacted], is a proactive team in the research of the stellar winds of massive stars. In particular, [redacted] and [redacted] have developed important prescriptions for the modelling of stellar atmospheres and their inhomogeneities. They have decades of academic experience, either researching, supervising doctoral studies, and organising scientific meetings, plus the required computational resources to run theoretical models for stellar structure and evolution. I must also mention [redacted], who is expert in performing spectral fittings for massive stars using the code CMFGEN.

The models performed by the Stellar Physics Department of the ASU recreate in 3D the overdensities, their sizes and space between them, to reproduce after the synthetic spectra to be compared with observations. The knowledge about such 3D clumping models are a perfect complement to our self-consistent wind solutions, which calculate the mass-loss rate but adopt the clumping as a free parameter. In parallel, I can compliment the Stellar Winds team at ASU with my knowledge about stellar structure and evolution of massive stars. Such expertise is evidenced in my most recent published manuscripts in the area.

Besides the two-way transfer of knowledge related to technical aspects of research, I also expect to transfer to the Ondrejov Observatory (OO) part of my soft skills related to leadership and group and team work. Such skills are going to be complemented with the workshops on transferable skills provided by MERIT and organised by the Central Bohemian Innovation Centre (SIC). I will attend the sessions of Open Science/Open Access, Leadership Skills, Citizen Science, and Funding Opportunities. These are the training sessions that suit better with my work profile, and where I can highlight the potential of the two-way transfer between the host institution (Ondrejov Observatory) and me.

1.4 Quality and appropriateness of the researcher's professional experience, competences and skills.

As a researcher, I have expertise in the implementation of computational codes for the calculation of both stellar structure and stellar evolution. In technical aspects, this implies the management of programming languages such as *Fortran*, *Python* and more sophisticated software systems such as *Mathematica*, which is required to develop multiple plots and graphs. Besides, I have expertise working in large collaborative teams from different parts of the world (Chile, Argentina, United States, Spain, Czech Republic, Belgium, Switzerland, Germany, Poland, United Kingdom, Ireland, Poland) involving different fundamental aspects (wind structure, internal structure, stellar evolution, stellar populations) and technical aspects (spectroscopy, data analysis, theoretical development) of the scientific work structure, as shown in my respective publications and conference attendees. Such a huge network of collaborators has not been created by chance, but thanks to my soft skills and my independent thinking capable of imagining research projects attractive for the scientific community.

Moreover, I have been a peer reviewer of scientific manuscripts for the journal Astronomy & Astrophysics, evaluating the academic work of colleagues in the area of Stellar Astrophysics. I have also been a reviewer of fellowship programs for the Czech Science Foundation (GAČR). In addition, I have also provided recommendation letters for doctoral students, giving them feedback for their future research applications.

Because of my academic career I have lived in different countries: the United States, Ireland, Belgium, Czech Republic and Poland. In these territories not only have I participated in the workplace but also in the social life, where I have learned about the history and culture of each country. I also participated in many outreach activities during my undergraduate period (astronomical observations, attendance to schools, etc.), so I have enough expertise to disseminate my research activities or Astronomy in general among the general public.

2. IMPACT

2.1 Credibility of the measures to enhance the career perspectives and employability of the researcher and contribution to his/her skills development.

This proposal is dedicated to the study of topics in the frontier of Astronomy, by means of the usage of some of the most sophisticated state-of-the-art computational programmes and softwares. Because of the upcoming discoveries, either from astronomical observation of massive stars with better resolution or the detection of new gravitational waves, it is expected a huge amount of new data to be released and thus the project I introduce in this proposal is crucial to manage such information and be at the forefront of the scientific research in Astrophysics. Concerning the programmes, these are being constantly upgraded by their developers (with me as collaborator for the codes GENEC and CMFGEN), which means that I will be updating my skill managing these codes regularly in time. This constant upgrade also implies a constant contact with my worldwide network of collaborators.

The focus of this proposal project is mostly academic because my goals in the long-term is the pursuing of a tenure track position as a PI, where I can not only continue doing research in the frontiers of Astronomy but also mentoring the new generation of researchers. In that line, **I expect as a short-term goal to continue working after the end of this MERIT project as a fellow researcher in the Czech Republic, either in Ondrejov Observatory or in Charles or Masaryk universities**. To achieve this goal, I consider it important to have an important academic work in terms of scientific publications and conference attendees, in order to be fully integrated into the research community. But also it is required to exploit the soft skills necessary to disseminate my scientific work towards a broader audience, and the training sessions of SIC are highly oriented to that purpose.

Moreover, together with the academic focus of my proposal I also aim to highlight its technological facet. Some of the previously mentioned programmes (CMFGEN, GENEC) require large amounts of computational work, and thus they require the development of clusters and supercomputers capable of dealing with such huge processes. For this reason, I apply to do my MERIT secondment in the BIT. Therefore, by means of this MERIT project I expect to strengthen my academic record and communication skills, together with having access to some of the most powerful computational resources.

2.2 Suitability and quality of the measures to maximise expected outcomes and impacts, as set out in the dissemination and exploitation plan, including communication activities.

Related to the purely academic aspect of our proposal, we will publish the results of our scientific research activities in Open Access academic journals with the highest impact in the field of Astronomy, such as *Astronomy & Astrophysics* (A&A, impact factor 6.240) and *Monthly Notices of the Royal Astronomical Society* (MNRAS, impact factor 5.235), with the respective press releases in collaboration with the outreach team of the Czech Academy of Sciences. Extra data, such as astronomical catalogues or the grid of evolution models, will be uploaded online by the respective platforms such as VizieR, being available to all the astronomical community.

Related to the dissemination of our work, I foresee to take advantage of the training sessions on transferable skills included in the MERIT fellowship to participate in public lectures, attendance to highschools, or any other activity required by SIC. These activities will be focused not only in the diffusion of our particular work about the study of the structure and evolution of massive stars, but also on more general aspects of academic life (for example, teaching to a large audience how an astronomer works). Some draft ideas are displayed in the following table:

Activity	Target audience	When	Where	Key indicators
2 conferences "Evolution of hot massive stars"	Physics and Astronomy undergraduate students	For the first and the second 12-months periods	Charles University in Prague, and Masaryk University in Brno	Focused to motivate undergraduate students to choose a thesis topic
2 conferences "The life of stars"	Highschool students	For the first and second 12-months periods	Whenever required by SIC, inside the Czech Republic	Focused to motivate highschool students to study Astronomy as a major.
2 conferences "Modelling and observing stars"	General public	For the first and second 12-months periods	Ondrejov Observatory	Focused to teach general public how astronomers work
2 articles in local Czech media	General public	For the first and second 12-months periods	Czech local newspaper or TV or radio	Focused to outreach to the general public our most recent research activities

It is important to mention however, that the number of activities is just referential, and we hope to do even more activities.

2.3 Sustainability of the candidates' research project in the Region. Opportunities to continue the research through regional/international collaboration with relevant industry or academic sectors.

Besides the academic work and the outreach activities scheduled as part of the MERIT fellowship, another aspect to highlight the established connections of the Ondrejov Observatory with Charles University in Prague and Masaryk University in Brno. These connections are relevant not only for the potential collaborations with academics working in such universities, in particular if we consider my short-term goal of work as a researcher in the Czech Republic, but also because it is an important opportunity to share our knowledge with the future postgraduate students. **As a research fellow, I want to contribute as an advisor for the next generation of Masters and Doctors in Astrophysics of the Czech Republic.** In addition, such experience will be fruitful to strengthen my professional expertise towards the goal of getting a longer stay in the Region.

3. IMPLEMENTATION

3.1 Quality and effectiveness of the work plan and assessment of risks.

My intended schedule of work for 30 months, from May 2024 to October 2026 (though the initial date might be modified if the MERIT fellowship deems it convenient) is organised as it is shown in the following Gantt chart:

	2024								2025												2026									
	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O
WP1: Self-consistent clumping structure																														
Replace velocity profile for 3D MC clumping simulator	🟦	🟦	🟦	🟦	🟦																									
Adapt 3D clumping structure to 1D				🟦	🟦	🟦	🟦	🟦																						
New wind solutions with clumping incorporated								🟦	🟩	🟩	🟩	🟩	🟩																	
New relationship between clumping and mass-loss rate														🟩	🟩	🟩	🟩	🟩												
Analysis, discussion and writing of the manuscript #1																			🟩	🟩	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥	🟥
WP2: Evolution models for very massive stars																														
Incorporate mass-loss recipe for WNh stars in GENEC	🟦	🟦	🟦																											
Run new self-consistent evolution tracks for VMS	🟦	🟦	🟦																											
Analysis of results for VMS evolution and comparison with observations			🟦	🟦	🟦																									
Impact of new mass remnants over the DCO merger rate					🟦	🟦	🟦	🟦	🟩	🟩																				
Discussion and writing of the manuscript #2					🟦	🟦	🟦	🟦	🟩	🟩																				
WP3: Evolution models for low metallicities																														
Extend self-consistent tracks to advanced evolution stages	🟦	🟦	🟦																											
Extend self-consistent tracks to lower metallicities	🟦	🟦	🟦																											
Compare results with observation diagnostics from XShooter database			🟦	🟦	🟦																									
Analysis, discussion and writing of the manuscript #3					🟦	🟦	🟦	🟦	🟩	🟩																				
WP4: Evolution models for Galactic Centre																														
Extend self-consistent tracks to higher metallicities					🟦	🟦	🟦																							
Stars at the Galactic Centre: WR and S-stars with $Z/Z_\odot = 2.0$								🟦	🟩	🟩	🟩	🟩	🟩	🟩	🟩															

Analysis and consequences over the gas dynamics in the GC													🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟥	🟥	🟥	🟥						
Discussion and writing of the manuscript #4																									🟥	🟥	🟥	🟥	🟥	🟥
Dissemination activities																														
Talks "Evolution of hot massive stars"							🟦	🟦	🟩										🟩	🟩	🟥									
Talks "The life of stars"										🟩	🟩	🟩										🟥	🟥	🟥						
Talks "Modelling and observing stars"													🟩	🟩	🟩										🟥	🟥	🟥			
Articles in local Czech media																🟩	🟩	🟩										🟥	🟥	

The schema is organised in such a way that I expect to have at least one of the manuscripts already published before the end of the first 12-months period, in particular the items WP2 and WP3. This will be possible because I have already started to work on the extension of the grid of evolution models adopting self-consistent winds, for the required mass and metallicity ranges, together with incorporating the evolution through the WR stage. For WP1, because of the higher computational effort required, we propose a wider period of time to develop the respective work. Concerning WP4, the required astronomical data (spectra of the stars at the GC) does not belong to the XShooter project and needs more treatment (normalisation and spectral fitting), thus I schedule the most time demanding part of the work for the final part of our 30-months period. I also incorporate extra rows in each item named Future work, because the publication of our intended results carries new scientific questions thus opening new projects. Important to mention that, the Gantt chart is organised on the basis of the intended work packages, being all of them capable of being carried out either from the OO or from the BIT. This organisation has the advantage of keeping the dates for the secondment at any time, depending on the schedule of the host institution.

About assessment of risks, it is important to mention that the majority of our research work is based on the availability of computational resources. Because of this reason, we are always at risk of work delays due to computational problems (memory allowance issues, clusters out of service for any unexpected reason beyond our limits, etc.). For example, we could deal with troubleshooting in the last stages of our GENEC evolution models, which are the most demanding in terms of computational time. The same with CMFGEN models: spectral fitting is a delicate process where any model lasts more than 20 hours to converge, and then the time until getting the most optimal spectral fit. For these examples is that, even when we point out the publication of 4 scientific articles, one per each RO, we put as a minimum threshold the publishing of 3 scientific articles for the end of this MERIT fellowship.

3.2. Relevance, feasibility and benefit for the research project objectives of the planned secondment. Quality of the secondment choice in terms of at least one of the following principles: intersectorality, interdisciplinarity or international mobility.

In this proposal, we address the three principles of intersectionality, interdisciplinary and international mobility.

Because of the link between our topic of research with the requirement of highly sophisticated computational resources, we establish **intersectorality** with technological development, thanks also to my intended secondment in BIT. Because of my scheduled outreach activities for public conferences and attendance to highschools, and my training in Leadership Skills and Citizen Science, we establish an **interdisciplinary** relationship between my particular research and the communication with the general public. And finally, because my already created international network of collaborators, plus my secondment in Germany, we also satisfy the requirements for **international mobility**.

Zápis z jednání Steering Committee MERIT ze dne 11.12.2023

Přítomni:

- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]
- [redacted]

Omluvena:

- [redacted]

Agenda:

1. **Zahájení, schválení programu schůze**

Program schůze:

- **Rekapitulace stavu úkolů z minulého jednání**
- **Představení výběrového procesu**
- **Schvalování předložených projektů**
- **Termíny následujících jednání + zamyšlení nad informacemi potřebnými pro monitoring vědeckých projektů**

Návrh usnesení:

Řídicí komise MERIT bere na vědomí program jednání.

Výsledky hlasování

Pro: 4; Proti: 0

Přijaté usnesení:

Řídicí komise MERIT bere na vědomí program jednání.

2. **Úkoly z minulého jednání**

- Vytvořeno sdílené úložiště pro členy SC v prostředí Microsoft 365
- Aktualizovaný jednací řád a seznam zúčastněných partnerských institucí programu MERIT poslán členům SC
- Připravena Dohoda o mlčenlivosti (Non-disclosure agreement) kvůli zajištění důvěrnosti informací členů Steering Committee, podepsána všemi členy (přílohy tvořily ještě prohlášení v AJ: Prohlášení o důvěrnosti, neexistenci střetu zájmů a nediskriminaci, kvůli splnění podmínek projektu vůči EU)

Návrh usnesení:

Řídicí komise MERIT bere na vědomí stav úkolů z minulého jednání.

Výsledky hlasování

Pro: 4; Proti: 0

Přijaté usnesení: *Řídicí komise MERIT bere na vědomí stav úkolů z minulého jednání.*

3. Stručné představení výběrového procesu

- PPT prezentace Programové manažerky

Návrh usnesení:

Řídicí komise MERIT bere na vědomí informaci o průběhu výběrového procesu první výzvy programu MERIT.

Výsledky hlasování

Pro: 4; Proti: 0

Přijaté usnesení: *Řídicí komise MERIT bere na vědomí informaci o průběhu výběrového procesu první výzvy programu MERIT.*

4. Schvalování předložených projektů

- Členům komise byla předem sdílena tabulka s přehledem kandidátů, jejich umístění, včetně navrhovaných secondmentů, stručné abstrakty řešených projektů, a dále kompletní projektové návrhy a hodnotící reporty z obou kol hodnocení
- Všechny projekty prošly hodnocením v mezinárodním transparentním výběrovém řízení v souladu s pravidly programu MERIT.

Návrh usnesení:

Řídicí komise schvaluje celkem 23 projektů předložených do první výzvy programu MERIT, z nichž 15 projektů, které získaly v hodnocení nejvyšší skóre, budou podpořeny, a 8 rezervních projektů může být podpořeno v případě, že některý z podpořených projektů nebude realizován.

Výsledky hlasování

Pro:4 ; Proti: 0

Přijaté usnesení – *Řídicí komise schvaluje celkem 23 projektů předložených do první výzvy programu MERIT, z nichž 15 projektů, které získaly v hodnocení nejvyšší skóre, budou podpořeny, a 8 rezervních projektů může být podpořeno v případě, že některý z podpořených projektů nebude realizován.*

Řídící komise zároveň navrhuje prověřit zejména ruské žadatele a žadatele z třetích zemích z důvodu bezpečnostního rizika realizace jejich projektů (BIS).

5. Plán pro druhou výzvu a termíny následujících setkání

- ČERVENEC 2024 – monitoring po prvním reportovacím období (zprávy o průběhu realizace projektů, komunikační a diseminační aktivity vědců, účast vědců na akcích SIC apod.)
- ZÁŘÍ 2024 – schvalování projektů vybraných v druhé výzvě programu

- LEDEN 2025 – monitoring po druhém reportovacím období (zprávy o průběhu realizace projektů, komunikační a diseminační aktivity vědců, účast vědců na akcích SIC apod.)

Návrh usnesení:

Řídicí komise MERIT bere na vědomí plán pro druhou výzvu programu a termíny následujících jednání.

Výsledky hlasování

Pro:4; Proti: 0

Přijaté usnesení

Řídicí komise MERIT bere na vědomí plán pro druhou výzvu programu a termíny následujících jednání. Řídíce komise stanovila termín na příští setkání k prvnímu reportovacímu období dne 25.7.2024.

6. Zamyšlení nad informacemi potřebnými pro monitoring projektů

- Monitoring bude probíhat jednou za 6 měsíců, informace budou pravidelně poskytovány ze strany výzkumných organizací (supervizor + vybraný stážista)

Návrh usnesení:

Řídicí komise MERIT bere na vědomí obsah monitorovacího reportu a schvalují navržené změny.

Výsledky hlasování

Pro:4.; Proti:0

Přijaté usnesení

Řídicí komise MERIT bere na vědomí obsah monitorovacího reportu a schvaluje navržené následující změny, které budou vloženy do monitorovacího reportu:

- neúspěchy a případné změny projektu,

- informace, zda je projekt v souladu s harmonogramem,

- informace o tom, v jakém stavu se projekt nachází,

- milníky projektu.

Monitorovací Report bude upraven a poslán Řídicí komisi k odsouhlasení.

Zapsala:
[redacted]

Zápis ověřil:
[redacted]

Příloha: Seznam schválených projektů

Seznam 15 kandidátů s nejvyšším skóre

Name of the candidate	Host organisation	Final score
[redacted]	ELI Beamlines Facility - The Extreme Light Infrastructure ERIC	95,8
[redacted]	Institute of Animal Physiology and Genetics of the Czech Academy of Sciences	95,7
[redacted]	National Institute of Mental Health	94,7
[redacted]	Astronomical Institute of the Czech Academy of Sciences	89,9
[redacted]	Astronomical Institute of the Czech Academy of Sciences	89,7
[redacted]	Institute of Animal Physiology and Genetics of the Czech Academy of Sciences	87,8
[redacted]	Institute of Thermomechanics of the Czech Academy of Sciences	85,6
[redacted]	Astronomical Institute of the Czech Academy of Sciences	84,1
[redacted]	ELI Beamlines Facility - The Extreme Light Infrastructure ERIC	83,3
[redacted]	Czech University of Life Sciences Prague	82,3
[redacted]	Institute of Physics of the Czech Academy of Sciences / HiLASE	81,5
[redacted]	Czech Technical University in Prague, Czech Institute of Informatics, Robotics, and Cybernetics	81,4
[redacted]	Research Institute of Geodesy, Topography and Cartography	81,1
[redacted]	Institute of Physics of the Czech Academy of Sciences / HiLASE	80,1
[redacted]	UCEEB Czech Technical University in Prague, University Centre for Energy Efficient Buildings	78,9

Seznam 8 rezervních kandidátů

Name of the candidate	Host organisation	Final score
[redacted]	National Institute of Mental Health	76,8
[redacted]	Institute of Microbiology of the Czech Academy of Sciences	76,1
[redacted]	Research Institute of Geodesy, Topography and Cartography	76,1
[redacted]	Astronomical Institute of the Czech Academy of Sciences	74,7
[redacted]	UCEEB Czech Technical University in Prague, University Centre for Energy Efficient Buildings	74,6
[redacted]	National Institute of Mental Health	74,5
[redacted]	Institute of Animal Physiology and Genetics of the Czech Academy of Sciences	73,8
[redacted]	ELI Beamlines Facility - The Extreme Light Infrastructure ERIC	73,6