

## THE ANNUAL REPORT

Name and surname	Rafia Sarwar
Project title	Gamma-ray burst and gravitational-wave event rates: modern population synthesis
Scientific disciplines	Astronomy
Supervisor	Prof. dr. hab. Michal Hanasz
Foreign scientific supervisor	Dr. Dorottya Szecsi

### Year of study: (the academic year 2021/ 2022)

#### 1. Description of the progress in the preparation of the doctoral dissertation and the progress in conducting scientific research

In recent years theoretical and observational stellar astrophysics strongly altered the paradigm of our current understanding of the life cycle of massive stars, from their birth in the dense interstellar medium to their final fate of collapsing into compact objects. If these compact objects are insufficiently close orbits, they start losing orbital energy via gravitational wave (GW) emission. Stellar evolutionary models combined with binary population synthesis studies are commonly used to statistically infer the event rates of these gravitational waves. Despite their significance, many if not all the evolutionary models of massive stars do not take in the final phase of the stellar explosion. The complexity of the problem is due to the intricate dependence of the explosion physics on the structure of the exploding star. Therefore, it is crucial to develop a new computer routine that associates stellar models with various types of supernovae in accordance with their explosion energies and ejecta mass. This present PhD project aims to study the astrophysical sources that are anticipated progenitors of gravitational waves with associated gamma-ray bursts.

This can be achieved by developing a new computer routine 'FINFAT' to decide the final fate of stars given in a population expected to undergo based on the stellar models. These stellar models can be evolved using various stellar evolutionary simulations such as MESA and Bonn Code.

#### Scientific goals:

1. First scientific goal: General training on the use of the MESA software.
2. Second scientific goal: Preparation of simulation setups based on the existing literature and most recent observation.
3. Third scientific goal: Computation of stellar models for single and binary stars.

#### 2. Participation in classes

[Title of courses, amount of hours, ECTS credits].

1. Name of the course: Gravitational-wave progenitors  
Course code on USOS: 0800-M-GRAVPROG  
Form of classes: General  
Form of classes: Lecture  
Final grade: 5  
Number of hours: 90 hours  
Number of ECTS points: 3 ECTS credits
2. Name of the course: Elements of occupational health and safety and ergonomics (general training)  
Course code on USOS: 9001-eBHP  
Final grade: ZAL  
Number of hours: 10 hours  
Number of ECTS points: 1 ECTS credit

<p>3. Name of the course: Scientific data presentation and copyright I Course code on USOS: 7405-AC-SDPC1-1 Form of classes: Seminar Final grade: 5 Number of hours: 10 hours Number of ECTS points: 1 ECTS credit</p> <p>4. Name of the course: Scientific methodology Course code on USOS: 7405-AC-SM-1 Form of classes: Seminar Final grade: 5 Number of hours: 30 hours Number of ECTS points: 3 ECTS credits</p> <p>5. Name of the course: Supervisory mentoring Course code on USOS: 7405-AC-SMEN-1 Form of classes: Supervisor mentoring Final grade: 5 Number of hours: 10 hours Number of ECTS points: 1 ECTS credit</p>
<p>3. Participation in scientific conferences. [name of conference, organizer, dates]</p> <p>1. Workshop title: Bringing Stellar Evolution and Feedback Together Date: 25 - 29 April 2022 Venue: The Lorentz Center, Niels Bohrweg 2333 CA Leiden, Netherlands.</p> <p>2. Conference name: The PHAROS Conference 2022 Date: 16 - 19 May 2022 Venue: La Sapienza University, Aula Magna, Piazzale Aldo Moro, 5, 00185 Rome, Italy.</p> <p>3. Conference name: XV Kopernikańskie Seminarium Doktoranckie Date: 20 - 22 June 2022 Venue: Nicolaus Copernicus University, Toruń, Poland.</p>
<p>4. Internship. [Name of the institution, place, dates, description of the internship].</p> <p>Project title (tentative): Searching for binary black holes in the Milky Way with LISA Date: May 2020 - Present Collaborator Names: Tassos Fragos, Simone S. Bavera, Florian Giraud Collaborator's Institute: Departement d'Astronomie, Université de Genève, Chemin Pegasi 51, CH-1290 Versoix, Switzerland.</p> <p>Due to the COVID restrictions and other travelling constraints internships are being continued online.</p>
<p>5. Initiating a doctoral assessment process – yes/no [delete as appropriate].</p> <p>Not applicable</p>
<p>6. Submission of the doctoral dissertation – yes/no [delete as appropriate].</p> <p>Not applicable</p>

7. Teaching practice

[Title of courses, amount of hours].

Not applicable

8. Applying for a research grant.

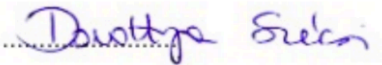
The centre of excellence fully funds this PhD position for four years including all the expenses for foreign business trips to participate in conferences and schools.

20 - 09 - 2022

Date



PhD student's signature



Scientific Supervisor's signature

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Signature of the Head of ISD AC