BRAVE: Binary star physics in the era of electRomagnetic and grAvitational waVe sciEnce

A Data Management Plan created using DMPonline.be

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Project abstract:

Summary: Stellar multiplicity is a ubiquitous outcome of star formation. At least 50% of all sun-like stars have companions and that fraction approaches 100% for the most massive stars. This makes binaries and multiple systems the norm rather than the exception. Binary physics is thus an absolutely necessary and critical ingredient for understanding how stars evolve. However, comprehensive models of various physical processes involved in binary-star evolution are still lacking, and those that do exist suffer from important theoretical uncertainties (associated with, e.g., mass transfer, the angular momentum budget, mass loss, and orbital evolution). As such, present-day predictions for binary-star evolution – and their end-of-life products – are seriously flawed. This obstacle leads to highly uncertain predictions for the frequency of core-collapse supernovae, black holes and neutron stars, and hence the frequency of gravitational wave events that can be detected with current and upcoming facilities. The overarching goal of this ambitious C1 BRAVE project is to fundamentally improve our understanding of binary-star physics by (i)} using and developing novel theoretical and observational methods to probe the physics of binary stars and (ii) examining in unprecedented detail the role of the binary components in stellar evolution. We will develop new 3D radiative-hydrodynamical models for studying the mass and angular momentum budget in binary systems. These models will be confronted with high-quality data that not only trace the contemporary impact, but also the long-term outcome of the binary interaction. This will lead to new publicly available binary-evolution algorithms that will allow us to explore the binary-star parameter space in statistical studies and to follow in detail the evolution of each component in the system. As such, the results of this C1 will strongly impact the wide range of fields in astronomy relying on a firm understanding of binary star evolution, and will lead to the consolidation of a KU Leuven excellence pole on binary star evolution that is unique at the international scientific landscape.

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Research Data Summary

List and describe all datasets or research materials that you plan to generate/collect or reuse during your research project. For each dataset or data type (observational, experimental etc.), provide a short name & description (sufficient for yourself to know what data it is about), indicate whether the data are newly generated/collected or reused, digital or physical, also indicate the type of the data (the kind of content), its technical format (file extension), and an estimate of the upper limit of the volume of the data.

Dataset name / ID	Description	New or reuse	Digital or Physical data	Data Type	File format	Data volume	Physical volume
		Indicate: ***N****(ew data) or* ***E****(xisting data)*	Indicate: **D**(igital) or **P**(hysical)	Indicate: **A**udiovisual **I**mages **S**ound **N**umerical **T**extual **M**odel **SO**ftware Other (specify)		Indicate: <1GB <100GB <1TB <5TB >5TB NA	
WP1.1	3D simulations	N	D	M	txt, fits	<5TB	
	MPI-AMRVAC	E	D	SO	Fortran code	<100GB	
WP1.2+1.3	MESA models	N	D	M	txt, fits	<5TB	
	MESA	E	D	SO	Fortran code	<100GB	
WP2	MAGRITTE	E	D	SO	C++/Python code	<100GB	
WP2.1	RT-RC emulator	N	D	N	code	<100GB	
WP2.2	RHD modules	N	D	N	code	<100GB	
WP2.3	RH models	N	D	M	txt, fits	<5TB	
WP4.1	BOSS-3D	E	D	SO	IDL/Fortran code	<100GB	
WP4.2	3D analysis	N	D	M	txt, fits	<5TB	
WP4.3	3D spectral analysis	N	D	M	txt, fits	<5TB	
WP4.4	MESA models	N	D	M	txt, fits	<5TB	
WP4	TESS&Gaia observations	E	D	N	fits	>5TB	
WP6.1	sampling & interpolation techniques	N	D	N	numerical methods in code	<100GB	
WP6.2-6.5	binary simulations	N	D	M	txt, fits	<5TB	
WP6.3	Bayesian analysis tools	N	D	N	numerical methods in code	<100GB	
WP6.4	population models	N	D	N	txt, fits	<5TB	

If you reuse existing data, please specify the source, preferably by using a persistent identifier (e.g. DOI, Handle, URL etc.) per dataset or data type:

Software codes used:

- MPI-AMRVAC: amrvac.org
- MESA: docs.mesastar.org
- MAGRITTE: GitHub.com/Magritte-code
- BOSS-3D: https://doi.org/10.1051/0004-6361/202141831

Observational data used:

- TESS archival photometry: https://archive.stsci.edu/missions-and-data/tess
- Gaia archival astrometry: https://gea.esac.esa.int/archive/

Are there any ethical issues concerning the creation and/or use of the data (e.g. experiments on humans or animals, dual use)? If so, refer to specific datasets or data types when appropriate and provide the relevant ethical approval number.

- No

Will you process personal data? If so, please refer to specific datasets or data types when appropriate and provide the KU Leuven or UZ Leuven privacy register number (G or S number).

- No

Does your work have potential for commercial valorization (e.g. tech transfer, for example spin-offs, commercial exploitation, …)? If so, please comment per dataset or data type where appropriate.

- No

Do existing 3rd party agreements restrict exploitation or dissemination of the data you (re)use (e.g. Material or Data transfer agreements, Research collaboration agreements)? If so, please explain in the comment section to what data they relate and what restrictions are in place.

- Yes

Software codes and archival observations are free to use but need to be acknowledged and/or cited in publications following the instructions of the original authors/source.

Are there any other legal issues, such as intellectual property rights and ownership, to be managed related to the data you (re)use? If so, please explain in the comment section to what data they relate and which restrictions will be asserted.

- No

Documentation and Metadata

Clearly describe what approach will be followed to capture the accompanying information necessary to keep data understandable and usable, for yourself and others, now and in the future (e.g. in terms of documentation levels and types required, procedures used, Electronic Lab Notebooks, README.txt files, codebook.tsv etc. where this information is recorded).

Combining a human-readable ascii format (like a .csv/txt file) with appropriate column names ensures simple reuse of model output data. All newly-developed source code materials for simulations and numerical models will be described in detail in open-access journal publications.
All these computational tools will be open-source om GitHub with accompanying readme.txt files with detailed description of the input and output parameters. Software code will include readme files on Github and will be commentated inline in the code (ReadMe files on BitBucket and/or Github and documented inline within the code using, e.g. docstrings in Python code.).
Journal publications will use dedicated journal standards (e.g. keywords) to identify research context.

Will a metadata standard be used to make it easier to find and reuse the data?

If so, please specify which metadata standard will be used.

If not, please specify which metadata will be created to make the data easier to find and reuse.

- Yes

Numerical models and simulations will follow the standard for astronomical data and metadata, the most commonly-used being FITS. A description of astronomical metadata standards can be found the Strasbourg Astronomical Data Center https://cds.unistra.fr/data-publication/
All newly-developed numerical models will be available in an open online repository or 'synthetic virtual observatory' that can be used for training algorithms, teaching, reprocessing etc. For this we will follow the standars of the Virtual Observatory (https://www.ivoa.net) and IVOA fits standards as used in the astronomical community.

Data Storage & Back-up during the Research Project

Where will the data be stored?

- Other (specify below)
- Shared network drive (J-drive)
- Personal network drive (I-drive)

All material and codes in process will be stored on the shared internal netword of the Institute of Astronomy of KU Leuven.
All final new source code will be stored and shared on Github.
All fill numerical models and metadata will be stored long-term on public data repositories of the Virtual Observatory and the CDS.

How will the data be backed up?

- Other (specify below)

Continuous data preservation (beyond the 10-year requirement) is possible thanks to the well-developed in-house storage and backup system of the Institute of Astronomy of KU Leuven.

Is there currently sufficient storage & backup capacity during the project?

If no or insufficient storage or backup capacities are available, explain how this will be taken care of.

- Yes

How will you ensure that the data are securely stored and not accessed or modified by unauthorized persons?

The Institute of Astronomy of KU Leuven has an automatic periodic backup (daily and off-site) on the network server of raw and processed data according to KU Leuven and in-house security standards: all data are secured with access restrictions on file-system level.

What are the expected costs for data storage and backup during the research project? How will these costs be covered?

Data storage needs are estimated at 50 TB. Including backups this totals 150 TB of server space or 15keuro.
These costs are currently included partially in the BRAVE budget and partially in the recently granted KU Leuven Methusalem SOUL budget.

Data Preservation after the end of the Research Project

Which data will be retained for 10 years (or longer, in agreement with other retention policies that are applicable) after the end of the project?

In case some data cannot be preserved, clearly state the reasons for this (e.g. legal or contractual restrictions, storage/budget issues, institutional policies...).

- All data will be preserved for 10 years according to KU Leuven RDM policy

Continuous data preservation (even beyond the 10-year requirement) is possible thanks to the well-developed in-house storage and backup system of the Institute of Astronomy and the continuous data preservation of the Virtual Observatory & CDS.

Where will these data be archived (stored and curated for the long-term)?

- Other (specify below)

All data will be stored long-term on the backup system (onsite and offline) of the Institute of Astronomy and on the servers of the Virtual Observatory & CDS.

What are the expected costs for data preservation during the expected retention period? How will these costs be covered?

The costs for back-up and storage are included in the project budget and the general working budget of the Institute of Astronomy.

Data Sharing and Reuse

Will the data (or part of the data) be made available for reuse after/during the project?
Please explain per dataset or data type which data will be made available.

- Yes, as open data

All computational tools will be open-source on Github for the benefit of the scientific community at large, in particular for those astrophysical projects that rely on modern numerical modelling.
Moreover, the output of all models will be available in an open online repository or ‘synthetic virtual observatory’ at the Virtual Observatory.
Furthermore, all relevant tables, databases etc. given in the publications will be downloadable from the Strasbourg Astronomical Data Center (CDS). The CDS is a data center dedicated to the collection and worldwide distribution of astronomical data and related information (https://cds.unistra.fr/about/cds/).
All journal publications will be open access via the ArXiv.org and Lirias servers.

If access is restricted, please specify who will be able to access the data and under what conditions.

N/A

Are there any factors that restrict or prevent the sharing of (some of) the data (e.g. as defined in an agreement with a 3rd party, legal restrictions)?

Please explain per dataset or data type where appropriate.

- No

Where will the data be made available?

If already known, please provide a repository per dataset or data type.

- Other data repository (specify below)
- Other (specify below)

All computational tools will be open-source on Github (GitHub.com)
The output of all models will be available in an open online repository or 'synthetic virtual observatory' at the Virtual Observatory (ivoa.net) and the CDS (https://cds.unistra.fr/data-publication/).
All journal publications will be open access via the ArXiv.org and KU Leuven Lirias servers.

When will the data be made available?

- Upon publication of research results

Which data usage licenses are you going to provide?

If none, please explain why.

- CC-BY 4.0 (data)
- GNU GPL-3.0 (code)

Do you intend to add a persistent identifier (PID) to your dataset(s), e.g. a DOI or accession number? If already available, please provide it here.

- Yes, a PID will be added upon deposit in a data repository

Journal publications will receive a DOI. Large data sets that are published on the CDS data center will also receive a dedicated DOI, complementary to the article DOI.

What are the expected costs for data sharing? How will these costs be covered?

Publication costs are budgeted in the project. There are no associated costs with making the data available on the Virtual Observatory and CDS servers.

Responsibilities

Who will manage data documentation and metadata during the research project?

The PI and team members will be responsible for the garanteeing data quality, documentation, storage and backup, in collaboration with the IT team of the Institute of Astronomy of KU Leuven.

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Who will manage data preservation and sharing?

The PI and team members will responsible for uploading the data to the relevant back-up and online sites. The IT team of the Institute of Astronomy of KU Leuven will be responsible for the continued back-up after the project.

Who will update and implement this DMP?

The PI, with assistance from the institute's project coordinator, bears the end responsibility of updating & implementing this DMP.