David Douwe Hendriks, PhD

Contact

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Research and professional activities

Apr 2024 - Present

Lead research software engineer: "Development of the Morpheus Fluid Meshless Computational fluid dynamics framework"
Collaborators: Prof. Justin Read, Dr. Linghan Li

Lead research software engineer at the spin-out company Morpheus Fluid ltd, hosted at the business incubator SetSquared. Responsible for the implementation of new features in the GPU-ported version of the computational fluid-dynamics framework Morpheus Fluid, including providing multi-resolution, multi-GPU, multi-timestepping and multi-species features as well as extensions of the supported physics like heat transfer, bulk motion and elastic boundaries.

Jan 2022 - Present

Research Fellow: "Bayesian data-assimilation methods for models with thousands to millions of parameters"
Collaborators: Dr. Payel Das, Dr. Yunpeng Li, Dr. Simon Hadfield

Improved Hamiltonian Monte-Carlo parameter uncertainty inference techniques using normalizing flows and action-angle transformations. Benchmark tests indicate faster sampling and uncertainty inference than the current standard, NUTS, after building the transport map. Implemented the workflow in PYRO/NUMPYRO/TORCH and working on the public release and accompanying paper. Applied for a low-TRL UKRI funding grant to develop and apply the technique further.

Oct 2018 - Oct 2023

PhD study: "Stellar binaries throughout the cosmos: interactions and remnants"
Supervisors: Dr. R.G. Izzard, Dr. A. Gualandris, University of Surrey*,* UNIS*, Guildford*

Through population-synthesis studies, I have studied the interactions and remnants of stellar binaries throughout the cosmos, resulting in a published study on the mass-stream trajectories and orbital torques in mass-transferring systems with asynchronous donors, and a published study on pulsational pair-instability supernovae (PPISNe) that show that the peak in the primary-mass distribution of binary black-hole mergers at $35\,M_\odot$ is not caused by PPISNe because that would be in tension with observed super-luminous supernova rates. I have supervised several students throughout the course of the PhD, including an international summer student on a project on globular cluster evolution and black hole retention. Moreover, I have developed and published an extensive Python-based population-synthesis tool and robust interface to the rapid stellar evolution code BINARY_C called BINARY_C-PYTHON. The thesis is available here.

Sep 2017 - Sep 2018

Master Thesis: "Black hole mass distribution with Pulsational Pair Instability Supernova and the measure of stellar explodability"
Supervisors: Dr. S.E. de Mink, Dr. M. Renzo, API*,* UvA*, Amsterdam*

Used population synthesis techniques to model high-mass binary systems and compact object formation. Implemented several pulsational pair-instability mechanisms and quantitatively compared their primary mass distributions.

Jan 2017 - Sep 2018

Entrepreneur at Demonstrator lab VU, Amsterdam
Supervisor: Dr. T. in ´t Veld, Prof D. Iannuzi, VU, UvA*, Amsterdam*

Entrepreneur at VU Demonstrator lab. Developing a diagnostic apparatus for quantitatively determining the severity of patients with Dry Eye Syndrome. With the use of sensors, we correlate the evaporation of the eye surface to the rise of humidity in preocular compartments. This includes in-depth evaporation knowledge, doing field research and correlating questionnaire results with the measurements.

Research interests

My research interests primarily focus on the fields of computational (Astro)physics. Specifically, I specialize in theoretical stellar population evolution, exploring interactions between binary stars and their impact on the surrounding environment, including aspects such as chemical evolution. Additionally, I investigate which of these binary systems form compact object pairs that eventually merge and become observable through gravitational wave detectors.

In recent work, I have been dedicated to enhancing sampling techniques and improving uncertainty estimation. This involves integrating cutting-edge machine learning methods, such as normalizing flows and probabilistic programming languages, with well-established sampling techniques like Hamiltonian Monte Carlo. I aim to leverage the knowledge and expertise gained from this project to further advance my research in other areas.

My current occupation introduced me into the world of computational fluid dynamics, which is an important toolkit in

both astrophysics as more generally. I would like to bring the skills I am developing here back to astrophysics to be able to perform fluid-dynamics focussed studies, including but not limited to mass-transfer interactions.

Technical skills

Proficient in using GNU/Linux and Windows. My preferred programming stack includes Python and C. I have hands-on experience with a variety of tools and technologies, such as MySQL, Django, Mathematica, HTML, CSS, JavaScript, Perl, Git, Flask, Docker, and text processing with LaTeX, Emacs (org-mode), HUGO, and Obsidian. I have worked as a technical software engineer at True and I have developed several websites. Additionally, I chaired the web development committee at the NSA association and gained valuable experience as a system administrator. In the field of astrophysics, I have used and contributed to detailed stellar evolution codes (MESA), detailed accretion-disk evolution codes (VADER), population synthesis codes (I developed binary_c-python), N-body simulation codes (NBODY6++), and created a ballistic stream integrator. I have experience working in and with large simulation software code-bases and I am one of the main developers of the computational fluid dynamics software behind the Morpheus Fluid company.

Career & Employment

Apr 2024 - Present

Research software engineer: "Development of the Morpheus Fluid Meshless Computational fluid dynamics framework"

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Mar 2017 - Oct 2018

Administrative/technical employee at Anton Pannekoek Instituut, Amsterdam

Administrative/technical employee at the Anton Pannekoek Instituut (API).

Developed and maintained a website for alumni at the API Astronomy Institute. Created views to visualize supervisor and student connections, built automatic survey tools and export mechanisms for the administration department. The website was built with Python & Django, powered by a PostgresQL database and hosted on a Linux machine using Docker.

Sep 2016 - Dec 2016

Graduate Teaching Assistant at UvA, Amsterdam

Teaching assistant at Programming for Physics and Astronomy, assisting Dr. I. van Vulpen and Drs. M. Stegeman.

Teaching first-year students the basics of Python, and skills to tackle physics problems through scripts and simulations.

Mar 2015 - Dec 2016

Technical Assistance Engineer at True, Amsterdam

Investigating and improving the server monitoring system

Technical employee focused on the improvement of the server status monitoring system at True. I implemented an early form of time-series analysis machine learning using the Holtz-Winters exponential smoothing algorithm to create a dynamical warning system that learned from the behaviour of each of the servers.

Sep 2013 - Sep 2018

Research assistant at Oogheelkundig Medisch Centrum (OMC) and Entrepreneur at D-Lab VU University

Investigating and assisting the research on Dry-eye diseases

Assistant at the development and design of protocols to investigate the "Dry eye" syndrome. We developed a spectacle to measure evaporation rates of tear fluid in a compartment enclosing the eyes. We were granted lab space to develop the tools further during the years 2017 and 2018, under the name Dr. Dry-eye. We set up data analysis workflow and business plans to roll out the measurement device to several Opthtalmologists.

Feb 2014 - Feb 2015

Boardmember, Treasurer at NSA, Amsterdam

Financial responsible at the study association for physics and mathematics

As a full-time board member of the study association for Physics and Mathematics, I was responsible for all the financial aspects of the organization. This included making the budget, checking the finances of each committee, contacting debtors and creditors, managing the treasury, doing financial analysis and keeping the financial policy in check. Next to these project-specific responsibilities, there were many general organizational activities. During this year we streamlined the financial administration, set up a new digital system to buy things in our common room and launched a new website.

Extra curricular activities

Jan 2018 - July 2018	Organizing national astronomy olympiad at UvA in June 2018, Amsterdam Under the supervision of Dr. A. Watts (API), Amsterdam
2014 - 2019	Member of study association committees at NSA, Amsterdam *Committee member of the following committees:* • **Treasury committee**: Checking the finances of the study association, and analyzing the activities of the current treasurer. • **Outreach committee (*Physicsfair*)**: Organizing outreach activities regarding physics demonstrations for classes and public events. • **Website committee**: Developing and maintaining the new website of the physics association, as chairman. The development team works with Python and Django.
Feb 2017 - Apr 2017	Developing a software package to visualise (GIFs) physics simulations For Dr. I. van Vulpen(Nikhef), Amsterdam

Education

Oct 2018 - Oct 2023	PhD Astro (Astronomy and Astrophysics), **University of Surrey**, Guildford, Surrey, UK Astrophysics
Sep 2015 - Sep 2018	Master Astro (Astronomy and Astrophysics), **University of Amsterdam**, Amsterdam Science park, NL Gravitational Astroparticle Physics in Amsterdam (GRAPPA) track Graduation date: September 2018
Sep 2011 - Aug 2015	Bachelor Physics and Astronomy, **University of Amsterdam**, Amsterdam Science park, NL Minor: Computational Sciences Graduation date: July 2015

Publication list

In prep.	A. Gration, **D. D. Hendriks**, D. Heber, R. Izzard, P. Das, *The effect of binary stars on the mass estimates of dwarf galaxies* **Contribution:** Co-designed the research methods, responsible for the simulations and text relating to the stellar population evolution, provided thorough feedback on the paper.
In prep.	N. R. Rees, R. G. Izzard, **D. D. Hendriks**, *A Stellar Evolutionary Grid for Binary Population Synthesis: From the Main Sequence to Helium Ignition* **Contribution:** Co-designed the research methods and simulation pipeline, provided advice on code-base structure, provided thorough feedback on the paper. I will take over this project-line.
In prep.	**D. D. Hendriks**, R. G. Izzard, *Disky business: disk mass-transfer onto main-sequence accretors*
In prep.	**D.D. Hendriks**, P. Das, Y. Li, S. Hadfield. *Accelerating Hamiltonian Monte-Carlo sampling with Action-Angle transformations*
Accepted in A&A	M. Matteuzzi, **D. D. Hendriks**, R. G. Izzard, A. Miglio, K. Brogaard, M. Tailo, J. Montalban, *Metal-rich red horizontal branch stars as post-common-envelope phase products* https://ui.adsabs.harvard.edu/abs/2024arXiv240811095M/abstract **Contribution:** Co-designed the research methods and simulation pipeline, provided thorough feedback on the paper (several iterations). I used this study to further develop my code binary_c-python and extend it with Bayesian statistical sampling tools, allowing an end-to-end pipeline from observation to parameter inference which I can now use for any observed star system.
Published.	R. G. Izzard, **D. D. Hendriks**, and D. P. Nemergut, *libcdict: fast dictionaries in C*, Journal of Open Source Software, 8(92), 4756 https://doi.org/10.21105/joss.04756 **Contribution:** Provided code-design advice, helped debugging, provided feedback on the paper.
Published.	R. M. Yates, **D. D. Hendriks**, A. P. Vijayan, R. G. Izzard, P. A. Thomas, P. Das, *The impact of binary stars on the dust and metal evolution of galaxies*, Monthly Notices of the Royal Astronomical Society, Volume 527, Issue 3, January 2024, Pages 6292–6311, https://doi.org/10.1093/mnras/stad3419 **Contribution:** Co-designed the research methods and simulation pipeline, responsible for stellar evolution simulations, wrote sections relevant to binary star interactions, provided thorough feedback on the paper (several iterations). I strongly advocated for this project because I aim to use this pipeline in the future.
Published.	**D.D. Hendriks**, L.A.C. van Son, M. Renzo, R.G. Izzard, R. Farmer. *Pulsational pair-instability supernovae in gravitational-wave and electromagnetic transients*, Monthly Notices of the Royal Astronomical Society, Volume 526, Issue 3, December 2023, Pages 4130–4147, https://doi.org/10.1093/mnras/stad2857
Published.	**D. D. Hendriks**, R. G. Izzard, *Mass-stream trajectories with non-synchronously rotating donors*, Monthly Notices of the Royal Astronomical Society, Volume 524, Issue 3, September 2023, Pages 4315–4332, https://doi.org/10.1093/mnras/stad2077
Published.	G. M. Mirouh, **D. D. Hendriks**, S. Dykes, M. Moe, R. G. Izzard, *Detailed equilibrium and dynamical tides: impact on circularization and synchronization in open clusters*, Monthly Notices of the Royal Astronomical Society, Volume 524, Issue 3, September 2023, Pages 3978–3999, https://doi.org/10.1093/mnras/stad2048 **Contribution:** Co-designed the research methods and simulation pipeline, provided thorough feedback on the paper (several iterations).

PUBLISHED. **D. D. Hendriks**, R. G. Izzard. BINARY_C-PYTHON*: A Python-based stellar population synthesis tool and interface to* BINARY_C. Journal of Open Source Software, 8(85), 4642, May 2023 https://doi.org/10.21105/joss.04642

PUBLISHED. N. S. Sartorio, A. Fialkov, T. Hartwig, G. M. Mirouh, R. G. Izzard, M. Magg, R. S. Klessen, S. C. O. Glover, L. Chen, Y. Tarumi, **D. D. Hendriks**, *Population III X-ray binaries and their impact on the early universe*, Monthly Notices of the Royal Astronomical Society, Volume 521, Issue 3, May 2023, Pages 4039–4055, https://doi.org/10.1093/mnras/stad697

Contribution: Provided advice on the physics and prescriptions of Pulsational Pair-instability supernovae (PPISNe) in BINARY_C, provided thorough feedback on the paper (several iterations), in particular on the sections related to PPISNe.

PUBLISHED. M. Renzo, **D. D. Hendriks**, L. A. C. van Son, R. Farmer, *Pair-instability Mass Loss for Top-down Compact Object Mass Calculations*, American Astronomical Society. Research Notes of the AAS, Volume 6, Number 2, February 2022, https://doi.org/10.3847/2515-5172/ac503e

Contribution: Co-designed the research methods, advocated for the redesign of the prescriptions for PPISNe, provided thorough feedback on the paper (several iterations).

PUBLISHED. L. A. C. van Son, S.E. De Mink, F. S. Broekgaarden, M. Renzo, S. Justham, E. Laplace, J. Moran-Fraile, **D. D. Hendriks**, and R. Farmer, *Polluting the Pair-instability Mass Gap for Binary Black Holes through Super-Eddington Accretion in Isolated Binaries*, 2020 ApJ 897 100 https://doi.org/10.3847/1538-4357/ab9809

Contribution: Originated one of the ideas studied in this paper during my Masters Thesis.

Talks, posters, workshops and organisation

Talk Leiden Oct 2024	In-person talk at the Challenges and future perspectives in gravitational- wave astronomy: O4 and beyond workshop at the Lorentz-center in Leiden, Netherlands on combining GW merger predictions from population-synthesis results with semi-analytical galaxy evolution model results and starformation rates using SSPC.
(Invited) Talk ESAC Sep 2024	Invited (in-person) talk at the *Natural Language Processing workshop at ESAC, Madrid, Spain*, on the Astrotalks project and the ongoing efforts to combine that with large language-model features.
(Invited) Talk Demoblack June 2024	Invited (online) talk at the DEMOBLACK group meeting in Heidelberg on mass-transfer interactions, asynchronously rotating donors, accretion disk formation and accretion disk wind mass loss.
(Invited) Talk Buenos Aires May 2024	Invited talk at the *1st. Padova – Buenos Aires Workshop on Massive Stars and Interacting Binaries* on mass-transfer interactions, asynchronously rotating donors, accretion disk formation and accretion disk wind mass loss.
Hackathon session DotAstronomy April 2024	Organised and lead a successful hackathon session at DotAstronomy 2024 in Madrid, Spain on combining the Astrotalks platform with talk summaries and transcriptions generated with LLMs
Talk CCA workshop stable MT Mar 2024	Talk at the *Stable Mass Transfer in Binaries: from onset to remnants workshop* on mass-transfer interactions, asynchronously rotating donors, accretion disk formation and accretion disk wind mass loss..
(Invited) Talk CAR Hertfordshire Feb 2024	Talk at the *CAR seminar series, Hertfortshire* on binary interactions, population synthesis and gravitational wave mergers.
(Invited) Talk IrenA Nov 2023	Talk at the *IrenA seminar series* on pulsational pair-instability and features in the primary-mass distribution.
Talk DEVISE AI workshop Jul 2023	Talk at *DEVISE AI workshop, university of Surrey* on uncertainty quantification and sampling techniques in AI.
Talk Imitation game Mar 2023	Talk at *Imitation game Sepnet conference* on pulsational pair-instability and features in the primary-mass distribution.
Talk BridGCE Dec 2022	Talk at *BridGCE 2020* conference on recent developments in binary_c and binary_c-python with focus on nuclear yields and data formats.
(Invited) Talk NSA Lustrum amsterdam Apr 2022	Talk at *NSA lustrum science conference* on pulsational pair-instability and features in the primary-mass distribution.
Poster EAS 2022	Poster at *EAS 2022 Valencia* on improving Hamiltonian monte-carlo samplers action-angle transformations techniques: Link to interactive poster
Poster EAS 2022	Poster at *EAS 2022 Valencia* on matching the feature in the observed binary black hole mass distribution by varying the pulsational pair-instability mass loss and onset mass: Link to interactive poster
Organised PIMMS 2021	Co-organised the *PIMMS 2021 Workshop at University of Surrey* on astroseismology in binary star systems.
Public lecture GAS 2021	Public lecture at the *Guildford Astronomical Society in Surrey* on gravitational waves and their astrophysical origins.
Talk/Organised binary_c workshop 2020	Workshop talk at the binary_c *workshop 2020 in Surrey* on software development and mass transfer in populations. Supporting organiser of the event.
Talk BridGCE 2020	Conference talk at the *BridGCE 2020 conference* on disk mass-transfer and population statistics.
Winterschool Tenerife 2019	Attended the winter school "Universe in a box" in Tenerife 2019.

Supervision

Supervised summer-exchange	**Sergi Pradas, 2019**: Project on retention of black holes in cluster. Varied cluster mass, density and natal kick prescriptions and used NBODY6++ and binary_c.
Co-Supervised Third-year project	**Sam Green, 2019**: Project on orbital evolution of stars in binary systems with post(AGB) circumbinary accretion and jets. Varied angular-momentum loss in winds (equatorial vs polar) and used binary_c.
Co-Supervised Third-year project	**Will Dickinson, 2019**: Project on neutron-star natal kicks and orbital evolution of stars in binary systems after a supernova. Varied kick prescriptions and used binary_c.
Co-Supervised Final-year project	**Sophie Dykes, 2020**: Project on mass-dependent birth-property distributions and multiplicity fractions of stellar systems. Implemented Moe & diStefano (2017) initial distributions in binary_c-python and generated population statistics.
Co-Supervised Final-year project	**Stefan Bell, 2020**: Project on L2 mass-loss from binary systems and orbital torques. Wrote a ballistic trajectory integrator and varied mass-ratio of binary system.
Co-Supervised Final-year project	**Daniel Tracey, 2021**: Project on uncertainty analysis of initial properties of binary system V106. Implemeted MCMC sampling interfacing with binary_c-python.
Supervised Final-year project	**Jeffrey Lau, 2023**: Project on age-velocity dispersion relation of stars in the Milky Way. Using GAIA and LAMOST data to find the velocity dispersion of RGB-stars and red-clump stars as a function of galactrocentric distance and age. Using impulse-approximation theory to estimate the mass and other interaction properties of a recent fly-by of Sagittarius dwarf galaxy.
Co Supervised Final-year project	**Anna Roberts, 2024**: Project on chemical surface abundance due to evolutionary processes and binary interactions, how they differ from their birth-abundances, and whether using certain elements to infer birth-metallicity could lead to wrong conclusions.

Code development/contribution

2024 - Current
Lead research software engineer

Morpheus Fluid (Proprietary repository)

Lead research software engineer at the spin-out company Morpheus Fluid Ltd, hosted at the business incubator SetSquared. Collaborators: Prof. Justin Read, Dr. Linghan Li. Responsible for implementing new features in the GPU-ported version of the meshless computational fluid-dynamics framework Morpheus Fluid. This includes multi-resolution, multi-GPU, multi-timestepping, and multi-species features, as well as extending the supported physics with heat transfer, bulk motion, and elastic boundaries.

2023 - Current
Creator

Synthetic stellar pop convolve (SSPC) repo & docs.

Synthetic Stellar Pop Convolve (SSPC) is a code for convolving synthetic stellar populations with cosmological star-formation rates, used primarily in studies involving gravitational-wave events and supernova transient events. SSPC can process both event-based and ensemble-based data, allows for additional weights like detection probability to be included during convolution and can convolve data either by integration or by Monte-Carlo sampling. The code, developed mainly by me but with important initial guidance from Lieke van Son, is still in beta, with ongoing improvements and future feature additions planned, including better support for various data types and spatially resolved star-formation rates.

2018 - Current
Creator

binary_c-python repo & docs

I have created the Python-based stellar population-synthesis framework binary_c-python (published JOSS paper) which is multi-processed and can run on HPC-clusters. This framework interfaces with binary_c through Python-C bindings and API calls. Used in many projects and several published papers. Currently implementing Monte-Carlo sampling techniques and adaptive-importance sampling.

2022 - Current
Creator

MESA runner and grid interpolation builder & Documentation

Built a MESA grid runner and track interpolation table builder together with Natalie Rees (Surrey), Dr. Rob Izzard (Surrey) and Dr. G. Mirouh (Granada), to provide updated stellar tracks in binary_c. Automatically runs MESA grids on HPC clusters, extracts the desired quantities from the MESA output and compiles interpolation tables. Implemented automatic quality checks on the interpolation tables and flags intersecting stellar tracks to avoid ill-defined values in the interpolation table. Currently working on a closed-loop testing feature that loads the interpolation tables into binary_c and compares the stellar tracks to the original mesa tracks through binary_c-python.

2022 - Current
Creator

Action-angle Hamiltonian Monte-Carlo

Developing a Bayesian uncertainty estimation and likelihood exploration tool based on Hamiltonian Monte-Carlo, normalizing flows and action-angle transformations with Dr. Payel Das, Dr. Yunpeng Li and Dr. Simon Hadfield, using the pyro/numpyro/torch probabilistic frameworks. Currently still in progress, and working on the technical paper and code release.

2022 - Current
Creator

Ballistic Integrator & Ballistic integration routines

Created a ballistic integrator that evolves the trajectory of a mass-transfer stream for my paper on asynchronously rotating donors in binary star systems. Takes into account the rotation of the reference frame. Future ideas are to automatically generate the equations of motion through symbolic programming in any (non-)inertial reference frame.

2018 - Current
Co-developer

binary_c

During my entire Ph.D. I have assisted Dr. Rob Izzard with the development of binary_c, a rapid binary stellar evolution framework written in C, from the level of technical design considerations to implementing features in the code. Implemented a standardized (event-based) output framework, remnant-mass routines, and ballistic stream interpolation-table functionality.

Websites

2023 - Current	devise-flf.notion.site/ Knowledge-base on machine learning and AI tools for research for the DEVISE-FLLF collaboration. Focussed on writing low-threshold articles that include examples and resources on machine-learning techniques and AI tools for researchers.
2018 - Current	Astrotalks Created static aggregate website for online astrophysics seminar talks. Using scrapers to collect new talks and online video material of astronomy and astrophysics. Currently rewriting to a dynamic website with mongo-db backend, and integrating chatbot functionality powered by the AstroLLama language model in collaboration with the UniverseTBD group.
2018 - Current	Physics-fair.nl Created and maintained Django-based website for the Physics-Fair outreach organisation at the University of Amsterdam. Used to manage outreach events, an experiment database, generates instruction manuals for the experiment presentations.
2014 - Aug 2018	NSAweb.nl Created Django-based website for the physics student association at the University of Amsterdam. Used to manage events,c members, media and newsletters.
2017 - 2018	API-alumni.nl Created Django-based website for the Anton Pannekoek Institute for Astronomy Alumni at University of Amsterdam. Used to manage alumni members, send automated surveys, create student-supervisor relation and current alumni occupation visualisations and insights.

Courses and certificates

April 2015	Mathematica Student Certificate
Sep 2010 - Sep 2011	Cambridge Certificate in Advanced English

Outreach activities

During my bachelors and masters I organized many physics-demonstration events (open-days, workshops, quizes) through the Physics-Fair, which after retirement of Paul Vlaanderen we took over as an outreach organisation/comittee. Organized astronomy Olympiad 2018 at the API. During my PhD I frequently helped with open days and public stargazing events where we showed the public around the telescope. I also often participated in the World Space Week in Guildford, where we demonstrated models of single star evolution using Window to the stars and binary-star evolution using Hyperion.

References

Dr. R. G. Izzard, University of Surrey Astrophysics (UK) (r.izzard@surrey.ac.uk),
Dr. P. Das, University of Surrey Astrophysics (UK) (p.das@surrey.ac.uk),
Dr. M. Renzo, University of Arizona & Steward Observatory (US) (mrenzo@arizona.edu),
Dr. R. Yates, University of Hertfordshire (UK) (r.yates3@herts.ac.uk),
Dr. A. Gualandris, University of Surrey Astrophysics (UK) (a.gualandris@surrey.ac.uk),
Prof. S.E. de Mink, Max Planck Institute for Astrophysics (DE), sedemink@mpa-garching.mpg.de