Fran Bartolić

Curriculum Vitae

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Personal information

Nationality Croatian

Languages Croatian (Native), English (Fluent)

Education

2017–2021 (expected) **Ph.D. Astrophysics**, *University of St Andrews*, St Andrews, Scotland.

I am currently doing a PhD in Astrophysics at the University of St Andrews in Scotland. This position is a part of a new scheme with a strong focus on Data Science and transferable skills. As a part of this scheme, during my PhD I will undertake a 6 month internship in industry. My research is on statistical modeling gravitational microlensing events with a focus on exoplanets. I am interested in probabilistic inference, Bayesian statistics and Machine Learning, both in the context of astronomy and elsewhere.

2015–2017 **M.Sc. Physics with Astrophysics**, *University of Rijeka*, Rijeka, Croatia.

Cumulative GPA: 4.7/5. I spent the first three semesters doing courses in theoretical physics and astronomy. In the final semester and during the summer I worked on a research project at Lund Observatory in Sweden.

2012–2015 **B.Sc. Physics**, *University of Split*, Split, Croatia.

Cumulative GPA: 4.5/5. I took courses in theoretical physics and programming. In the final semester I did a short research project as an exchange student in Lund, Sweden.

Research Experience

09/2017–today **Ph.D. project**, *School of Physics & Astronomy, University of St Andrews*, St Andrews, Scotland.

I am working on modeling gravitational microlensing events using Bayesian statistical methods. The main challenge in this area is dealing with complex non-linear and degenerate parameter spaces, a regime where even the most sophisticated statistical methods regularly fail. I am approaching the problem bottom-up, starting with simple fully Bayesian models, solving one challenging problem at the time, and writing usable open-source code in the process.

Supervisor: Dr. Martin Dominik

02/2017–09/2017 **Master's thesis project**, *Lund Observatory, Sweden*, Lund, Sweden, 30 weeks FTE work.

The title of my master's thesis is *Planets Orbiting Evolving Binary Stars*, and the subject is exoplanet dynamics. The goal of the project was to see what happens to circumbinary planets as the binary star evolves up to the *common-envelope* phase. In particular, I looked at the influence of mean-motion resonance passage on the stability of orbiting planets as the binary's orbit shrinks due to tidal interaction. I approached the problem in two ways. First, by developing an analytical Hamiltonian model of high-order resonances which can be used to estimate the change in eccentricity. Second, by using an NBODY code `REBOUND` coupled with a stellar evolution code `binary_c` to investigate the problem in detail and validate the analytical model. The long-term goal of this kind of work is to put dynamical constraints on circumbinary planet evolution during late stages of stellar evolution. This is useful because given a detection of a circumbinary planet around an evolved binary we might be able to say if it formed with the binary and dynamically evolved to its current orbit or if it formed during the late stages of binary evolution.

Supervisors: Dr. Alexander J. Mustill & Prof. Dijana Dominis Prester

07/2016–08/2016 **Summer student programme**, *Nicolaus Copernicus Astronomical Center*, Warsaw, Poland, 4 weeks FTE work.

I spent a month in Warsaw working on MHD simulations of accretion disks with the `PLUTO` code. During my time there I ran several non-ideal MHD simulations of accretion disks around *cataclysmic variable* stars in order to investigate the stability and structure of such disks. I also wrote Python code for visualization of the Pluto output variables in 2D axisymmetric spherical coordinates. The main skills I learned there are working with Linux systems & clusters, using a modern fluid dynamics code such as `PLUTO`, and basic physics of magnetohydrodynamics in the nonrelativistic regime.

Supervisors: Dr. Miljenko Čemeljić & Prof. Włodzimierz Kluźniak

01/2015–06/2015 **Bachelor's thesis project**, *Lund Observatory*, Lund, Sweden, 10 weeks FTE work.

In my bachelor's thesis project, *Tidal Evolution of Close-In Extra-Solar Planets*, I investigated the role of planet induced stellar tides on the orbital evolution of planets orbiting evolved stars. I wrote `C++` code which solves analytical models of the tidal interactionto see how often planets spiral into the star during late stages of stellar evolution and I compared my results with recent exoplanet observations.

Supervisors: Dr. Alexander J. Mustill & Dr. Dejan Vinković

Publications

2018 V. Bozza, E. Bachelet, **F. Bartolić**, T. M. Heintz, A. R. Hoag, and M. Hun-dertmark. *VBBINARYLENSING: a public package for microlensing light-curve computation.*, 479:5157–5167, October 2018. doi: 10.1093/mn-ras/sty1791

Skills

Programming I have extensive experience in `Python`, together with libraries `NumPy`, `Pandas`, `matplotlib`, and `Jupyter` notebooks. Besides Python. I have intermediate experience with `C/C++`, and have written code combining Python and C++. I have used `C#` in the past.

Data science	Extensive experience with the probabilistic programming library `PyMC3` together with `theano`. I have implemented simple machine learning models in `Tensorflow` and `PyTorch`.
Statistics	Extensive experience with Bayesian modeling and MCMC methods. Some experience with classification problems.
Other technical	`Git` version control, `Vim`, LaTeX, `Linux` systems, `Bash` shell.
Communication	I have given talks at conferences and meetings in academia, as well as talks to the general public. I have given tutorials for an undergraduate course in in astronomy. I have experience with describing complex statistical methods to a lay audience.
Organization	I am organizing a regular meeting on Data Science at my department and co-organising a weekly meeting on coding.
Mentoring	I have supervised a summer student working on a machine learning project in astronomy.

Awards, Competitions and Honors

2016 *Erasmus+ Internship* scholarship.

2015 *Dean's Award for undergraduate academic excellence*, University of Split.

2014 *Erasmus+ Exchange* scholarship.

Talks

01/2019 *Gaussian process models of correlated noise in microlensing lightcurves*, "23rd International Microlensing Meeting", Flatiron Institute, New York, USA.

12/2018 *Automatic Differentiation*, talk at the weekly *Code & Cake* meeting, St Andrews, UK.

08/2018 *Bayesian modeling of gravitational microlensing events*, "ScotDIST Annual Conference", Glasgow, UK.

05/2018 *Fitting a model to data*, talk at the weekly "Code& Cake" meeting, St Andrews, UK.

04/2018 *Modeling gravitational microlensing events*, short talk at the "Scottish Exoplanet/Brown Dwarf Spring meeting", St Andrews, UK.

09/2017 *Dynamics of circumbinary planets and the role of mean-motion resonances*, astronomy department seminar, Lund, Sweden.

05/2017 *Dynamics of circumbinary planets*, "Astro Journal Club" presentation, Lund, Sweden.

05/2015 *The Giants of Ragnarök*, bachelor's thesis public defense, Lund, Sweden.

Outreach activities

12/2018 *How to find exoplanets*, talk for the general public at the St Andrews Observatory Open Night.

2017 *ALVA astronomy club*, Board member.

09/2014 *European Researchers' Night*, volunteer, Split, Croatia.

04/2014 *Festival of Science*, volunteer, Split, Croatia.

Supervision

Summer 2018 Drew Millard, summer student at St Andrews. I supervised him on a project on using machine learning to classify astrophysical time series data.

Teaching experience

2019 Tutor for the course *Astronomy and Astrophysics 2*, an undergraduate astronomy course, University of St Andrews.

2018 Tutor for the course *Astronomy and Astrophysics 1*, an introductory undergraduate astronomy course, University of St Andrews.