

## Adrian Bittner



### Title

Stellar Kinematics and Population Properties of Bar-built Nuclear Discs in Milky Way-type Galaxies

### Abstract

Bars are a major driver of secular evolution in disc galaxies, promoting the inflow of gas to the centre, where stellar structures, such as nuclear discs are built. We constrain the formation of these structures by deriving their stellar kinematics and mean population properties. To this end, we use observations with unprecedented spatial resolution, obtained with the MUSE integral-field spectrograph for a sample of 21 Milky Way-type galaxies in the local Universe. We show that nuclear discs are characterised by a high rotational support, i.e. near-circular orbits with low velocity dispersions, and are significantly younger, more metal-rich, and less  $[\alpha/\text{Fe}]$ -enhanced, as compared to their surroundings. These findings are consistent with the picture of bar-driven secular evolution and contrast with the formation of old and kinematically hot classical bulges in violent accretion events. Moreover, nuclear discs exhibit well-defined radial gradients of the population properties with single slopes, suggesting that they are continuous components from their outer edge to the galaxy centre. We argue that these continuous (stellar) nuclear discs may form from a series of bar-built (gas-rich) nuclear rings that grow in radius, as the bar evolves. In this picture, nuclear rings are simply the star-forming outer edge of nuclear discs. Finally, we do not find evidence for the presence of classical bulges in the centres of these galaxies. This could result from feedback processes efficiently preventing the formation of classical bulges or may challenge the paradigm of hierarchical structure formation, questions we will address in a dedicated MUSE survey.

# Adrian Bittner | Curriculum Vitae

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## Education

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Jul. 2018 – expected in Jun. 2021

**PhD in Astrophysics**, European Southern Observatory (ESO), Munich, Germany

- Thesis: *“Formation and evolution histories of nuclear stellar structures in barred disc galaxies”*

Oct. 2015 – Mar. 2018

**MSc in Astrophysics**, University of Munich, Germany

- Thesis: *“Milky Way-like disc galaxies in cosmological zoom-simulations”*
- Grade: 1.1 ( $\approx$  3.9 GPA)

Oct. 2012 – Sep. 2015

**BSc in Physics**, University of Munich, Germany

- Thesis: *“Impact of ISM turbulence on the formation of stars and stellar clusters”*
- Grade: 1.8 ( $\approx$  3.2 GPA)

## Research Experience

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Planned for 2021

**Observing Run**, Atacama Pathfinder Experiment (APEX), San Pedro, Chile

- Support observations of the APEX telescope (depending on COVID-19 situation in Chile)

Aug. 2018

**Scientific Visit**, Armagh Observatory, Armagh, Northern Ireland

- Support the development of a Python implementation of the full-spectral fitting software *GandALF* and its integration into the GIST framework.

Nov. 2017 – Dec. 2017

**Scientific Visit**, Instituto de Astrofísica de Canarias (IAC), Tenerife, Spain

- Lead the development of the GIST framework, an extensive, multi-purpose research pipeline for analysis, statistical modelling, and visualisation of spectroscopic data. The software package is publicly available, widely-used, and described in a dedicated scientific publication.

Apr. 2016 – Sep. 2016

**Scientific Visit**, European Southern Observatory (ESO), Santiago, Chile

- Lead a research project investigating the spiral structure in extragalactic disc galaxies.
- Multiple observing nights at ESO’s Very Large Telescope in Chile.

## Awards/Grants

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- 2018 – 2021: PhD stipend within the International Max-Planck Research School for Astrophysics at the European Southern Observatory (covering salary and travel expenses; approx. 75000 Euro)
- 2018: PhD stipend of the University of Oxford (covering salary and university fees; *declined*)
- 2018: Graduated with a MSc degree from the University of Munich in the top 10% of the class
- 2017: Grant for a scientific visit at the IAC; Hanns-Seidel-Foundation (Flight and allowance)
- 2016: Grant for a scientific visit at the European Southern Observatory (Flight and allowance)
- 2014 – 2018: Studentship of the Hanns-Seidel-Foundation (approx. 14400 Euro)
- 2012: Award for outstanding students, German Mathematical Society

## Refereed Publications

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- 10) **A. Bittner**, A. de Lorenzo-Caceres, et al.: “Galaxies within galaxies in the TIMER survey: stellar populations of inner bars are scaled replicas of main bars”; accepted for publication in A&A
- 9) D. Rosado-Belza, J. Knapen, J. Falcón-Barroso, **A. Bittner**, et al.: “The kinematics of young and old stellar populations in nuclear rings of MUSE TIMER galaxies”; A&A (2020), 644, A116
- 8) **A. Bittner**, P. Sanchez-Blazquez, et al.: “Inside-out formation of nuclear discs and the absence of old central spheroids in barred galaxies of the TIMER survey”; A&A (2020), 643, A65
- 7) D. Gadotti, **A. Bittner**, et al.: “Kinematic signatures of nuclear discs and bar-driven secular evolution in nearby galaxies of the MUSE TIMER project”; A&A (2020), 643, A14
- 6) J. Neumann, F. Fragkoudi, ... and **A. Bittner**, amongst others: “Stellar populations across galaxy bars in the MUSE TIMER project”; A&A (2020), 637: A56
- 5) K. Fahrion, M. Lyubenova, ... and **A. Bittner**, amongst others: “The Fornax3D project: Non-linear colour-metallicity relation of globular clusters”; A&A (2020), 637: A27
- 4) K. Fahrion, M. Lyubenova, ... and **A. Bittner**, amongst others: “The Fornax3D project: Globular clusters tracing kinematics and metallicities”; A&A (2020), 637: A26
- 3) **A. Bittner**, J. Falcón-Barroso, et al.: “The GIST pipeline: A multi-purpose tool for the analysis and visualisation of (integral-field) spectroscopic data”; A&A (2019), 628: A117
- 2) E. Iodice, M. Sarzi, **A. Bittner**, et al.: “The Fornax3D project: Tracing the assembly history of the cluster from the kinematic and line-strength maps”; A&A (2019), 627: A136
- 1) **A. Bittner**, D. Gadotti, et al.: “How do spiral arm contrasts relate to bars, disc breaks and other fundamental galaxy properties?”; MNRAS (2017), 471: 1070

## Talks & Conferences

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- **Invited Seminar Talk:** *Science Coffee*, University College London (MSSL), November 2020
- **Invited Seminar Talk:** *Galaxy Coffee*, Max-Planck Institute for Astronomy, October 2020
- **Seminar Talk:** *Café Club*, Laboratoire d'Astrophysique de Marseille, September 2020
- **Seminar Talk:** University of Oxford, September 2020
- **Contributed Talk & Discussion Panel Member:** *Linking the Galactic and Extragalactic*, December 2020, Wollongong, Australia (online due to COVID-19)
- **Contributed Talk:** *Extragalactic Spectroscopic Surveys: Past, Present and Future of Galaxy Evolution*, October 2020, Santiago de Chile (delayed due to COVID-19)
- **Contributed Talk:** *Bars in Disc Galaxies*, March 2020, Oxford (delayed due to COVID-19)
- **Invited Seminar:** *Institute of Cosmology & Gravitation*, May 2020, Portsmouth (online)
- **Contributed Talk & Poster:** *Galactic Dynamics in the Era of Large Surveys*, July 2019, Shanghai
- **Contributed Talk & Poster:** *European Week of Astronomy*, June 2019, Lyon

## Community Service

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- Member of the ESO Student Selection Committee (since Apr. 2020)
- LOC member of the conference “Inward bound – bulges from high redshifts to the Milky Way”
- Co-organizer of the ESO Journal Club (Aug. 2018 to Feb. 2020)
- Co-organizer of the ESO weekly social event (since Oct. 2018)
- Co-organizer of the ESO Ski Outing 2020

## Public Outreach

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- Weekly planetarium shows at the ESO Supernova Planetarium & Visitor Centre
- Public outreach talk at the European Researchers Night 2019
- Talk in the medical physics “*LIFE*” seminar about integral-field spectroscopy in Astronomy

## General Skills

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- **Programming:** Python (expert knowledge); C++ (intermediate); Bash/Unix and High-Performance Computing systems; Basic knowledge of parallelization strategies with Python and OpenMP
- **Software Development:** Git; CI/CD pipelines with GitLab; Writing clean, readable, and well-documented code that can be modified by others; Designing flexible software architectures that can process large amounts of data simultaneously; Strong testing and debugging skills
- **Languages:** German (native); English (full professional proficiency); Spanish (elementary)