

Sabine Thater



Title

Expanding the extreme ends of the supermassive black hole scaling relations with dynamical modelling

Abstract

The formation of supermassive black holes (MBH) is thought to be tightly linked to the formation and growth of their host galaxy bulges. MBH mass measurements of local galaxies based on stellar or gaseous motion reveal strong correlations of the MBH mass with bulge properties, such as bulge mass, stellar velocity dispersion and light concentration. However, the black hole sample and its covered mass range are limited, revealing an increased scatter for the high and low mass end of the scaling relations. While it is crucial to expand and constrain these regions in order to investigate on the universality of the scaling relations for different galaxy populations and possible different galaxy formation scenarios, the MBH measurements are challenging due to the need of time-expensive (preferable IFU) data and resolution arguments.

I present my dynamical MBH measurements of almost 20 galaxies expanding on both the high and low mass end of the scaling relations. For our measurements we made wide use of IFU data, such as SINFONI, NIFS, MUSE, ALMA, and more. We took special care in testing dynamical measurement methods on different tracers (stars vs gas) and other systematics. I will also discuss formation scenarios of galaxies harbouring strongly undermassive black holes or possibly no black holes at all. A strong tool to give implications about the formation and growth of MBHs is the analysis of the galaxy's central orbital distributions. I will conclude my talk with a discussion on what we can learn from examining orbital distributions in galaxy evolution and formation context and how measurement uncertainties are affecting our MBH results.

Curriculum Vitae

DR. SABINE THATER

Work Address

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RESEARCH INTEREST

Black Hole - Host Galaxy Co-evolution • Supermassive Black Holes in Nearby Galaxies • Galaxy Kinematics and Dynamical Modeling • Cold Molecular Gas vs Stellar Motion • Systematic Effects of Stellar Population Variation and Dark Matter • Integral field spectroscopy

EDUCATION

Doctor Rerum Naturalium, Physics and Astronomy, University of Potsdam, Germany 2015 - 2019
THESIS - "The interplay between massive black holes and their host galaxies"
Advisor: Davor Krajnović, Lutz Wisotzki

Diploma of Physics, University of Potsdam, Germany 2007 - 2014
THESIS - "Structure and Kinematics of NGC 4414: A search for a Supermassive Black Hole"
Advisor: Davor Krajnović, Lutz Wisotzki

PROFESSIONAL EXPERIENCE

Postdoctoral researcher September 2019 - present
University of Vienna

- Co-development and application of novel chemo-dynamical Schwarzschild code (first release event in October 2020)
- Deriving supermassive black hole masses in international collaborations
- Analysis of orbital distribution around massive black holes
- Co-Supervision of PhD projects and supervision of Master and Bachelor projects
- Organization and co-leading of dynamical modelling workshops

PhD researcher August 2015 - August 2019
Leibniz-Institut für Astrophysik Potsdam (AIP), Germany

- Deriving the Supermassive Black Hole masses of the SMASHING sample (12+2 galaxies) based on dynamical Jeans and Schwarzschild modelling of stellar kinematics (SINFONI, MUSE)
- Black hole determination based on cold molecular gas (ALMA)
- Structural galaxy analysis: Stellar population synthesis and bulge-disc decomposition with GALFIT

Summer Studentship June 2013 - August 2013
Space Telescope Science Institute, Baltimore, U.S.

- *Relation between Jet Speed and Jet Kinetic Power* with Eileen Meyer
- Creating a database of Jet components from radio monitoring observations (with Perl) and relating the jet speed with different Active Galactic Nuclei (AGN) properties

Summer Studentship

July 2011 - September 2011

Instituto de Astrofísica de Canarias, La Laguna, Spain

- *Search for Cataclysmic Variables in the EMPHaSSiS survey* with Alessandro Ederoclite
- Creating a catalogue of Cataclysmic variable (CV) properties and magnitudes using Virtual Observatory in order to find colour cuts for distinguishing CVs from AGN

Student Research Assistant

February 2010 - August 2014

Leibniz-Institut für Astrophysik Potsdam, Germany

- Transforming an eRosita exposure map into an expected number density of AGNs
- Creating a polar catalogue including photometric characteristics and the ephemeris
- Testing eRosita simulations using an eRosita object detection script

MEMBERSHIPS

International Astronomical Union	2020 - present
Österreichische Gesellschaft für Astronomie und Astrophysik	2020 - present
Astronomische Gesellschaft (Germany)	2014 - present
Deutsche Physikalische Gesellschaft	2007 - present

AWARDS AND FELLOWSHIPS

Traveling grant for IAU symposium 353 of \$300	2019
NAOJ visiting joint research program (together with Satoru Iguchi) with a \$1,550.00 stipend	2018
Teaching Assistantship with an annual \$28,500.00 stipend from Tufts University	2014-2015
McCarthy Fellowship of \$5,000.00 from Tufts University	2014-2015
6. Place in Youth Culture Price of Hann. Münden	2004

SUPERVISION EXPERIENCE

Co-Supervision of one PhD project and main supervision of two Bachelor projects

- Tadeja Veršič - "Measuring the stellar-to-halo-mass ratio and probing the evolution of galaxies with discrete tracers "
- Florian Wolf - "Testing black hole scaling relations with reverberation mapped black hole masses"
- Shelley Harrisberg - "Testing black hole scaling relations with gas-based black hole masses"

TEACHING EXPERIENCE*Teaching Staff*

September 2019 - present

University of Vienna, Austria

- Introduction to Astronomy (Recitation class)
- Research seminar for Master students
- Theoretical physics I: Classical mechanics (Recitation class)

Teaching Assistant

September 2014 - July 2015

Tufts University, Medford, MA, U.S.

- Physics 1: Introductory Physics - Mechanics (Recitation and laboratory class)
- Physics 2: Introductory Physics - Electrodynamics (Laboratory class)

Teaching Assistant to the course *Astronomical Digital Image Processing*
Universität Potsdam, Potsdam, Germany

March 2011 - July 2011

OBSERVATIONAL EXPERIENCE

- IFU observations of nearby galaxies using the 2.7m Harlan J. Smith telescope of the McDonald Observatory in Texas and the 8.1m telescopes of Gemini Observatory
- Photometric observations of polars and exoplanets using the Potsdam 70 cm telescope

PUBLIC OUTREACH

- *The dark hearts of galaxies* Public talk at AIP May 2018
- Assisting in *Long Night of Science* and *Open Day* events of AIP 2011 - 2018
- Guiding tours around the historical campus of Royal Observatory Berlin October 2012/July 2014

COMMUNITY SERVICE

- Expert referee for Monthly Notices of the Royal Astronomical Society 2020 - present
- Activities in the Leibniz PhD Network 2017 - 2020
- PhD student representative for the students of AIP 2017 - 2019
- Launch and organization of the PhD Colloquium for the students of AIP to present their current research 2017 - 2019

CONTRIBUTED CONFERENCE TALKS

- *SMASHING: a homogeneous sample of dynamical MBH measurements*
Supermassive Black Holes (Online), Chile, December 2020
- *Chemo-dynamical modelling of external galaxies*
Linking the Galactic and Extragalactic, Wollongong (Online), Australia, December 2020
- *Supermassive black hole scaling relations from low to high-mass*
European Week of Astronomy, Leiden (Online), Netherlands, June 2020
- *The orbital distribution in the vicinity of massive black holes*
Dynamical Reconstruction of Galaxies, Leiden, Netherlands, February 2020
- *Testing the robustness of black hole mass measurements with ALMA and MUSE*
IAU 353 Symposium: Galactic Dynamics in the Era of Large Surveys, Shanghai, China, July 2019
- *Revisiting the black hole - galaxy scaling relations with the SMASHING sample*
The Physics of Galaxy Scaling Relations and the Nature of Dark Matter, Kingston, Ontario, July 2018
- *The extreme ends of the supermassive black hole scaling relations*
Challenges in Galaxy Evolution, Florence, Italy, August 2017
- *The interplay between massive black holes and their host galaxies*
641. WE-Heraeus-Seminar, Bad Honnef, Germany, April 2017

COLLOQUIA AND SEMINAR TALKS

- *Expanding the extreme ends of the SMBH scaling relations with NIFS and SINFONI observations*
Gemini Observatory, Hilo, U.S., January 2020
- *The robustness of supermassive black hole mass measurements*
University of Vienna, Vienna, Austria, November 2019
- *Revealing the centre of NGC 6958 with ALMA and MUSE*
NAOJ, Mitaka, Japan, March 2018
- *Measuring supermassive black hole masses using Integral-field Spectroscopy*
Ehime University, Ehime, Japan, March 2018
- *The interplay between massive black holes and their host galaxies (SMASHING)*
University of California, Irvine, U.S., July 2017
Texas A & M, College Station, U.S., June 2017
- *The interplay between central black holes and their host galaxies*
University of Potsdam, Potsdam, Germany, July 2016
- *Relation between Jet Speed and Jet Kinetic Power*
Space Telescope Science Institute, Baltimore, U.S., Aug. 2013
- *Search for Cataclysmic Variables in the EMPhaSSiS survey*
Instituto de Astrofísica de Canarias, La Laguna, Spain, Sep. 2011

ACADEMIC REFERENCES

- Reference 1: Dr. Davor Krajnović, Leibniz-Institute for Astrophysics Potsdam, dkrajnovic@aip.de
- Reference 2: Prof. Dr. Glenn van de Ven, University of Vienna, glenn.vandeven@univie.ac.at

PUBLICATIONS

5 refereed publications and 5 un-refereed publications. 4 publications are as first author.

Total citations: 56 times.

1. Jethwa, P. , **Thater, S.**, Maindl, T., Van de Ven, G. *DYNAMITE: DYNAmics, Age and Metallicity Indicators Tracing Evolution*, Astrophysics Source Code Library, record ascl:2011.007, 2020
2. Nguyen, D.D., den Brok, M., Seth, A.C., Greene, J.E., Cappellari, M., Jensen, J.B., **Thater, S.**, Iguchi, S., Imanishi, M., Izumi, T., Davis, T., Neumayer, N., Nyland, K., Nakanishi, K., Bureau, M., Ngyuen, P.M., Onishi, K., Nguyen Q.L., Tsukui, T., Voggel, K.T., Dinh, T.V. *The MSSM₄ Project - I: Dynamical measurement of the central black hole mass in NGC 3504 using molecular gas kinematics*, Astrophysical Journal, 892, 1, 2020
3. **Thater, S.**, Krajnović, D., Nguyen, D.D., Iguchi, S., Weilbacher P.M. *Testing the robustness of black hole mass measurements with ALMA and MUSE*, Proceeding of IAU Symposium 353, Galactic Dynamics in the Era of Large Surveys, 2020
4. **Thater, S.**, *The interplay between massive black holes and their host galaxies*, University of Potsdam, 2019, <https://doi.org/10.25932/publishup-43757>
5. **Thater, S.**, Krajnović, D., Cappellari, M., Davis, T.A., de Zeeuw, P.T., McDermid, R.M., Sarzi, M. *Six new supermassive black hole mass determinations from adaptive-optics assisted SINFONI observations*, Astronomy & Astrophysics, Volume 625, A62, 2019
6. Krajnović, D., Cappellari, M., McDermid, R.M., **Thater, S.**, Nyland, K., de Zeeuw, T., Falcón-Barroso, J., Khochfar, S., Kuntschner, H., Sarzi, M., Young, L.M. *A quartet of black holes and a missing duo: probing the low-end of the $M_{BH} - \sigma$ relation with the adaptive optics assisted integral field spectroscopy*, MNRAS, 477, 2670, 2018
7. **Thater, S.**, Krajnović, D. et al. *A low upper mass limit for the central black hole in the late-type galaxy NGC 4414*, Astronomy & Astrophysics, Volume 597, A18, 2017
8. Izzo, L., Ederoclite, A., Della Valle, M., Mason, E., Williams, R.E., Altamore, T., Cassatella, A., Gilmozzi, R., Patat, F., Schmidtobreick, L., Selvelli, P., Tappert, C., **Thater, S.**, Covone, G., Dall’Ora, M., Paolillo, M. *Optical and near infrared multi-site follow up of the recurrent nova T Pyx*, Memorie della Societa Astronomica Italiana, Volume 83, p.830, 2012

ADDITIONAL PUBLICATIONS

Order based on alphabet and not based on contribution

- *Being a Doctoral Researcher in the Leibniz Association: 2019 Leibniz PhD Network Survey Report*
Beadle, B., Do, S., El Youssoufi, D., Felder, D., Gorenflós López, J., Jahn, A., Pérez-Bosch Quesada, E., Rottlieb, T., Rüter, F., Schanze, J.-L., Stroppe, A.-K., **Thater, S.**, Verrière, A., Weltin, M.
Online: <https://www.ssoar.info/ssoar/handle/document/69403>
- *Doctoral Researchers in the Leibniz Association: Final Report of the 2017 Leibniz PhD Survey*
Arcudi, A., Cumurovic, A., Gotter, C., Graeber, D., Philippe, J., Ott, V., Schanze, J.-L., **Thater, S.**, Weltin, M., Yenikent, S.
Online: <https://www.ssoar.info/ssoar/handle/document/61363>

CIRCULATED PUBLICATIONS

- **Thater, S.**, Krajnović, D., Weilbacher, P.M., Nguyen, D.D., van de Ven, G., Bureau, M., Cappellari, M., Davis, T.A., Iguchi, S., McDermid, R., Onishi, K., Sarzi, M. *A cross-check of SMBH mass estimates of NGC 6958 I: Stellar dynamics from GLAO-assisted MUSE observations*