

COMMENTARY TO HABILITATION THESIS¹

Name of the habilitation thesis

Mapping galactic nuclei: From the Galactic center to distant quasars and back

Name and surname of the applicant

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In this Habilitation Thesis, I first recall how we have mapped the gas and the stellar content in the central parsec of our Galaxy, which is the closest galactic nucleus, about hundred times closer than galaxies in the Local Group and about thousand times closer than the closest galaxy cluster. Around the compact radio source Sgr A* associated with the supermassive black hole (SMBH), there are fast-moving B-type stars and dust-enshrouded stellar objects that must have formed recently during the last hundred thousand to a few million years. This indicates a recent period of star-formation preceded by an infall of a large amount of cold and dense gas. The amount of gas consumed by star-formation is linked to the amount of gas available for accretion. Hence, our Galactic center has likely been much more active and luminous a few million years ago, at the level of an active Seyfert galaxy. There are over a million of active galaxies, but in their case a similar spatial resolution is unavailable. Therefore, the mapping of the distribution of gas in active galactic nuclei (AGN) has traditionally been conducted in the time domain to replace the lack of a sufficient angular resolution to resolve the inner regions. This so-called reverberation mapping employs the reprocessing of the variable X-ray/UV continuum emission by more distant portions of the accretion disc as well as by broad-line region clouds. In my work, I focused on the comparison of the radius of H-beta-emitting clouds with the distance of MgII-emitting material as well as the radius corresponding to the FeII pseudocontinuum. In contrast with the radius-luminosity relations for H-beta as well as the UV and optical FeII emission, the MgII radius-luminosity relation is flatter, though it still exhibits a significant correlation. These correlations open a way to measure supermassive black hole masses in distant quasars using just one-epoch spectroscopy and thus to study their growth during the cosmic history. One can also employ the MgII radius-luminosity relation to standardize quasars and use them as alternative probes in cosmology. Finally, it is beneficial to combine the processes taking place in AGN with the visibly rich and dense stellar content in the Galactic center to see how

¹ The commentary must correspond to standard expectations in the field and must include a brief characteristic of the investigated matter, objectives of the work, employed methodologies, obtained results and, in case of co-authored works, a passage characterising the applicant's contribution in terms of both quality and content.

an intermittently increased nuclear activity could have been impacting stars and vice versa. In particular, we studied the interaction of red giants with the once activate jet in the Galactic center and found that a large number of repetitive jet-star encounters can effectively ablate the envelopes of red giants. This can potentially address the lack of large red giants in the innermost 0.5 pc of the Galactic center.

In summary, the spatial details accessible for the Galactic center complement the temporal studies of mostly unresolved AGN. On the other hand, the study of a sample of AGN with various accretion rates teaches us about the past and the potential future of the Milky Way.

[1]² ZAJACEK, Michal*(corresponding author)*, Gerold BUSCH, Monica VALENCIA-S, Andreas ECKART, Silke BRITZEN, Lars FUHRMANN, Jana SCHNEELOCH, Nastaran FAZELI, Kevin C. HARRINGTON and J. Anton ZENSUS. Radio spectral index distribution of SDSS-FIRST sources across optical diagnostic diagrams*. *Astronomy & Astrophysics*. 2019, 630(A83, Article A83). ISSN 1432-0746. Available at: doi:10.1051/0004-6361/201833388

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
100	100	100	80

[2] ZAJACEK, Michal*(corresponding author)*, Bozena CZERNY, Mary Loli MARTINEZ-ALDAMA, Mateusz RALOWSKI, Aleksandra OLEJAK, Swayamtrupta PANDA, Krzysztof HRYNIEWICZ, Marzena SNIEGOWSKA, Mohammad-Hassan NADDAF, Wojtek PYCH, Grzegorz PIETRZYNSKI, C. Sobrino FIGAREDO, Martin HAAS, Justyna SREDZINSKA, Magdalena KRUPA, Agnieszka KURCZ, Andrzej UDALSKI, Marek GORSKI and Marek SARNA. Time-delay Measurement of Mg II Broad-line Response for the Highly Accreting Quasar HE 0413-4031: Implications for the Mg II-based Radius-Luminosity Relation. *Astrophysical Journal*. 2020, 896(2, Article 146). ISSN 1538-4357. Available at: doi:10.3847/1538-4357/ab94ae

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
80	100	100	70

[3] ZAJACEK, Michal*(corresponding author)*, Anabella ARAUDO, Vladimir KARAS, Bozena CZERNY and Andreas ECKART. Depletion of Bright Red Giants in the Galactic Center during Its Active Phases. *Astrophysical Journal*. 2020, 903(2, Article 140). ISSN 1538-4357. Available at: doi:10.3847/1538-4357/abbd94

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
100	100	100	100

[4] ZAJACEK, Michal*(corresponding author)*, Bozena CZERNY, Mary Loli MARTINEZ-ALDAMA, Mateusz RALOWSKI, Aleksandra OLEJAK, Robert PRZYLUSKI, Swayamtrupta PANDA, Krzysztof HRYNIEWICZ, Marzena SNIEGOWSKA, Mohammad-Hassan NADDAF, Raj PRINCE, Wojtek PYCH, Grzegorz PIETRZYNSKI, Catalina Sobrino FIGAREDO, Martin HAAS, Justyna SREDZINSKA, Magdalena KRUPA, Agnieszka KURCZ, Andrzej UDALSKI, Vladimir KARAS, Marek SARNA, Hannah L. WORTERS, Ramotholo R. SEFAKO and Anja GENADE. Time Delay of Mg ii Emission Response for the Luminous Quasar HE 0435-4312:

² Bibliographic record of a published scientific result, which is part of the habilitation thesis.

toward Application of the High-accretor Radius–Luminosity Relation in Cosmology. *Astrophysical Journal*. 2021, 912(1, Article 10). ISSN 1538-4357. Available at: doi:10.3847/1538-4357/abe9b2

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
80	100	100	70

[5] ZAJACEK, Michal*(corresponding author)*. Enhanced Doppler Beaming for Dust-enshrouded Objects and Pulsars in the Galactic Center. *Astrophysical Journal*. 2021, 915(2, Article 111). ISSN 1538-4357. Available at: doi:10.3847/1538-4357/ac043a

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
100	100	100	100

[6] ZAJACEK, Michal*(corresponding author)*, Bozena CZERNY, Narayan KHADKA, Mary Loli MARTINEZ-ALDAMA, Raj PRINCE, Swayamtrupta PANDA and Bharat RATRA. Effect of Extinction on Quasar Luminosity Distances Determined from UV and X-Ray Flux Measurements. *Astrophysical Journal*. 2024, 961(2, Article 229). ISSN 1538-4357. Available at: doi:10.3847/1538-4357/ad11dc

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
100	100	100	90

[7] ZAJACEK, Michal*(corresponding author)*, Swayamtrupta PANDA, Ashwani PANDEY, Raj PRINCE, Alberto RODRIGUEZ-ARDILA, Vikram JAISWAL, Bozena CZERNY, Krzysztof HRYNIEWICZ, Maciej URBANOWICZ, Piotr TRZCIONKOWSKI, Marzena SNIEGOWSKA, Zuzanna FALKOWSKA, Mary Loli MARTINEZ-ALDAMA and Norbert WERNER. UV Fell emission model of HE 0413–4031 and its relation to broad-line time delays*. *Astronomy & Astrophysics*. 2024, 683(A140, Article A140). ISSN 1432-0746. Available at: doi:10.1051/0004-6361/202348172

Experimental work (%)	Supervision (%)	Manuscript (%)	Research direction (%)
80	100	100	90