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Supervisor's report on PhD Thesis submitted by Marcel Štolc

Thesis title: **Stars moving near a galactic center**

Marcel Štolc worked out his Thesis within the framework of doctoral studies in the field of Theoretical Physics, Astronomy and Astrophysics (the study program P4F1), a joint branch of the Charles University in Prague (Faculty of Mathematics and Physics) in cooperation with the Astronomical Institute of the Czech Academy of Sciences during years 2019—2024. The Thesis was submitted for defense in spring 2024. It deals primarily with theoretical analysis of gaseous environment in the mutual interaction with stars and compact objects in cores of galaxies. Also discussed are observational consequences and future prospects for their verification with the focus towards the novel channel of UV spectral domain from space.

The Thesis discusses one of the current topics in accretion theory, namely, the gradual mass accretion fueling a supermassive black hole that acts as a central engine. The author's focus is on the well-accepted standard Shakura-Sunyaev thin accretion disc model, however, with additional perturbative elements taken into account. Specifically, the attention is concentrated on the broad optical, ultraviolet and X-ray spectral properties of such systems and their deviations from the standard profile of the Spectral Energy Distribution (SED). Marcel Štolc introduces and explores various options that may influence either geometry of the accretion flow, the presence (or absence) of a secondary black hole component (depending on its mass and other parameters), and a combination of the aforementioned components. The results exhibit the qualitative changes in the spectra caused by emerging gaps in the accretion flow. The author examines a possibility of inferring the perturbed system parameters based certain levels of uncertainty in the measured flux.

This work consists of five chapters plus Appendices. Chapter 1 contains introduction to the subject and a brief overview of the relevant literature including an extensive bibliography. Chapter 2 defines the model set-up, gives the starting points for its mathematical description and describes the main components: a supermassive black hole, an accretion flow, and the secondary orbiter of different mass. Chapter 3, titled "Results", describes the majority of new material, which has been also subject of two

scientific papers: (i) the first paper by M. Štolc et al. (2023, published in Monthly Notices of RAS journal), where Marcel is the leading author, and (ii) a review article by M. Zajaček et al. (2024, published in Space Science Reviews), where the candidate is a member of a broader team exploring the prospects of the subject with current and upcoming satellite missions. Indeed, fruitful collaboration with dr. Michal Zajaček as a consultant during the second half of the PhD study, as well as scientific discussions with other senior colleagues – prof. John Miller (consultant during the first half of the PhD study) and prof. Bozena Czerny – were very instrumental in different phases of the Thesis preparation.

Active participation in the student exchange program between Charles University and University in Cologne brought Marcel to the Galactic centre group at the 1st Institute of Physics in Cologne, where he presented the ongoing research at seminars (collaboration with prof. Andreas Eckart). Besides the work on two above-mentioned principal scientific papers, during his PhD study Marcel participated at several international conferences on current aspects of accreting systems and he presented his results in the form of seminars. Within the framework of the joint research projects of the group, he visited Cologne University in Germany, Center for Theoretical Physics of the Polish Academy of Sciences in Warsaw (Poland, prof. B. Czerny), and Shanghai Observatory in China (prof. Wenfei Yu).

Plenty of material remains for future research, part of which was already presented in a preliminary form in conference proceedings and oral or poster contributions (e.g. Štolc & Karas 2019, published in Astronomische Nachrichten). In particular, I notice a promising outlook to connect the results of the present Thesis with future detections of gravitational waves from merging systems of an orbiter and a supermassive black hole.

Regarding the formal aspects, the print appears to be (almost) perfect. The volume of this thesis conforms to usual standards (slightly over 100 pages) and it demonstrates that the author has achieved new results and is abound with ideas that he can pursue in his future career. Progress of the Thesis and the duration of its preparation were partially influenced by the period of Covid pandemics. It was pleasure to interact with Marcel during his Master and doctoral studies.

I conclude that the Thesis contains new scientifically valuable results and it proves to be on sufficient level. I thus recommend this work to be admitted for the defense and advice that Marcel Štolc be awarded PhD degree.

prof. RNDr. Vladimir Karas, DrSc.

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