Supervisor's report on the Ph.D. thesis by Mgr. Viktor Skoupý

During his Ph.D. studies, Mgr. Viktor Skoupý investigated the motion of a spinning extended test body in a Kerr black hole spacetime and the gravitational waves emitted by this body. His work contributed to the ongoing effort to provide sufficiently accurate gravitational waveform templates needed to detect signals from extreme mass ratio inspirals (EMRIs) by in development space-based gravitational wave observatories.

In an EMRI, a secondary stellar compact object is moving in the close vicinity of a primary supermassive black hole, while it radiates away energy and angular momentum in the form of gravitational waves. This radiation drives the secondary adiabatically towards the primary making the secondary to follow a spiral trajectory. The averaged fluxes of energy and angular momentum can be calculated by solving the Teukolsky equation (TE) in the frequency domain or in the time domain. Mgr. Skoupý used both approaches, which allowed him to cross check his calculations at each step of his work. For the frequency domain calculations, he developed a code in *Mathematica* using elements from the *Black Hole Perturbation Toolkit* repository, while for the time domain ones, he used and improved an existing time domain TE solver called *Teukode*, which is written in *C*.

The first step in his endeavour was to calculate the fluxes from a spinning test body moving on circular equatorial orbits around a Kerr black hole. For modeling the motion of the spinning body, he got familiar with the Mathisson-Papapetrou-Dixon equations under the Tulzcyjew-Dixon spin supplementary condition. For computing the fluxes, he got familiar with *Teukode*, while at the same time he started to develop his own frequency domain solver. The results from this first step were published only as a proceedings article of WDS 2020, since Piovano et al. *Physical Review D* **102**, 024041 (2020) reported their results earlier than us.

The second step was to compute the fluxes from eccentric equatorial orbits of a spinning body in a Kerr background. For this, Mgr. Skoupý was able to:

- find the relations between the orbital elements of eccentricity and semi-latus rectum with the constant of motion, i.e. the energy and angular momentum.
- find the orbital frequencies, which allowed him to further develop his frequency domain code in order to compute fluxes from equatorial orbits of a spinning body.

- introduce a piecewise polynomial approximation to model the source of a spinning body in *Teukode* and improve its accuracy.

These pioneering results were published in *Physical Review D* **103**, 104045 (2021). The next step was to linerize in the spin of the secondary the equatorial motion along with the respective fluxes, which allowed to evolve adiabatically equatorial inspirals and compute the gravitational-wave phase shift between an inspiral of a spinning and a nonspinning body. The latter work was published in *Physical Review D* **105**, 084033 (2022).

The final step in his Thesis was to compute fluxes from off-equatorial orbits of a spinning body in a Kerr background. To achieve this Mgr. Skoupý adopted and improved an existing frequency domain linear-in-spin approximation of the Mathisson-Papapetrou-Dixon equations. He further developed his frequency domain solver for off-equatorial orbits and compared its outcomes to the *Teukode* ones. The article discussing these breakthrough results has been accepted for publication by *Physical Review D*.

Mgr. Skoupý contributed with his frequency domain TE solver to a fourth publication *Physical Review D* **108**, 044004 (2023), which is not part of this Thesis. He participated actively to international conferences and workshops; he developed and sustained international collaborations, and he visited frequently institutions abroad. Mgr. Skoupý has been a valuable member in my group, who advised and helped actively other members.

In conclusion, Mgr. Viktor Skoupý is an independent researcher, who has provided pioneering results. In my opinion, his Thesis fulfills the requirements for a Ph.D. degree.

In Prague, 15 of August 2023

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