INTERNATIONAL SPACE SCIENCE INSTITUTE

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Subject: Dissertation assessment report for the PhD. candidate Ms. Gabriela Urbancová

Dear Dean Prof. PhDr. Korbelářová

It is a great pleasure to write this evaluation report for Ms Gabriela Urbancová dissertation with the title "X-ray binary systems and the internal structure of compact stars". The dissertation has been written in form of an annotated collection of papers, however, prior to the collection of papers, the dissertation related X-ray astronomy background physics and observations are well summarized in five substantial and coherent introductory chapters. The dissertation, written in English, summarizes well the results documented in four original manuscripts published in excellent astrophysical journals, one of them as first author. Two other peer reviewed articles have been submitted to a main journal. She published also as first author or co-author four workshop or international conference proceedings. This alone shows that the PhD candidate was very productive and justifies well the written dissertation in form of an annotated collection of papers.

In Paper I the authors explore the behaviour of the innermost stable circular orbits (ISCO) around a rotating oblate neutron star. In this work different numerical models have been applied that involve modern neutron star equations of state. They presented a ratio called *K* between the ISCO radius and the radius of the neutron star. They found that a non-monotonic behaviour of *K* can give rise to a neutron star spin interval in which ISCO appears for two very different ranges of neutron star masses. These results can be used to distinguish between different models of high-frequency quasiperiodic oscillations observed in low-mass neutron star X-ray binaries.

In Paper II the authors studied the braking index of isolated rotating neutron stars, so called pulsars. The braking index describes how the pulsar spin-down rate varies with its rotation frequency, this is fundamental to a better understanding of the pulsar magnetic dipole radiation and its variations. However, the pulsar matter composition, i.e., the equations of state are also fundamentals to describe the rotational behaviors of the pulsar spin variation. For the first time, the authors used microscopic realistic neutron star equations of state to determine its behavior and internal structure. In addition, they examined the effects of the baryonic mass of the pulsar, and possible core superfluidity, on the value of the braking index within the magnetic dipole radiation model. They concluded, that magnetic dipole radiation model alone, even with the more realistic equations of stats considered here, cannot explain the observational data on the braking index and other mechanisms have to be sought.

The paper III studied the constrains of twin-peak quasi-periodic oscillations with relativistic neutron star equation of state. Twin-peak quasi-periodic oscillations are observed in the X-ray power-density spectra of several accreting low-mass neutron star binaries. In this paper the authors extend the knowledge to compare quasi-periodic oscillations models with various neutron star equations of state. Based on this study they included also relativistic precession models.

They concluded, that special quasi-periodic oscillations behaviours for some neutron stars can be used to exclude a significant fraction of neutron star equations of states.

The fourth paper is to my understanding the bulk of her expertise and dissertation work of the PhD candidate. This paper study in detail the epicyclic oscillations in the Hartle-Thorne external geometry. The external Hartle-Thorne geometry describes the spacetime outside a slowly rotating compact star. For the rotation frequencies of more than 95% of known pulsars, is sufficiently accurate to describe in this metric the pulsar space-time. They are using realistic equations of state for the stellar matter in a self-consistent way. Following the Hartle-Thorne approach they calculated both the corresponding values of mass and angular momentum and the properties of the surrounding pulsar spacetime. The results are then applied to a range of geodetical models for QPOs. A key feature of the study is that it implements the recently discovered universal relations among neutron-star parameters so that the results can be directly used for models with different neutron stars masses, radii, and rotational frequencies.

The PhD candidate showed to be able to work on four different but related topics, all in theoretical and numerical astrophysics. In all these published papers she extensively contributed and lead the calculations of the complex theory for neutron star equation of states. She was able to combine the QPOs features to the possibility to determine the compactness of the neutron stars and to constrain the equation of states, i.e., probe the interior nuclear matter. She developed microscopic equations of state employed as input into different computational codes that solve Einstein's equations numerically, either exactly or using the perturbative Hartle-Thorne method, to calculate the moment of inertia and other macroscopic properties of rotating neutron stars. The measurement of neutron star mass and radius is one of the most direct and challenging ways to distinguish various equation of states, and her contribution was to give more observational constrains to exclude theoretically predicted equation of states for neutron stars. She couples her theoretical skills with a consistent effort in observational interpretation, together with the meticulousness in understanding theoretically every aspect of the studied topic. She is contributing with original research ideas to advance our understanding in forefront research topics like QPOs and equation of stat related to high-energy astrophysics. She acquired the capacity in being an independent scientist, but also able to collaborate with co-authors, this will surly help her in creating her own research projects and also to extend her network of scientific collaborators in the future. For all these reasons, I strongly recommend the candidate to be awarded with the doctoral degree.

Sincerely yours,

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