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V Praze dne 5. září 2008

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Referee report on Thesis submitted by Mr. Gabriel Török

On some aspects of high frequency quasiperiodic oscillations in X-ray fluxes of accreting compact objects

In his PhD Thesis, submitted to Silesian University (Opava 2008), Gabriel Török deals with the subject of quasi-periodic oscillations in accreting neutron stars and black-hole sources. This work is based on a collection of 17 research papers authored or co-authored by Török. Text starts with a summarising part of 35 pages, which is supposed to give a broader, unifying view of the subject and results achieved in the papers. The introductory part is supplemented with a collection of reprints.

This Thesis deals with an important and unsolved problem of current astrophysical research: the nature of quasi-periodic oscillations (QPOs) is an open and highly debated matter. This is particularly true with respect to a sub-type of QPOs, namely, the High-Frequency Quasi-Periodic Oscillations on which the presented study is focused.

I have been impressed by amount of original work done. During recent five years I have had an opportunity to read most of the papers authored by Török, attend several seminar talks, and watch Török's professional growth. He was given a great opportunity to gain expertise in an international environment of highest quality. Török made use of this opportunity and actively participated at scientific conferences and

workshops devoted to the subject, and, of course, he presented new results also at the annual meetings organized by Opava group. From talks and published papers it is very clear that the impact of Török's contributions is significant. I particularly praise the Papers No. 1, 2, and 3, which passed a tough referee process and appeared in the main journal of European astronomers, Astronomy and Astrophysics. Török is the leading author of these papers. Of more recent works, I value Török's original ideas about the QPO clustering (Paper 14) and the rms difference (Paper 16) as extremely inspiring.

As for the Thesis organization, I would personally prefer a different layout for PhD Dissertation, namely, a uniform text rather than a collection of papers (to me, the latter arrangement appears to be more suitable for higher degrees rather than the first doctorate). However, the present format is also perfectly acceptable, and it is perhaps well-substantiated by the large number of papers produced by Török and included in the Thesis. I might have some reservations with respect to the breadth of the joining text that largely reiterates the papers but does not add much information above their content and often skips other people approaches to the subject. For example, there is very little discussion of the models of QPO sources involving magnetic fields, e.g. the so called accretion-ejection instability and several other ideas. These are also the topics of significant importance, and it would be a pity not to learn the author's judgment on them, while there is a lot of detailed discussion and focus on other issues – e.g. putative detections of QPOs in more massive than stellar black hole sources, and theoretical foundations of the Effect of Aschenbach. Also, in couple of places the joining text lacks some update for the developments of recent years (e.g., p. 17 of the Thesis: “It is not the goal of this paper...”; p. 23: “Observations available at the time of paper publication (2005)”, etc.). I therefore suggest that the Thesis discourse will be the right place at which the opinion's could be further clarified and debated. Here follow some points that the author could address during his presentation:

p. 18: “In general relativity ... the frequencies of the azimuthal, radial and vertical 'quasielliptic' orbital motion differ.” Apparently, the author ignores a purely Newtonian effect of obliquity of the neutron star (e.g. Morsink & Stella 1999, and subsequent papers), and so it would be helpful to comment on the importance of stellar oblateness, which according to the mentioned papers has a non-negligible effect on the frequencies. Oblate potential seems to be considered later in the text (p. 39) but the effect on frequencies is not quantified.

p. 20: “... given by well-known formulas (Aliev and Galtsov 1981, ...)”. It seems to me that the main message of the quoted paper, relevant for the present Thesis, concerns the idea of resonance, so it would be helpful to put the paper content in a broader perspective. I could not find any discussion of Aliev and Gümrükcüoğlu (2005) in the text.

p. 22: “Stella and Vietri (1999) introduced the 'Relativistic Precession Model' ...” The right formula was given in Karas (1999), suggesting different (lower) mass estimates for the neutron star. Is that relevant also for the present Thesis, where the mass constraints are employed?

p. 24: The author discusses Ultra-Luminous X-ray Sources and Sagittarius A* in the Galaxy Center, where the presence of QPOs is still somewhat questionable, while he does not mention the case of RE J1034+396 (Middleton et al. 2008). Could the author comment on the latter?

p. 26: In spite of some effort I could not fully grasp the physical origin of the mechanism discussed here and in Papers 6—8. I do understand the curve plotted in Figure 8, but could the author briefly explain what kind of physical motivation stands beyond this calculation?

p. 30: "...their argument is at present the subject of a study in progress of Paper 9 (Abramowicz et al. 2005)". Could the author update the Thesis to the current status of the problem?

p. 31: "Paper 12 shows that this conclusion is largely unwarranted." Should this formulation (and similarly elsewhere) be read as "partly warranted" or does the authors means "simply wrong" instead? It would be very interesting to have the authors' opinion available on this subject in greater detailedness. Likewise there are a couple of other places in the text where the formulations sound cautiously ambiguous.

p. 42: The concluding section, entitled "Eliminating queries (future prospects)", demonstrates that the understanding of the physical origin of QPOs is still ahead of us. In fact, the extremely rich and interesting interrelations between and among the properties of high-frequency QPOs have not yet been understood in spite of all progress to which Török has been systematically contributing. There are more ways of possible continuation; this Thesis is based on one of research lines connecting the high-frequency QPOs with oscillations of an accretion disc in strong gravity – a suggestion due to Abramowicz and Kluzniak, with both of whom Török regularly collaborates (indeed, Abramowicz is cited 362 times and Kluzniak is cited 245 times in the Thesis, giving the proper ratio of 1.48).

I do appreciate the careful style of Török's research effort, which is always very well focused to the point and demonstrates a lot of working knowledge and plenty of ideas for future. Most importantly, Török brings his own views and original discoveries. On the formal side of the Thesis, although the author has highly benefited from the opportunity for international collaboration, the English of the Thesis could be polished even more. However, this quibble merely reflects my ideas about the style and is not meant to degrade the high scientific value of Török's work.

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

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