Report of Supervisor on the doctoral thesis of RNDr. Gabriel Török

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

The presented thesis is concerned on some very important aspects of high-frequency quasiperiodic oscillations (HF QPOs) representing one of the most intriguing and puzzling phenomenon in the X-ray astronomy and relativistic astrophysics. The HF QPOs demonstrate themselves as a fast and quasiperiodic variability in the X-ray fluxes observed in binary systems containing black holes and neutron stars and a low mass companion star (i. e. a star with mass smaller than the solar mass). Frequencies of HF QPOs correspond to orbital frequencies a few gravitational radii away of the centre of black hole (neutron star), where the strong gravity regime is relevant. Their physical nature is unclear because of very complicated phenomenology, nevertheless, there is widely spreaded believe (although not quite general) that a non-linear resonance phenomena should be relevant in the case of most interesting twin peak QPOs, i. e., pairs of two characteristic frequencies demonstrated in the variability Fourier power spectra of many QPOs presenting systems containing both black holes and neutron stars. The twin peak QPOs observed in the two kinds of X-ray systems show some similarities (probably atributed to the resonant phenomena) and some relevant differences (atributed to the presence of a solid surface in the case of neutron stars).

In this outstanding work of exceptional quality, Dr. Török brings very relevant contributions into the aspects of the QPO studies. First, he developed a very efficient method of determining the black hole spin on the basis of the Abramowicz-Kluźniak model of orbital resonances, dealing with an idea of non-linear resonances of oscillations with epicyclic frequencies or their combinations. These works have strong response and are often quoted.

Second, he contributed significantly to the development of the so called extended orbital resonance model (EXORM) dealing with the standard epicyclic oscillations and the humpy oscillations assumed to be related to the Aschenbach effect, i. e., the humpy LNRF velocity profille in the field of near-extreme Kerr black holes. The EXORM gives interesting results while fitting complex frequency patterns observed in microquasars with spin assumed to be a~1, however, the physical origin of the humpy oscillations is not recognized at present time.

Third, there is a series of very important papers related to the systems containing neutron star, related to clustering of the observed twin peak frequencies around frequency ratios of small integers. The most crucial discovery of Dr. Török is the “energy switch“ effect of the twin peak QPOs in the neutron star systems, occuring while the oscillations cross the “resonant points”, i. e. frequency ratios 3:2 (4:3, 5:4). This discovery is considered to be a crucial one for understanding QPOs. In the “energy switch” work and a variety of other works Dr. Török exhibits both mastership in very complex techniques of X-ray variability data handling and deep theoretical insight. The doctoral thesis is very well written and composed of an introductory overview and 17 selected papers representing results of excelent scientific work. I have no doubt that Gabriel Török exhibits an outstanding ability to bring scientific results of the highest quality and I strongly recommend to approve him the Doctoral degree.

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