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Quasi-periodic oscillations from relativistic hydrodynamical slender tori

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We simulate a purely hydrodynamical torus with constant specific angular momentum around a Schwarzschild black hole. The goal is to search for quasi-periodic oscillations (QPOs) of the torus. Initial torus setup is subjected to radial, vertical and a diagonal (combination of radial and vertical) velocity perturbations. The hydrodynamical simulations are performed using the general relativistic magnetohydrodynamics code Cosmos++ and ray-traced using the GYOTO code. We found that exciting radial perturbations also trigger a plus mode, while vertical perturbations trigger an X-mode. The diagonal perturbation gives just a combination of radial and vertical perturbation. Existing radially perturbed hydrodynamic simulations are in full agreement with our findings. The behavior of QPOs in slender torus mimics those of non-slender torus. This confirms that in actual astrophysical accretion disks, no matter the model (thin, slim, thick), the QPOs will always be detected.

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