The Interplay among Black Holes, Stars and ISM in Galactic Nuclei
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m=1 mode instabilities in nuclear stellar disks around black holes

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Abstract. Using N-body numerical simulations, we investigate the stability of a nuclear disk of a few pc characteristic radius, around a supermassive black hole (SBH), and embedded in a galactic bulge. We find that with an SBH of a suitable range of mass, placed at its center, the nuclear disk is subject to one-armed (m=1) natural instabilities. We propose a feedback cycle for this mode, based on waves between corotation and OLR, and where the "indirect term", and the massive bulge play a fundamental role. Nuclear disks formed from accreted gas could be the precursors of this type of structure and may be common in central regions of galaxies. Density waves could be an efficient mechanism of fueling the gas in the central few tens of parsecs in galaxies.

In this work, we use N-body numerical simulations to investigate the conditions to have a natural m=1 instability in a nuclear disk with a central SBH. We find that m=1 mode instability is present in certain stellar disks harboring a SBH, which is not fixed, as long as we have $Mass_{SBH}/Mass_{disk} \geqslant 2.0$. This mass range condition for the SBH is in accordance with recent numerical works (Bacon et al. 2001, Jacobs & Sellwood 2001, Salow & Statler 2001). Our models also show that there is a strong correlation between the m=1 perturbation and the central mass displacement, suggesting a similar mechanism as the eccentric instability studied by other authors (Adams et al. 1989, Taga & Iye 1998). The m=1 perturbations in our models can be maintained during a time-scale of about ~ 20 orbital periods, being progressively suppressed afterwards by the heating of the disk. However, infall of gas clouds from the outer regions could cool the stellar disk and trigger again the m=1 instability. These modes could explain the dynamics of lopsided galactic nuclei like the structures observed in the M31 nucleus.

As for the initial conditions, the model galaxy is composed of a stellar nuclear disk, an analytical spherical bulge and a central SBH. The stellar disk is represented by 128k particles (in units of 1024), assumed to be initially axially symmetric, with an exponential density distribution, truncation radius of 50 pc and a Tommre parameter Q=1.5. The SBH is represented by a Plummer potential with a softening parameter $\epsilon = 0.3$ pc. There is also a spherical analytical potential representing the bulge (Hernquist 1990).

Figure 1 shows the morphology of the nuclear disk and the Fourier analysis, showing the m=1 amplitude, at successive epochs.

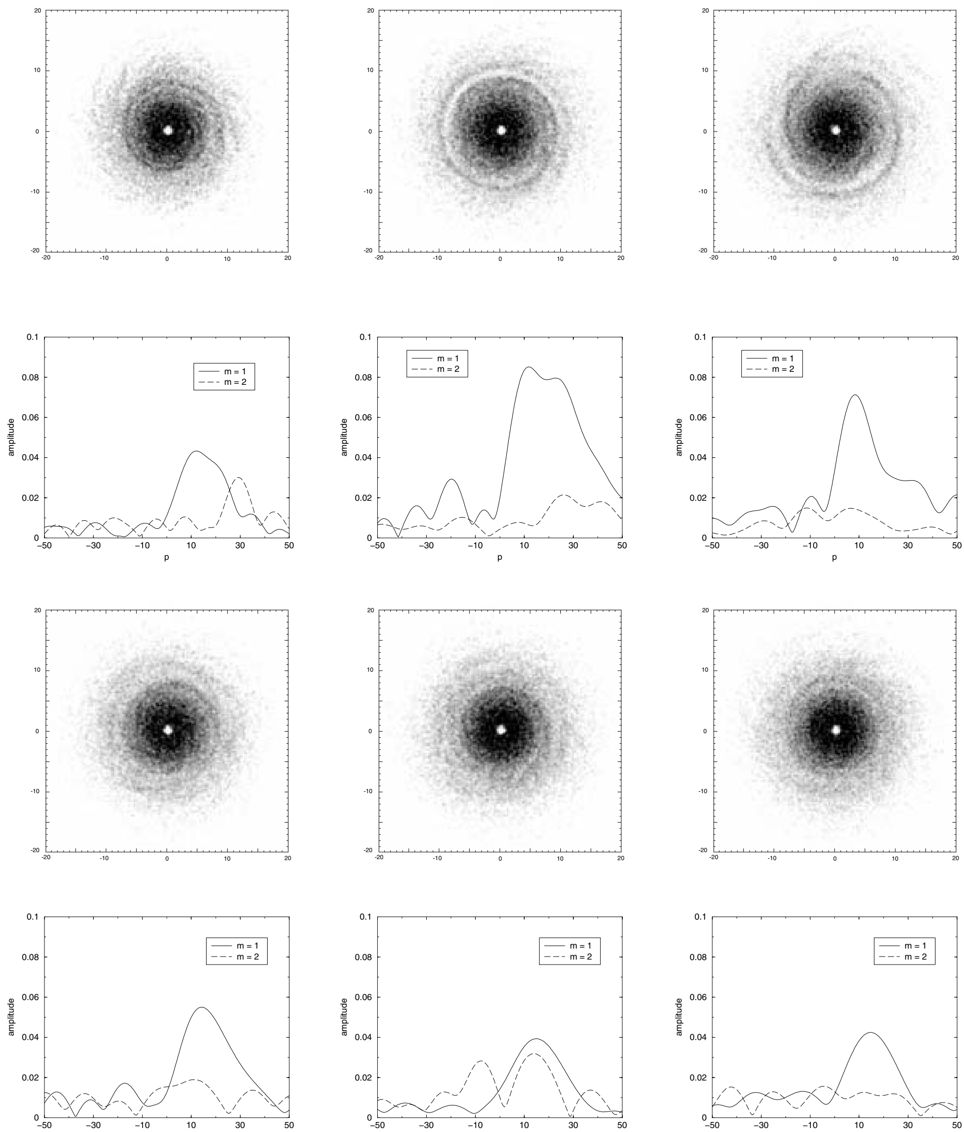

Figure 1. XY projection in squares of 40pc sizes and amplitude of Fourier component for a model with M_{SBH}=10M_{disk} at epochs T = 1 Myr, T = 1.5, T = 2, T = 3, T = 4, and T = 6 Myr, respectively.

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