Growing Stars in AGN Disks

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1 Introduction: Stars in AGN Disks

The outer parts ($> 1000\, R_{\rm S}$) of Active Galactic Nuclei (AGN) disks are expected to become self-gravitating and form stars[6]. Indeed, in our own Galactic Centre a few dozens of young hot stars are confined to two well defined rings of truly nuclear scale ($\sim 0.1\,{\rm pc}$)[3]. This lends support to theoretical predictions of star formation in accretion disks, but also creates a problem: how do luminous quasars transfer the gas to the super-massive black hole (SMBH) avoiding turning all of this gas into stars[4]. Here we attempt to answer whether the newly born stars can leave the disk midplane, cutting off their further growth by accretion.

2 Mechanisms for Stars–Gas Decoupling

Material falling into the inner regions of galaxies can have fluctuating angular momentum, changing the accretion disk orientation on the viscous time scale. However, we find that the gas forces acting on the stars, friction[1] and gravity, bind the stars and the gas disk together effectively[5]. Baring "catastrophic" events changing abruptly the gas disk orientation, the stars will follow the gas disk turning.

On the other hand, interactions between stars tend to thicken the stellar disk, eventually "relaxing" the system to spherical symmetry. So there is a competition between the scattering and the gas forces. To solve this problem, we performed N-body simulations (using `NEMO`[7]'s `gyrfalcON`[2]) of a disk-like stellar system where we added the gas forces. We find that, only when the surface density of the stellar system is comparable to or larger than the gas disk surface density, do most stars increase their velocity dispersion (Fig. 1a), making the stellar disk thicker with time. In that case, the rate at which stars accrete from the gas disk decreases (Fig. 1b).

3 Conclusions: Growing Stars

Disk plane changes are not fast enough to let stars leave the disk midplane, unless these changes take effect on time scales comparable to the dynamical time. N-body scattering is efficient in making the stellar disk much thicker, but only once most of the gas has already been transformed into stars. Without stellar feedback effects (e.g., supernovae, stellar winds), which were not included here, we find that it is hard to avoid rapid gas accretion onto embedded stars.

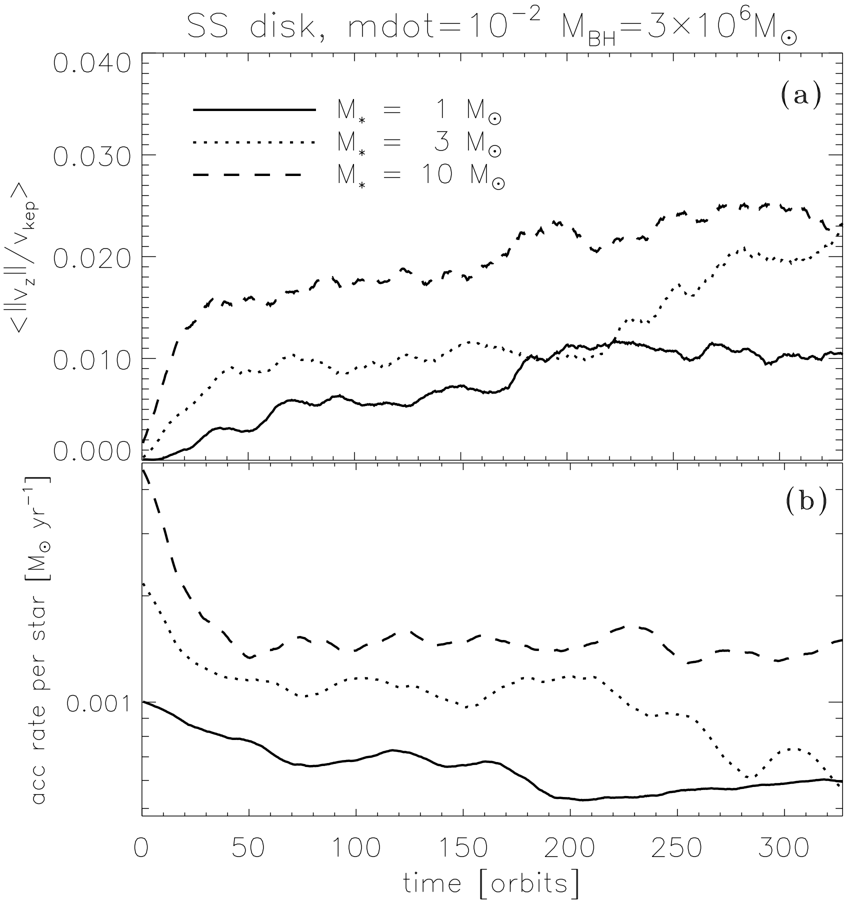

Fig. 1. (**a**) Vertical velocity dispersion as a function of time for stellar systems of different star masses and surface density comparable to the gas disk. Compare with the standard accretion disk $H/R = 0.0025$. (**b**) Average accretion rate per star. Note that while it does decrease as the stars leave the disk, it is still very large

References

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