A disk in the Galactic Center in the past?

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Abstract. We raise the question whether in the past a disk could have existed in our Galactic Center which has disappeared now. Our model for the interaction of a cool disk and a hot corona above (Liu et al. 2004) allows to estimate an upper limit for the mass that might have been present in a putative accretion disk after a last star forming event, but would now have evaporated by coronal action.

1 The evaporation process

We study the possibility of a cool disk existing in the Galactic Center in the framework of the disk-corona evaporation. Interaction between the hot corona and the cool disk underneath occurs via energy and mass exchange. The hot corona conducts heat downward by electrons. At the bottom the heat is radiated away. An equilibrium is established: If the density in the corona is too low, Bremsstrahlung is inefficient and the thermal conductive flux heats up some of the disk gas leading to mass evaporation from the disk into the corona. The resulting density increase in the corona raises the radiation loss and thereby counteracts further evaporation. If the coronal density is too high, radiative cooling is too strong and gas condenses into the disk. At the final equilibrium density one of the processes works, either evaporation of disk mass to the corona or condensation of mass from the corona into the cool disk. The outcome depends on the mass flow in the corona from outside.

2 The mass flow in the inner disk

Assuming the applicability of our model for the evaporation/condensation process we can estimate how much mass would have evaporated by coronal action during a given time interval. We get an upper limit for the mass that might have been left over in a putative accretion disk after a last star forming event, assuming that no thin disk exists now.

We consider the region at the distance $10^4 - 10^5$ Schwarzschild radii from the black hole which corresponds to $\frac{1}{400}$ to $\frac{1}{40}$ pc. For an assumed standard value of the viscosity parameter $\alpha = 0.3$ and no wind escape from the corona we found a rate of about $10^{-3}$ times the Eddington accretion rate corresponding to $10^{-4}$ solar masses per year.

Chandra observations directly image the hot X-ray-emitting thermal gas in the vicinity of the Bondi accretion radius where the surrounding gas is captured
by the gravitational pull of the central black hole, and determine temperatures and densities that allow to estimate a mass accretion rate of Sgr A* of $M_{\text{Bondi}} \sim (0.3 - 1) \times 10^{-5} M_\odot/yr$ (e.g. Baganoff et al. 2003). If we assume that inflow rate during the time since the last star forming event, always disk evaporation would have been present.

3 The history

We consider the history of our Galactic Center during the lifetime of the stars observed close to the Galactic Center. After the last star forming event in a then gravitationally unstable disk a certain amount of gas might have remained. This mass left over then should no longer have been gravitationally unstable. We here ask how much of this mass would have evaporated.

The observations, especially spectroscopy of one star, S0-2, observed in the vicinity of Sgr A* suggest that these stars are main sequence O/B stars (Eisenhauer et al. 2003, Ghez et al. 2003). The main sequence lifetime of these stars is of order of $10^{6.5} - 10^7$ years (Maeder & Meynet 1989). We consider the disk evolution during this time interval. From the evaporation rate we find an upper limit of 300 to 1000 solar masses for the amount of gas that remained in a disk after these stars had been formed and was then evaporated until now. This value is in the range of mass of the presently observed bright O/B stars close to the Galactic Center. This means about the same amount of mass as used up in star formation could have remained in a thin disk.

Such an estimate would also be of interest in the framework of star formation in the Galactic Center as recently discussed by Milosavljević and Loeb (2004). They suggest star formation in a warm molecular disk where newly formed self-gravitating objects can have protostellar disks where fragmentation leads to multiple clumps resembling the IRS 13 complex in the neighborhood of Sgr A*.

Interestingly this amount of gas is also close to that of the stability limit of a disk against self-gravitation. This suggests as a possible picture for the evolutionary history that a disk could have become unstable by self-gravitation and formed the presently observed young massive stars around the Galactic Center until the gravitational instability had ceased. Even if such a disk could have been too cool to allow magnetic dynamo action and would then have negligible internal viscosity and mass flow, it would have disappeared by now by evaporation.

References

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