Constraining the initial mass function of stars in the Galactic Centre

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Mass function of stars in the GC

- The initial stellar mass function is important for many astrophysical phenomena. So far, most stellar populations in e.g. the solar neighbourhood, open or globular clustes can be fit with one single mass function, like e.g. Kroupa (2001).
- In case of stars at the galactic center, evidence has been produced for both normal and top-heavy IMFs, e.g.
- Figer et al. (1999) and others found that the mass function of the Arches cluster is top-heavy.
- Kim et al. (2006), Espinoza et al. (2009) find normal mass function for Arches

Mass function of stars in the GC

- Maness et al. (2007) observed bright giant stars and found that the observed luminosity function best agrees with a long-standing top-heavy IMF.
- Buchholz et al. (2009) find that luminosity function of late-type stars in the GC agrees with that of late-type stars in the bulge.

Our idea is to use available observational constraints on the mass function and compare them with the results of stellar population modeling in order to derive the IMF and SFR of galactic center stars.

Constraints on the mass function of stars:

We use the following observations to constrain the mass function of stars in the innermost pc of the galactic centre:

- The enclosed mass within 1 pc of the galactic centre is $\sim 1.5 \cdot 10^6$ $M_\odot$, which gives a mass-to-light ratio for faint stars of $M/L_{Ks} = 1.4^{+1.4}_{-0.7} M_\odot/L_\odot$ (Schödel et al. 2009).
- 6000 stars brighter than $Ks < 17.5$ are within a projected distance of 1 pc from Sgr A* (Schödel et al. 2009). For a power-law density distribution with slope -1.75 about 3000 of these are in the innermost pc.
- The K-band luminosity function of the bright, late-type stars follows a power-law with slope 0.3 (Buchholz et al. 2009).
- There are about 200 to 300 bright, early-type stars inside the central pc (Bartko et al. 2009, Buchholz et al. 2009).

Testing different IMFs for the galactic centre

We tested the following IMFs against the above constraints:

(a) A Kroupa (2001) IMF, i.e. an IMF given by $\xi(m) \sim m^{-\alpha_i}$ with $\alpha_1 = 0.3$ ($0.01 < m/M_\odot < 0.08$), $\alpha_2 = 1.3$ ($0.08 < m/M_\odot < 0.5$) and $\alpha_3 = 2.3$ ($0.5 < m/M_\odot < 100$).

(b) A flat IMF with $\alpha = 1.35$ for ($1 < m/M_\odot < 120.0$) as found by Paumard et al. (2006) for the young stellar discs.

(c) The same IMF as above extended down to 0.1 $M_\odot$.

(d) An IMF with $\alpha = 0.85$ for ($0.01 < m/M_\odot < 120.0$) as suggested by Maness et al. (2007).

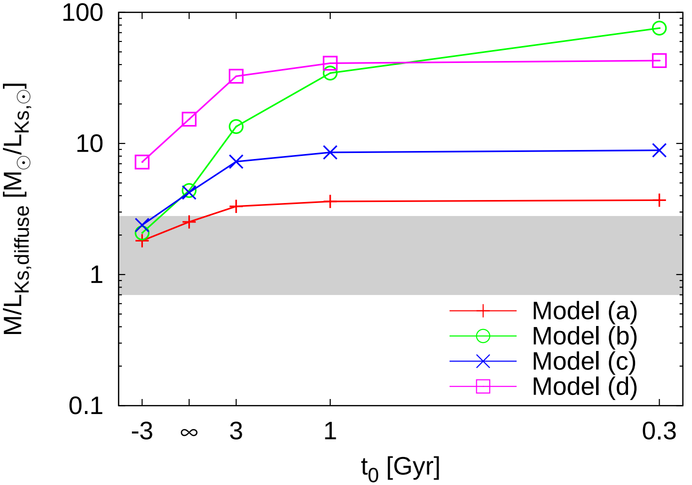
For all IMFs, we assumed different star formation rates SFR(t) $\sim e^{-t/t_0}$, with either $t_0 = \infty$ (constant SFR), $t_0 = 3$ Gyr, $t_0 = 1$ Gyr, $t_0 = 0.3$ Gyr (exponentially declining SFR), or $t_0 = -3$ Gyr (increasing SFR).

Assumptions about stellar evolution

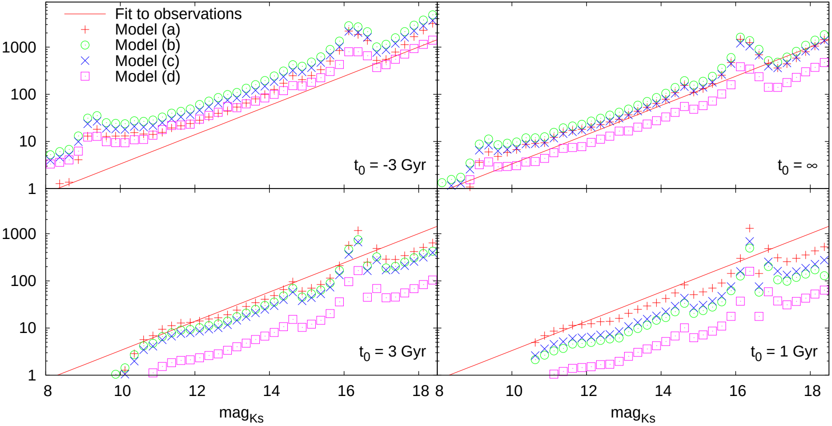
- Stars were created with a given IMF and SFR and then evolved up to 12 Gyr using the Padova stellar evolution tracks (Marigo et al. 2008, Bertelli et al. 1994).
- The total number of bright stars (Ks $<$ 17.5), the number of bright early-type stars and the K-band mass-to-light ratio M/L_{Ks}, was also calculated from the Padova isochrones.
- The total mass of remnants was calculated according to:

$$m_{\rm rem} = \begin{cases} 0.109\, m_{\rm init} + 0.394\, M_\odot, & 0.8 < m_{\rm init}/M_\odot < 8 \\ 1.35\, M_\odot & 8 \leq m_{\rm init}/M_\odot < 25 \\ 0.1\, m_{\rm init}, & 25 \leq m_{\rm init}/M_\odot. \end{cases}$$

Mass-to-light ratio of faint stellar population



Luminosity function of bright stars



Early-type stars

Kroupa IMF:

t_0/Gyr	Nr. of early-type stars	Av. age of late-type stars
-3	133	1170 Myr
∞	37	3950 Myr
3	3	8020 Myr
1	0	10570 Myr
0.3	0	11100 Myr

Paumard IMF (0.1 $M_\odot$ - 120 $M_\odot$):

t_0/Gyr	Nr. of early-type stars	Av. age of late-type stars
-3	702	1180 Myr
∞	192	2820 Myr
3	16	7100 Myr
1	0	10430 Myr
0.3	0	11150 Myr

IMF & SFR Summary

- Observational data of the galactic centre is most consistent with a standard IMF and a star formation rate which is constant or increasing with time.
- Slightly top-heavy IMFs are also possible if the star formation rate was constant.
- If the young stellar discs follow a top-heavy IMF, than the circumstances that led to their formation must be very rare.
- The average age of the late-type stars in the central parsec is around 1 to 2 Gyr.

The late-type star core

Currently three scenarios are discussed for the core seen in the distribution of late-type giant stars in the innermost 0.5 pc:

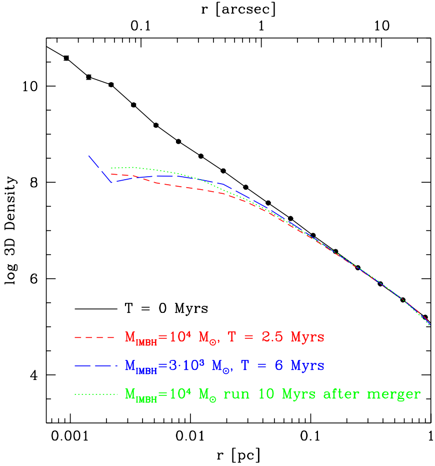
- Stellar collisions with black holes which have removed the late-type giants
- Inspiraling massive black holes which have depleted the inner cusp and formed a core
- An initial core profile which had insufficient time to form a cusp.

The first scenario seems very unlikely since it requires a very high BH density even if the age of the stars is 10 Gyr (see David Merritt's talk).

Depletion of stars due to inspiraling black holes

- Core formation is possible, but one needs either one very massive black hole or a cluster of $\sim$ 100 IMBHs

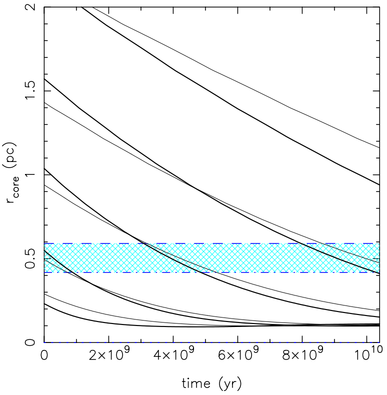
- Major merger within the last few Gyr can be ruled out for the MW



Baumgardt et al. 2006)

Evolution of an initial core profile

- Due to the small average age of late-type stars, they did not have much time to evolve away from the initial profile
- The observed core is therefore most likely the product of star formation



(from Merritt 2009)