Accretion of Stellar Winds in the Galactic Centre

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Abstract

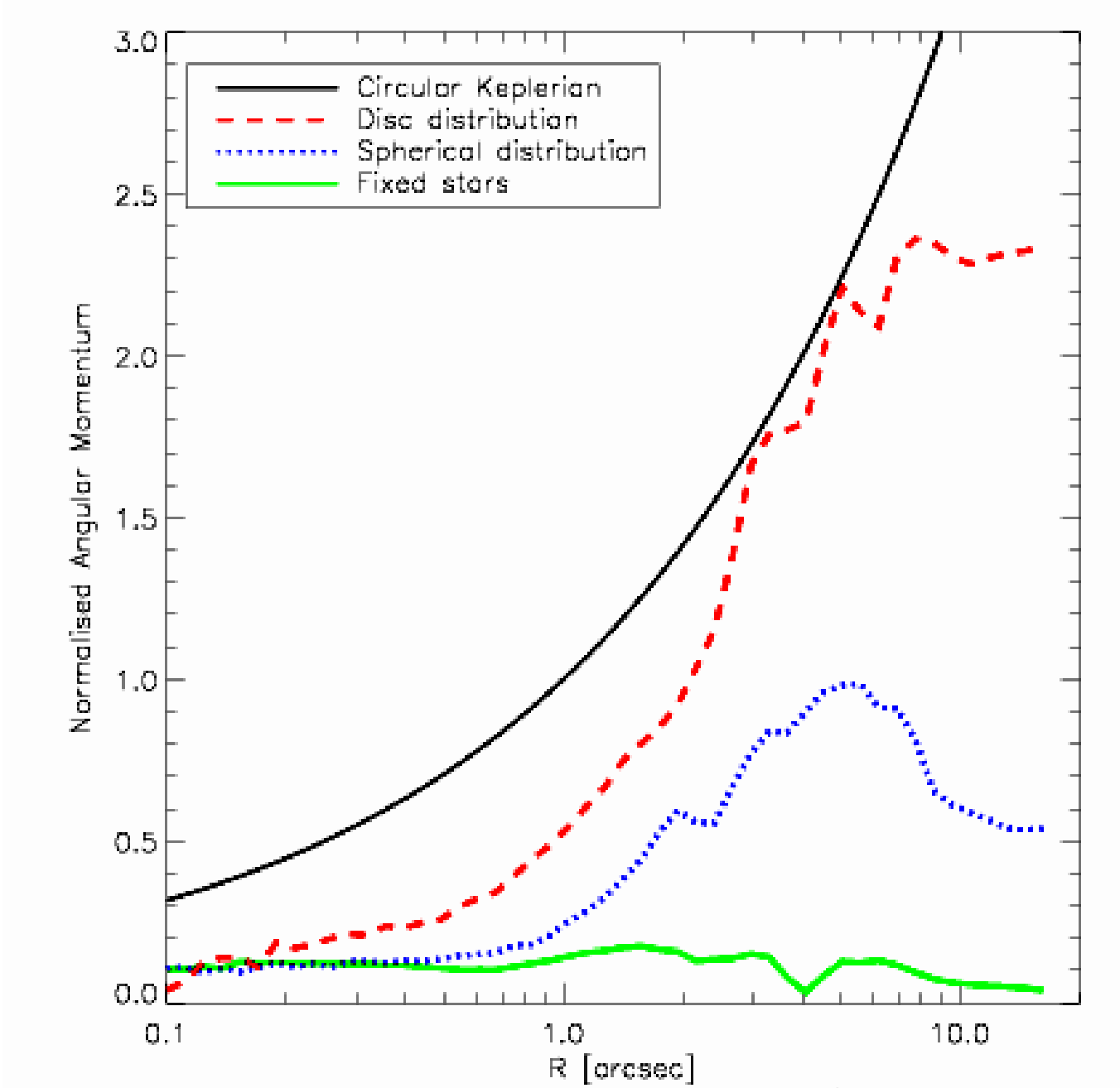
We report a 3-dimensional numerical study of accretion of stellar winds onto Sgr A*. This study differs from previous ones in that we allow the stars to be on realistic orbits, include the recently discovered slow wind sources and allow for optically thin radiative cooling. Our study highlights the importance of source distribution geometry and net angular momentum in the problem. We find that for wind sources distributed in a disc, the accretion rate is a few × 10^{-6} M_{sun}/yr, an order of magnitude lower than the one reported by previous studies, and much more in line with the Chandra observations. In addition, introducing the slow winds, we find these to shock and rapidly cool, forming cold gas blobs, filaments, and a disc. The accretion rate in this case consists of two components: a hot quasi steady-state one, and a cold one that is highly time variable. Such variability can in principle lead to strongly non-linear response through accretion flow physics not resolved here. The results are sensitive to the distribution of stellar wind sources and their properties. Better observational constraints on these quantities are necessary to improve the model.

1. Introduction

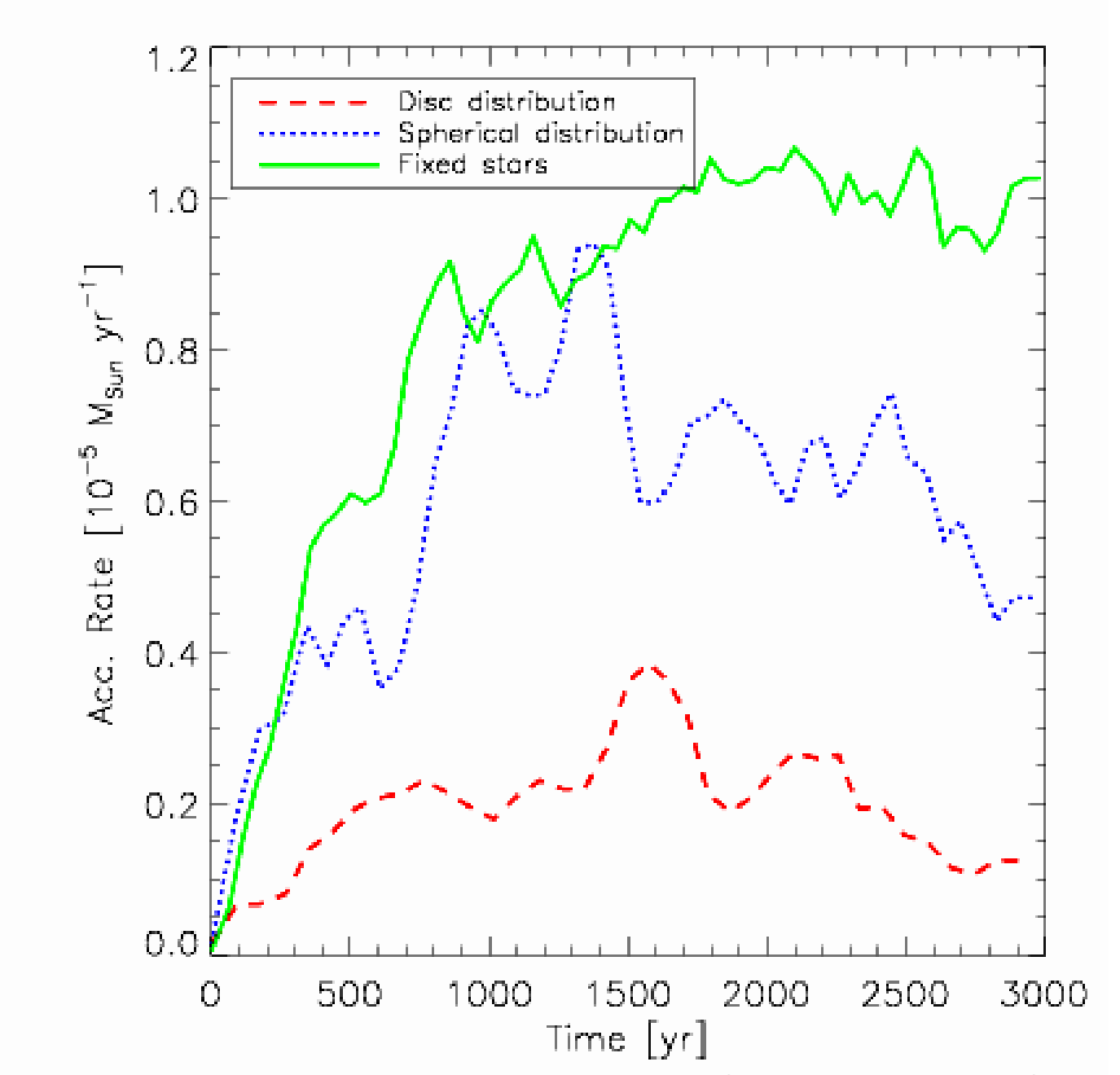
There are dozens of young stars in the inner parsec. Many of them are Wolf-Rayet's (WRs) or luminous blue variable candidates (LBVs), and they appear to be confined to two almost perpendicular discs. The winds these stars produce should be more than enough to power Sgr A* accretion. The aim of this work is to study the dynamics of the gas expelled from the stars, especially to determine which fraction of it flows to the super-massive black hole (SMBH).
To achieve this goal we run 3D SPH simulations with Gadget 2, including a sink (the SMBH) and sources (the stars) of particles.

2. Influence of the Angular Momentum

All the previous work in this subject considered wind sources fixed in space. To test the importance of this issue, we run different simulations with 40 stars. In one of them the stars are fixed (green curves below). In this case the angular momentum of the gas is negligible and the accretion rate is high and fairly constant. If we allow the stars to rotate around the SMBH in random orientations (blue), the angular momenta do not cancel out completely (because of the finite number of sources). The accretion rate now is variable because the stellar geometry changes with time, and it has a lower value. Finally, if the stars are confined to a disc (red), the gas average angular momentum is Keplerian and the accretion rate is even lower, ~ 2× 10^{-6} M_{sun}/yr, consistent with X-ray estimates.



Total angular momentum of the gas as a function of radius for different simulations.



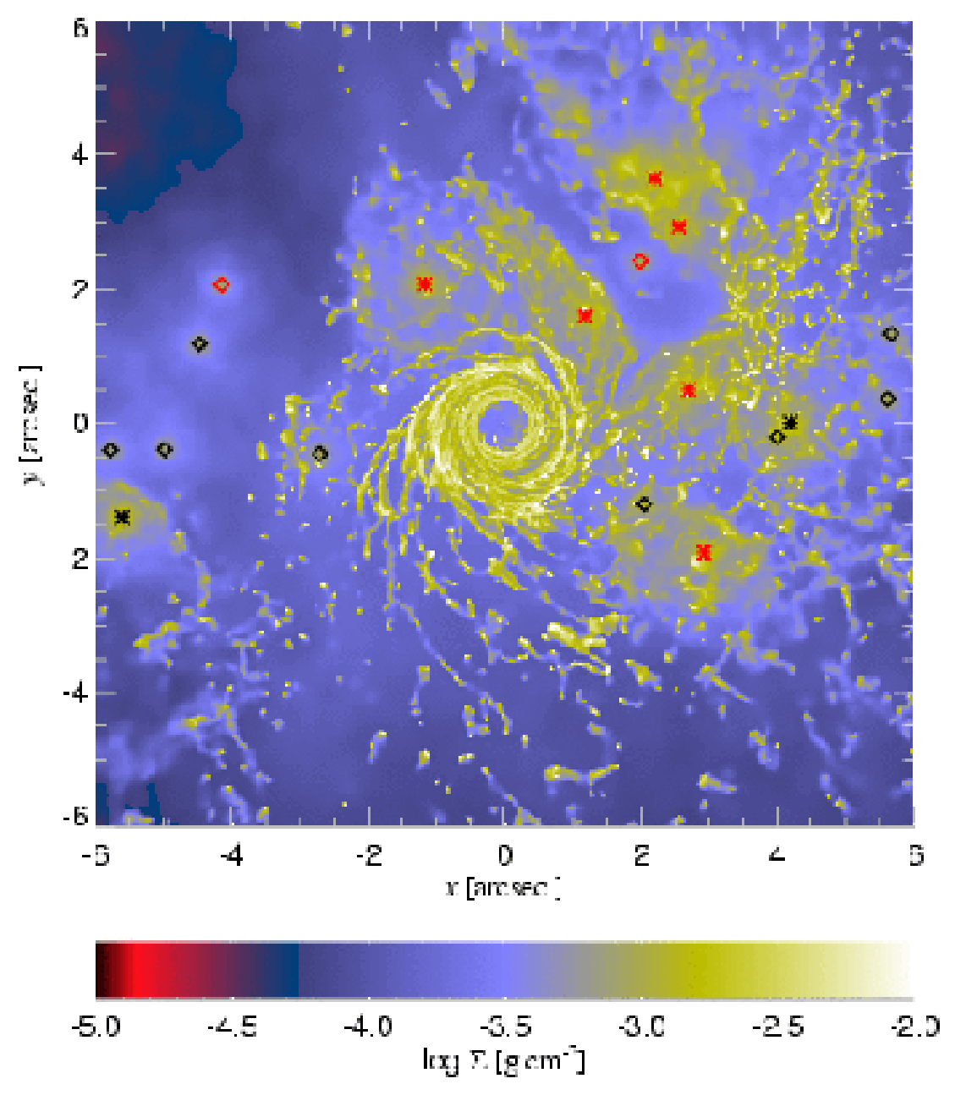
Accretion rate as a function of time for different simulations.

3. Slow Winds and Cooling

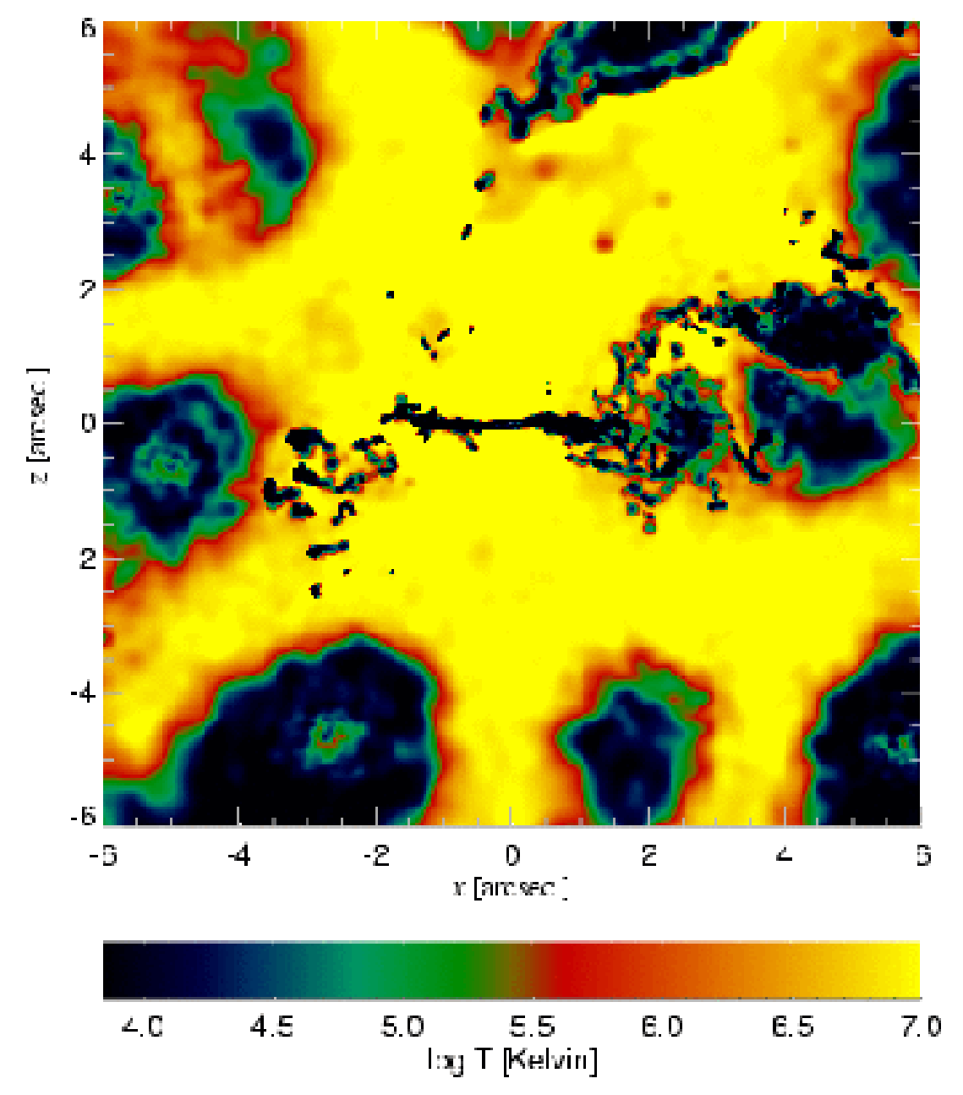
Recent observations indicate that a number of stars in the GC produce winds with velocities even lower than 300 km/s. When such winds collide, the temperature they get is 10^6 K, so they suffer radiative cooling. We now run simulations including two kinds of stars: WRs, with wind velocity of 1,000 km/s, and LBVs, with 300 km/s. We put 20 stars in two discs, with most of the LBVs in the inner one.

3.1. Gas Morphology and Temperature

The winds from LBVs collide, cool and form clumps. Clumps directed inward are sheared by Sgr A* potential, settle on coplanar circular orbits and thus form a disc. The winds from WRs cannot cool and stay at 10^7 K. We find that the inner parsec is a two-phase medium.



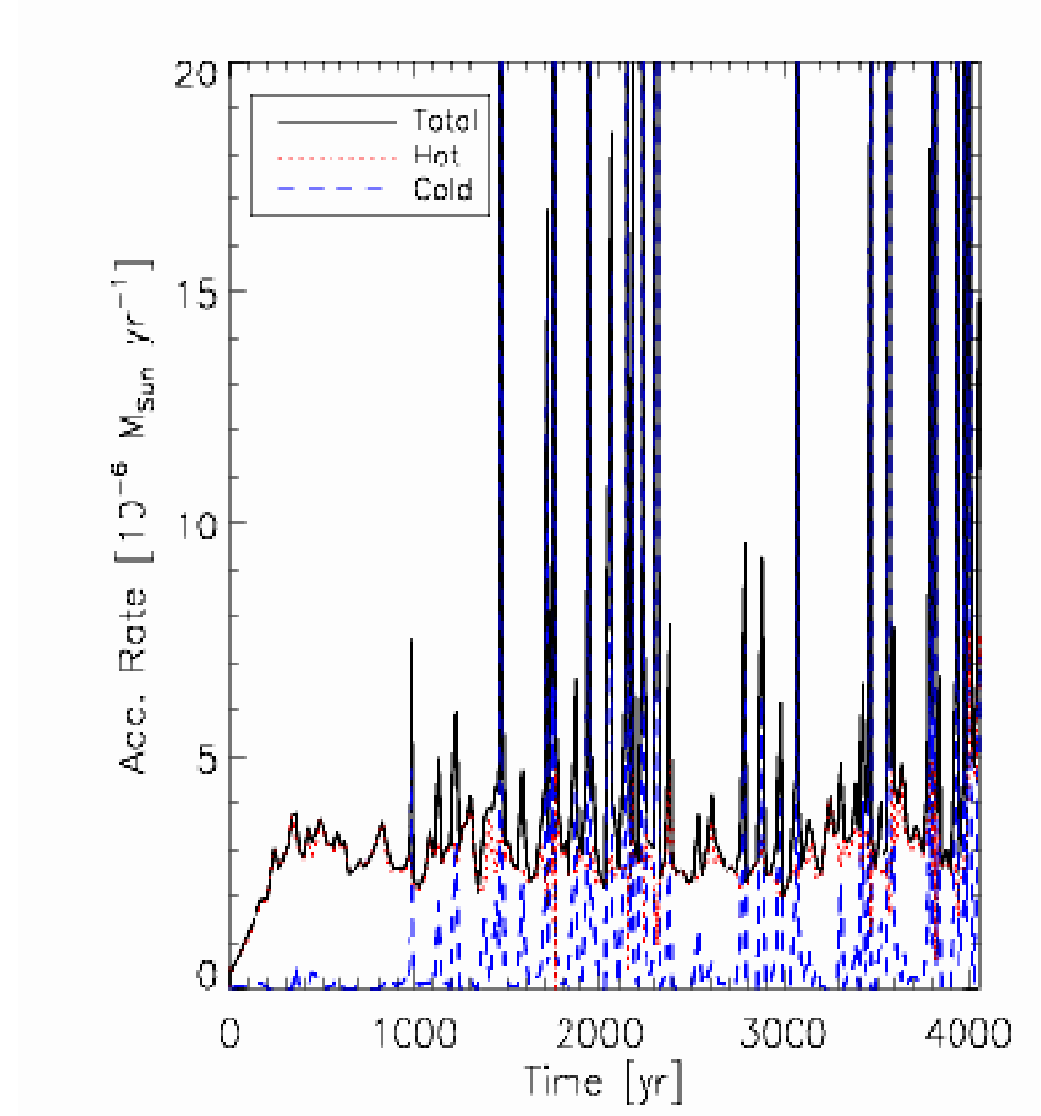
Column density of the gas.
The LBVs disc is seen face-on



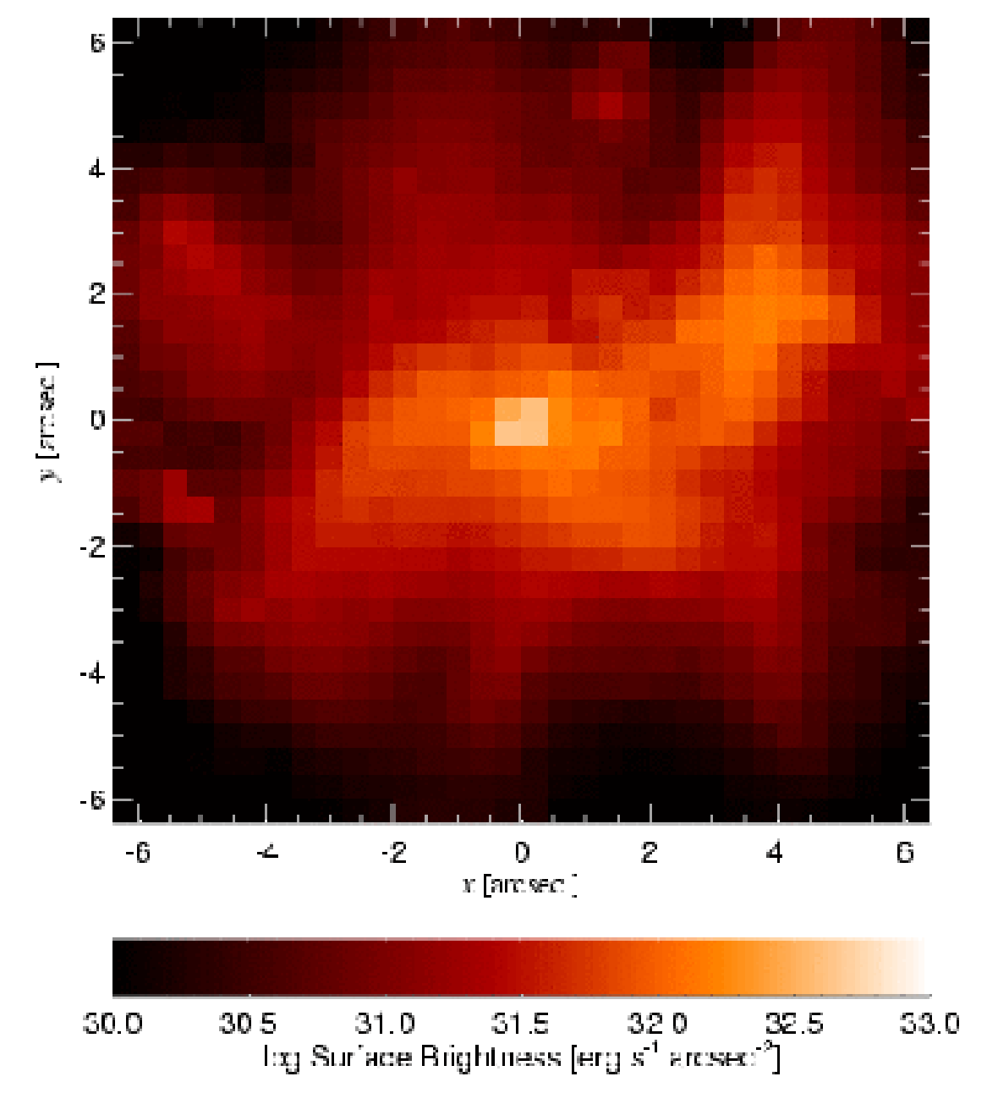
Temperature of the gas.
The LBVs disc is seen edge-on

3.2. Accretion and X-ray Emission

The particles are considered accreted when they get within 0.07" from the SMBH. The accretion rate of hot gas is almost constant, while accretion of cold gas consists of separate clumps infall events. The X-ray emission is extended, but has a well defined peak in the inner ~ 1", similarly to Chandra observations.



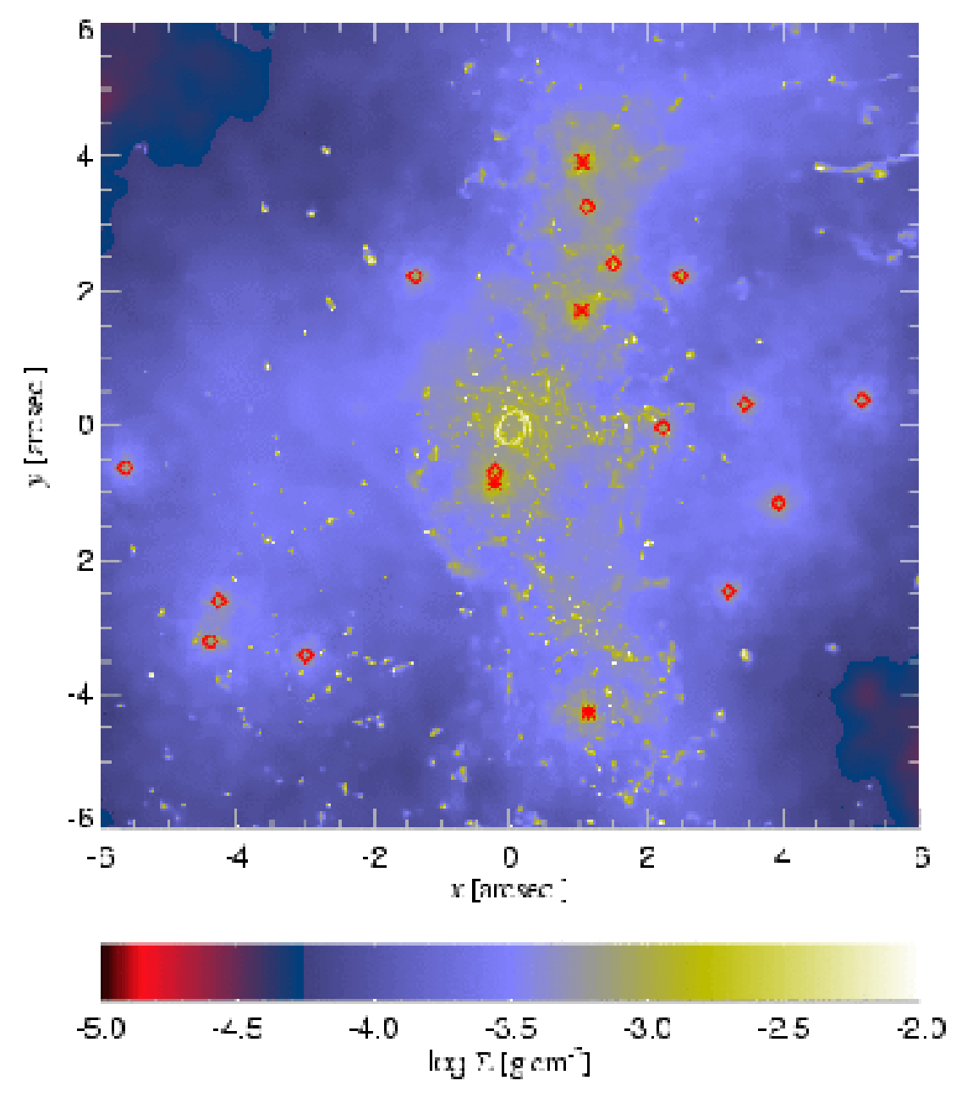
Accretion rate onto Sgr A*, divided into a hot and a cold components.



Simulated Chandra view of the inner 14" of the GC.

3.3. Changing the Initial Conditions

To test the dependence of our results on the distribution of the orbits, we repeated the simulation, this time putting the stars in randomly oriented orbits. There is no disc formed, only a tiny ring. However, the accretion rate is roughly the same and there is a two-phase medium. This shows that we need better determined stellar wind sources properties and orbits to provide more realistic models.



Column density of the gas in the case of isotropic orbits.

For a movie, more details and references, please check
Accretion of cool stellar winds on Sgr A: another puzzle of the Galactic Centre?*
MNRAS Letters, in press (`astro-ph/0502044`)
`http://www.MPA-Garching.MPG.DE/~jcuadra/Winds`

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