Forming misaligned stellar discs around a massive black hole: Cloud infall in the Galactic Centre

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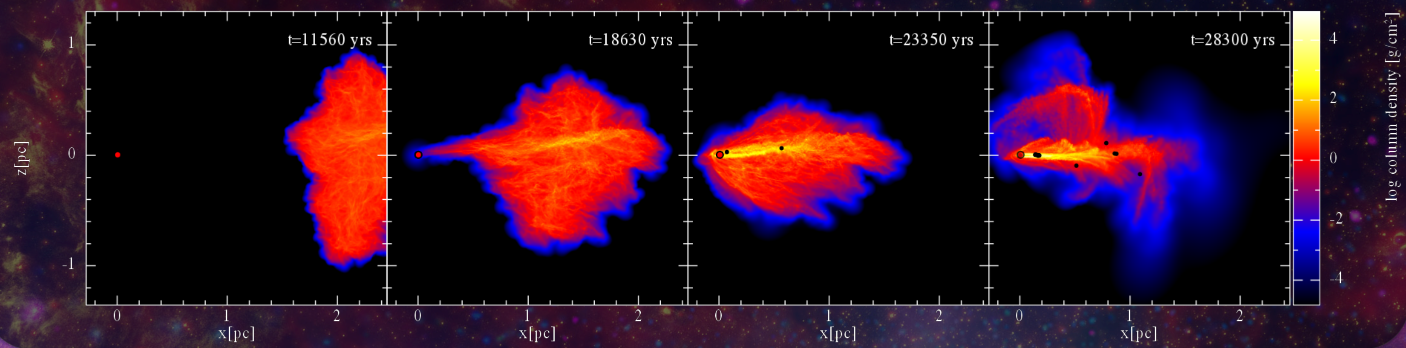
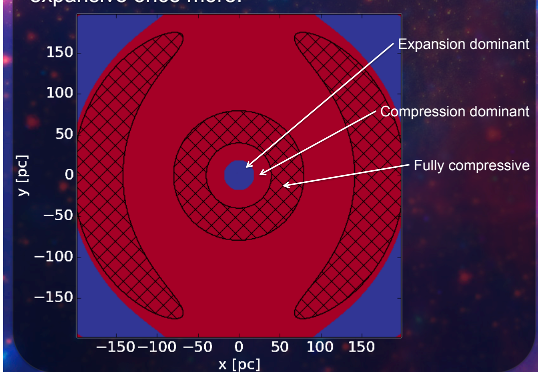
Sgr A* is known play host to either one or two discs of ~6 Myr old massive stars, orbiting between 0.05 and 0.5 pc (Paumard et al. 2006). We know that a fragmenting gas disc can provide an origin for these stars by *in situ* fragmentation. Bonnell & Rice (2008) showed this taking place following the infall and capture of a massive cloud. We have expanded on this scenario by considering the infall of a cloud whose shape can generally be described as prolate to the orbital plane. Below we show column densities from the side of an SPH simulation of a cloud of 2×10^4 $M_\odot$ falling towards a black hole of 4×10^6 $M_\odot$ which can be seen as the red-filled circle at the origin. Material in the midplane formed a disc following the cloud's tidal disruption. Gas at the bottom of the cloud swept around at 60° from the disc due to the difference in the initial direction of the angular momentum vector. Nine stars bound to the black hole formed by the end of this simulation, shown as black dots. They had a ≈ 0.09 pc, e ≈ 0.75 and 2-3 $M_\odot$. We present this simulation and fifteen others in Lucas et al. (2013).

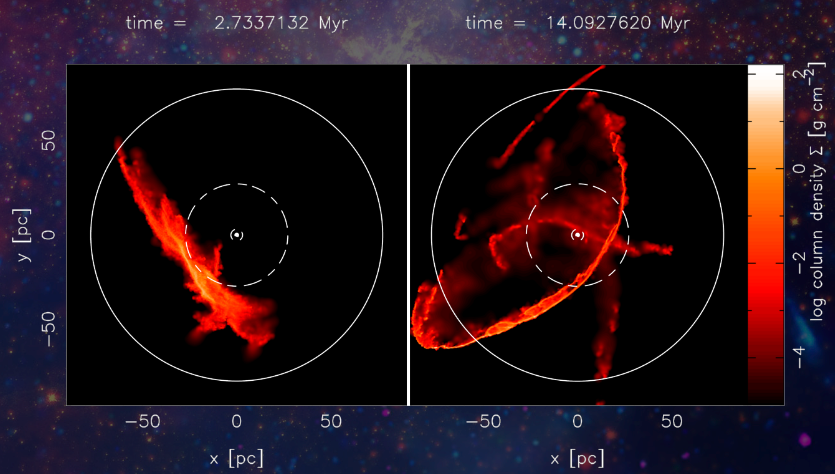


We are now investigating whether tides in the Galactic Centre are capable of compressing unbound gas to form clouds similar to G0.253+0.016 or 'the Brick'. Following Renaud et al. (2009) we have found the directions of the tides in the inner 200 pc of the Galactic Centre and plot them in the midplane below.

In red regions, the strongest of the three components of the tidal force is compressive, and in blue, expansive. Where the plot has been crosshatched, all the components are compressive. The central few parsecs experience very strong expansive forces. However the dominant tides beyond that point are compressive, with a fully compressive shell extending from 40 to 75 pc from the black hole and two more lying farther out along the major axis of the Galactic bar in the *x*-direction. Only beyond 200 pc, where the bar dominates the potential, is the dominant mode expansive once more.



We created a spherical cloud of 10^6 $M_\odot$ and radius 17 pc. Placing it 80 pc away from the black hole at the origin, we followed its evolution along an orbit bringing it in to a pericentre distance of 15 pc. Here we show the simulation at an early and late stage of its evolution; the contours show the potential in the midplane.



The cloud was tidally sheared during each pericentre, elongating the gas stream to the point that by 14 Myr the remnants of the cloud had become self-intersecting and formed a precessing 'D'-shaped ring. It is possible that the cancellation of angular momentum in shocking at the intersection could lead to gas moving in to smaller radii. The cross section of the flow can be seen to have greatly reduced over time.

In the near future we will re-run this simulation with self-gravity. We also aim to set up larger scale simulations encompassing the central few kiloparsecs of the Galaxy. By seeing how gas moves into the inner 100 pc, we hope to gain better understanding the initial conditions above really are. Using a re-simulation method similar to that employed by Bonnell et al. (2013) it should also be possible to follow the formation of massive star clusters in the Galactic Centre.

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Top row of plots made with SPLASH by Daniel Price (Price D., 2007, *PASA*, **24**, 159)
Background image: Hubble/Spitzer/Chandra composite of the Galactic Centre
Credit: NASA, ESA, STScI, SSC, CXC, Q.D. Wang (University of Massachusetts, Amherst), S. Stolovy (Caltech)

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