International Max-Planck Research School on Astrophysics at
the Ludwig-Maximilians-University of Munich

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Stars in the Galactic Centre

Sources and Probes of the Accretion on to Sgr A*

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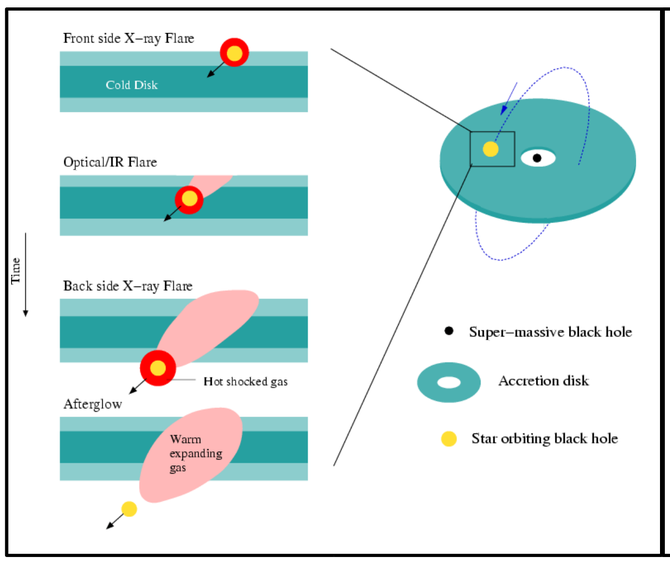
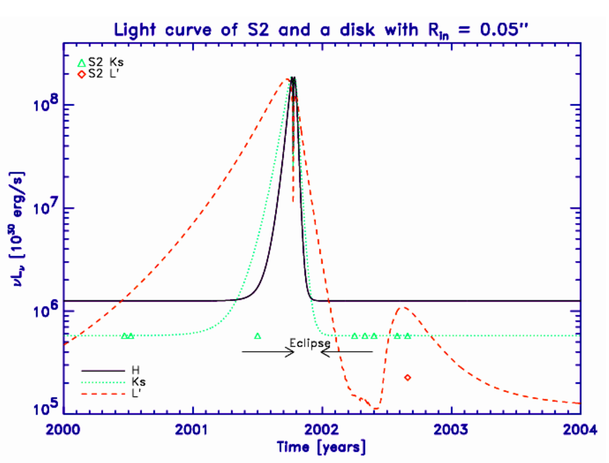
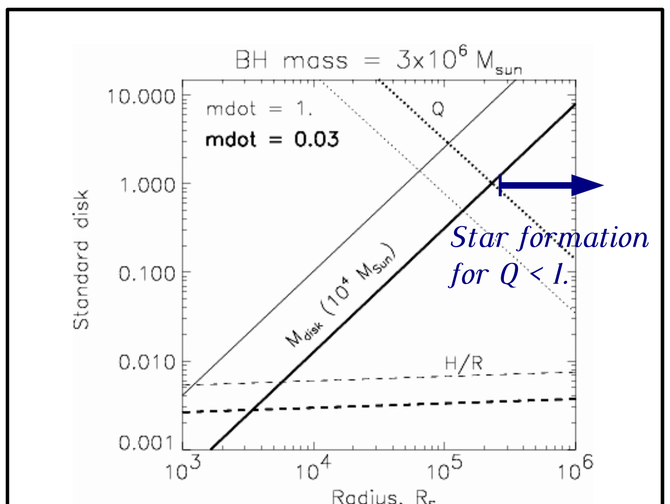
Abstract: SgrA* is the underluminous super-massive black hole located at the Galactic Centre (GC). Within 10" (~0.4 pc) of the black hole, there are thousands of stars. The interaction of these stars with an accretion disc would be observable as strongly variable emission in X-rays [1] and the near infra-red (NIR). Using *current* observations, we put strong constraints on the existence of a disc in the GC [2]. However, we argue that a massive accretion disc existing *in the past* is a plausible birth place for many of the stars [3]. Finally, we study the accretion of stellar winds on to SgrA* and find it to be very time dependent [4]. We show that, despite its current miserable luminosity, SgrA* is likely to be an important energy source for the inner Galaxy on long time-scales.



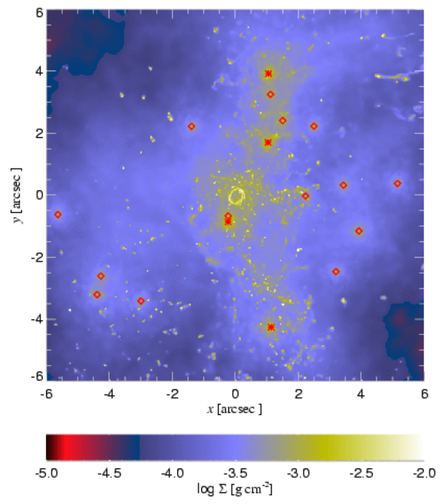
Star - disc collisions: X-ray flares from SgrA* [1] Observations have revealed large magnitude X-ray flares from SgrA*. We pointed out that X-ray flares can be produced by star passages through an inactive disc. There are thousands of stars in the Sgr A* stellar cluster, and each star would cross a putative disc twice per orbit. We developed a simple model for the X-ray emission from a star-disc collision. The duration of the flares, their X-ray spectra, and the frequency of events appeared to be consistent with the observations. However, the recently discovered near infra-red (NIR) flares (believed to be related with the X-ray ones) originate very close to SgrA*, which is problematic for this model. Nevertheless, star-disc flares are still of interest in the nuclei of nearby inactive galaxies, especially in connection with perspective Constellation-X and XEUS X-ray missions.



Stellar observations as constrains on the existence of a disc [2]
We studied two ways in which stars could reveal a disc in the GC: the eclipse of close bright stars by the disc, and the increase in the flux of the disc due to illumination of its surface by such stars during close passages. Using the orbital parameters of the close star S2, and the fact that such effects have not been observed, we strongly rule out a disc unless it has a large inner radius or an NIR optical depth < 0.01.



A self-gravitating accretion disc and star formation in the GC [3]
There are two rings of young (few Myr) stars within 10" from SgrA*, where standard star formation cannot work. However, a massive accretion disc is expected to become self-gravitating and form stars. From the observed stellar dynamics we constrain the *initial* mass of the disc in the range 10^4 - 10^5 Msun. The current absence of such a disc implies that it was accreted either by the central black hole or by the new born stars.



Accretion of stellar winds in the Galactic centre [4]
Using the observed stellar orbits and wind properties, we model the gas in the 0.1 - 10" region around Sgr A*. We find that radiative cooling leads to the formation of cool filaments and clumps. These clumps frequently enter the inner region, dominated by the hot X-ray emitting gas, creating a two-phase medium. The infall of clumps also produces a variable accretion rate, making SgrA* an energetically important source on long time-scales.

References: **[1]** Nayakshin, Cuadra, and Sunyaev: "X-ray flares from Sgr A*: Star-disk interactions?" A&A, 413, 173 (2004). **[2]** Cuadra, Nayakshin, and Sunyaev: "Bright stars and an optically thick inactive disk in Sgr A* and other dormant galaxy centers" A&A, 411, 405 (2003) **[3]** Nayakshin and Cuadra: "Self-gravitating accretion disk in Sgr A* few million years ago: was Sgr A* a failed quasar?" A&A, in press (astro-ph/0409541) **[4]** Cuadra, Nayakshin, Springel, and Di Matteo: "Accretion of cool stellar winds on Sgr A*: another puzzle of the Galactic Centre?" MNRAS Letters, in press (astro-ph/0502044) *and* Cuadra et al: "Stellar Winds and Sgr A* accretion in the Galactic Centre" (in preparation)

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