Science Week

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Excellence Cluster Universe

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The Physics of Galactic Nuclei

Andreas Burkert, Christian Alig, Michaela Hirschmann, Martin Krause, Marc Schartmann

Using numerical simulations, we aim at a deeper theoretical understanding of the origin and evolution of complex stellar and gaseous structures in galactic nuclei as well as their interaction with central black holes. One of our primary focus will be the physics of nearby galactic nuclei that show Seyfert activities, together with the currently inactive Milky Way and Andromeda galaxy as well as the puzzle of the anti-hierarchical black hole growth.

Main topics and goals

★ Gas and dust structure and nuclear star formation

- origin of the thick turbulent (clumpy) gas tori?
- effects of turbulence in tori: thermal state, geometry, angular momentum transport, fueling of the SMBH?
- turbulence driver: radiative heating and pressure, jets and winds, rotation and shear or star formation?
- star formation in tori: nuclear stellar clusters or rings?
- mass accretion and ejection mechanisms in the nucleus?
- evolutionary sequence including inactive states?
- origin of the anti-hierarchical black hole growth?

★ The quiescent nucleus of the Milky Way

- why currently inactive? How to trigger active phases?
- origin of the hot bubble, the circumnuclear stellar disks (former torus?) and mini-spiral?

★ The nucleus of the Andromeda Galaxy

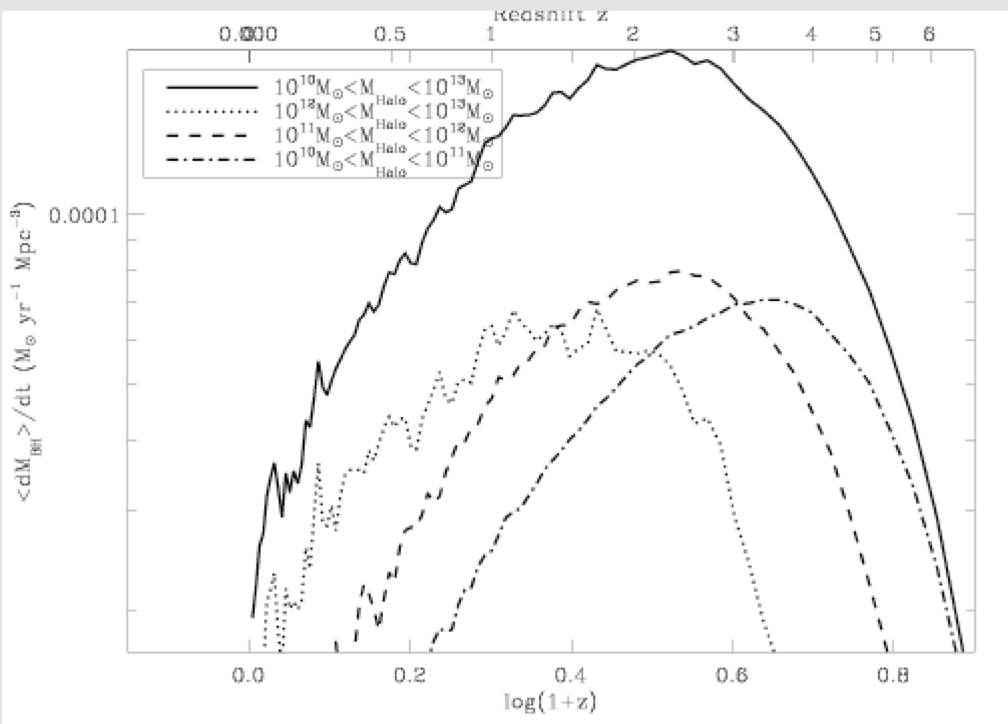
- origin of the outer eccentric old (P1+P2) stellar disks?
- inner young disk (P3) the result of mass loss of stars of the P1+P2 disk?

Current Projects

Origin of the anti-hierarchical growth of black holes

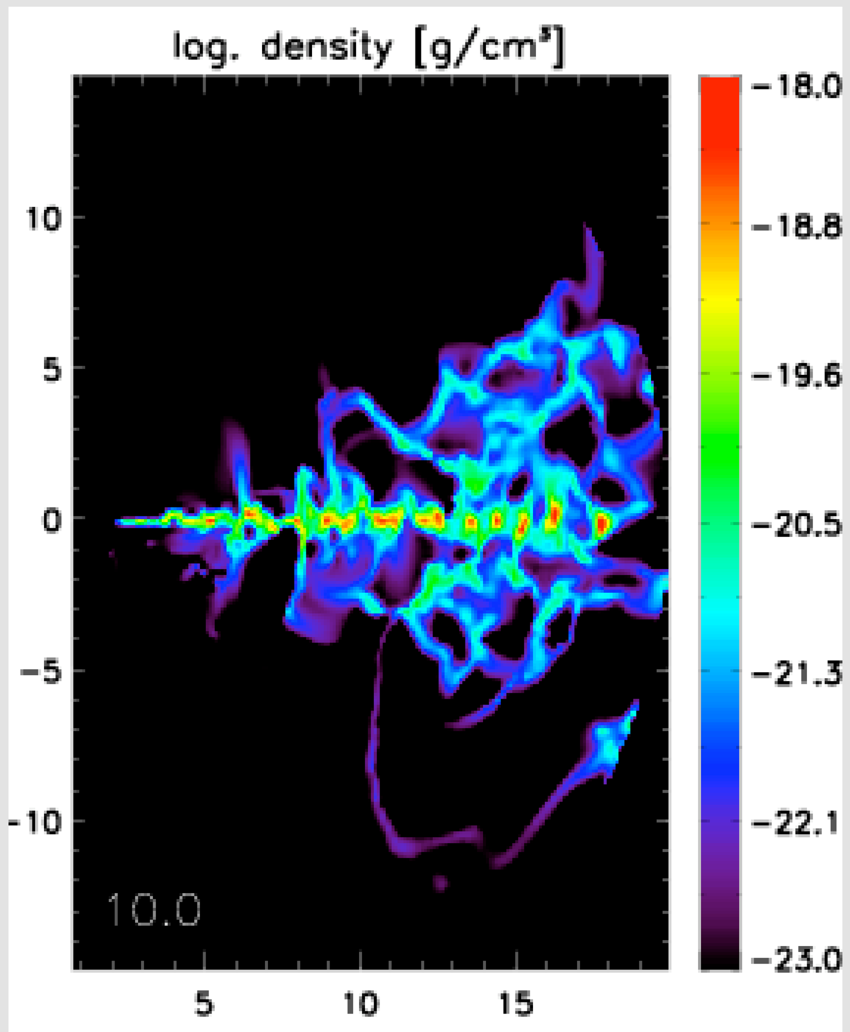
We calculate black hole growth rates, based on merger trees from cosmological dark matter simulations with the GADGET-2 code. These will be confronted with the observed quasar luminosity evolution (quasar downsizing).

Michaela Hirschmann



Turbulence in AGN tori

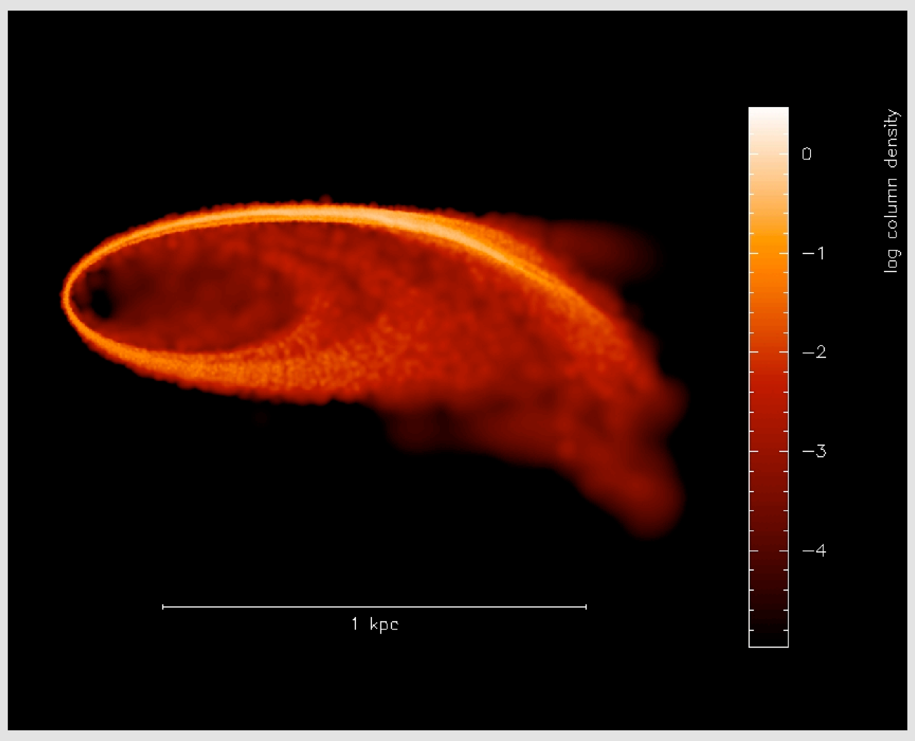
We study the characteristics of turbulence in AGN tori, stirred by discrete energy input mechanisms like supernova explosions or stellar winds and determine the timescales of the decay of the thickness of the resulting density distribution. Below, a cut along a meridional plane is displayed after 10 orbits. This study will show us, whether long term stirring processes are needed.



Marc Schartmann

Star formation in the galactic center

Christian Alig

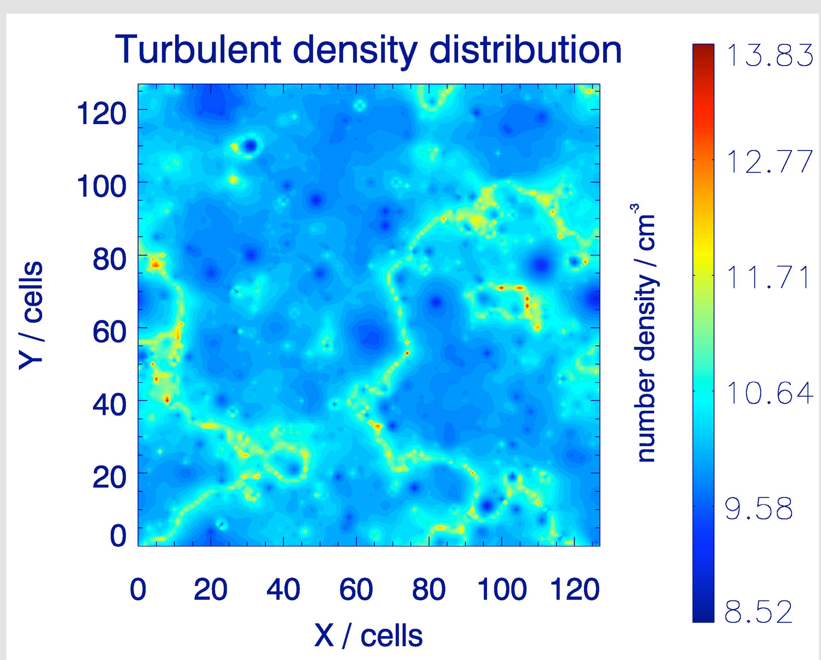


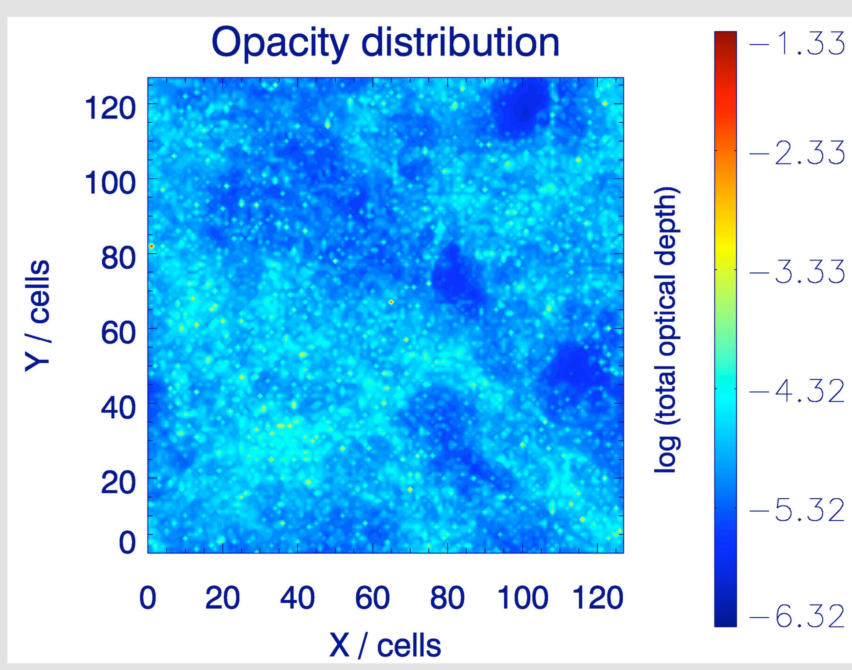
A molecular cloud modeled by a Bonnor-Ebert sphere is put into the potential of a supermassive black hole. We study disruption, disk-phase and fragmentation. Such a scenario might lead to a stellar disk, as seen in our own galactic center. The picture shows the capturing of a Bonnor-Ebert sphere (10^4 M_{sun}) after 250 Myrs by a black hole of 10^8 solar masses.

Radiation driven turbulence in molecular tori

Radiation from AGN might drive turbulence within the torus, which could keep it thick. We aim to perform 3D hydrodynamic simulations with radiative transfer to address this. The example gives an impression how a density slice looks like, and an integration of the total optical depth due to hydrogen and dust extinction at a wavelength just shortward of the Lyman edge.

Martin Krause





Contact: Prof.Dr. Andreas Burkert, Universitäts-Sternwarte München & Max-Planck-Institut für extraterrestrische Physik, burkert@usm.uni-muenchen.de, tel. +49 89 2180 6992