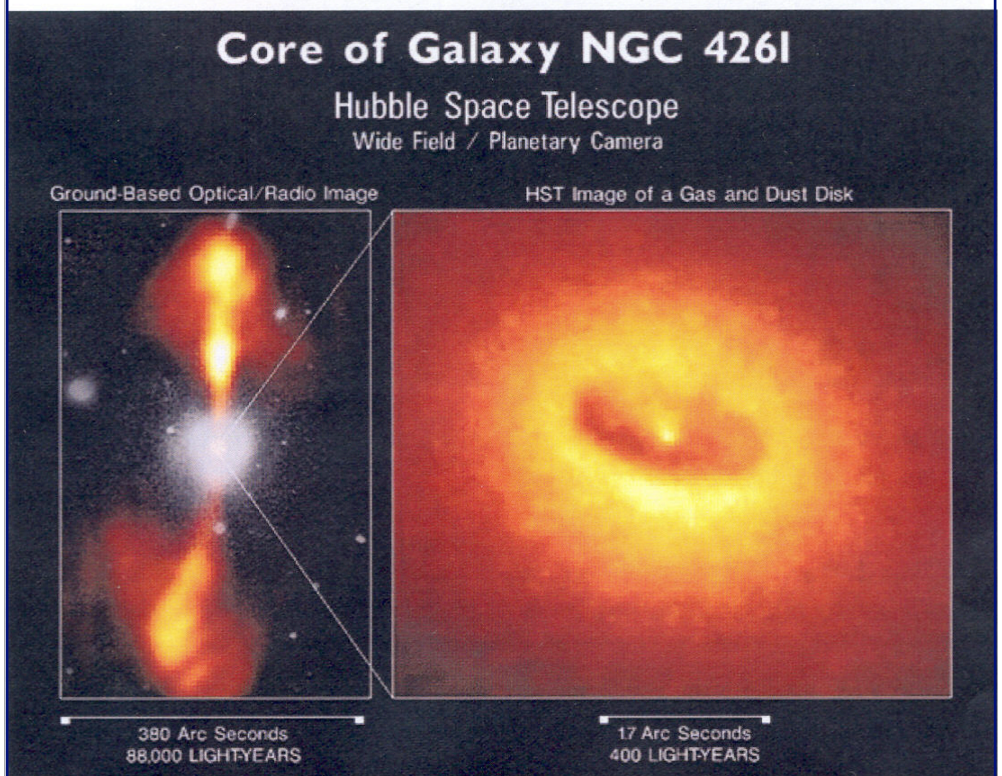
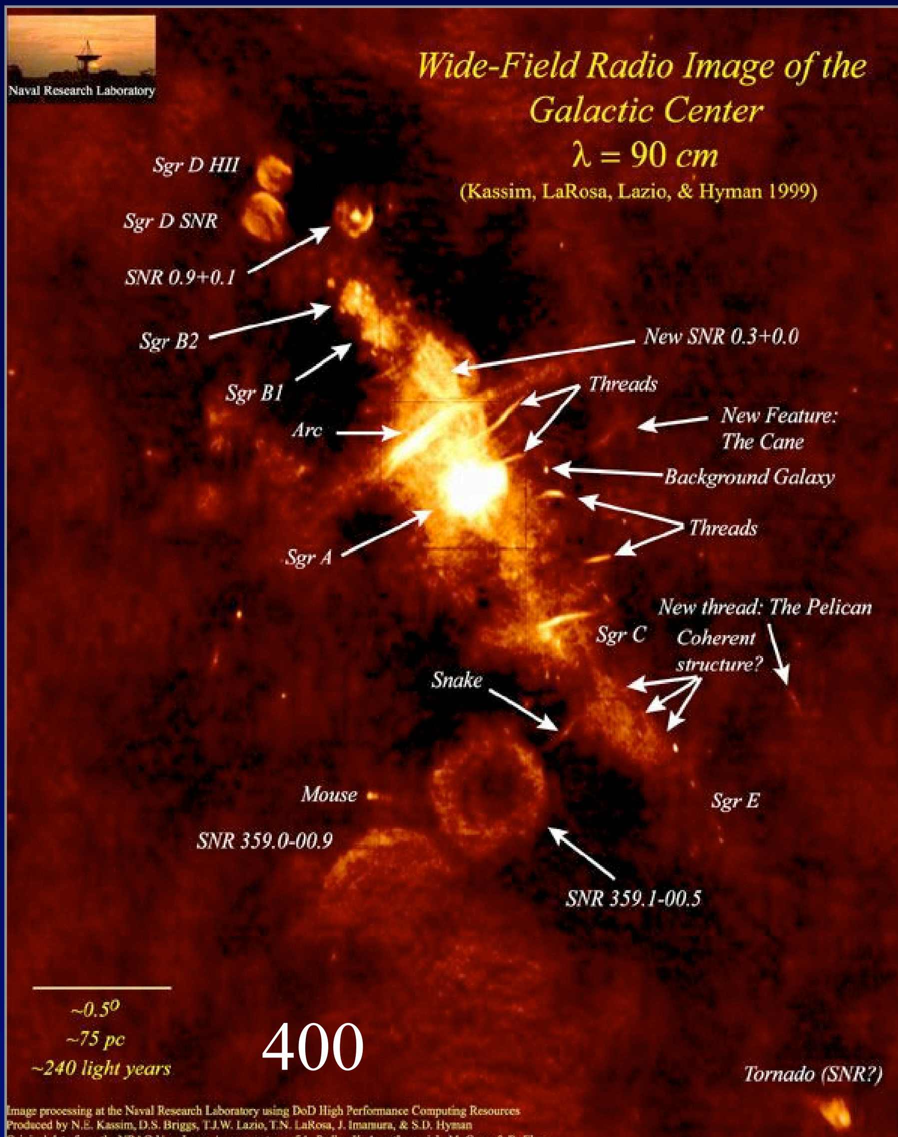
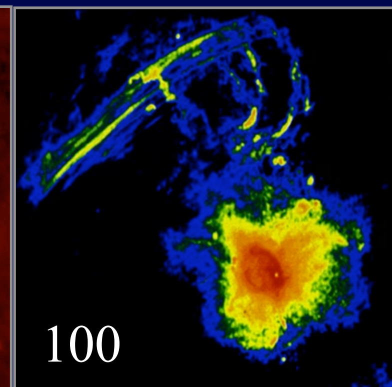
Proposal for a MPG fellowship on

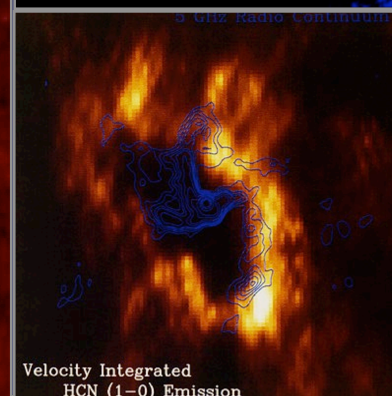
The Physics of Galactic Nuclei

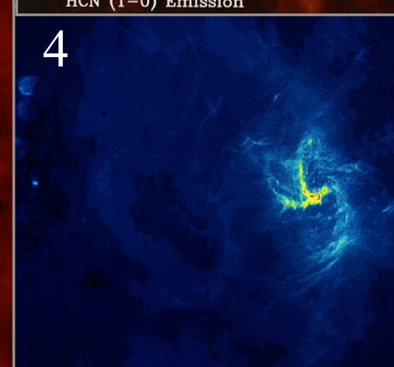


The Milky Way Nucleus as a Prototype Quiescent Seyfert









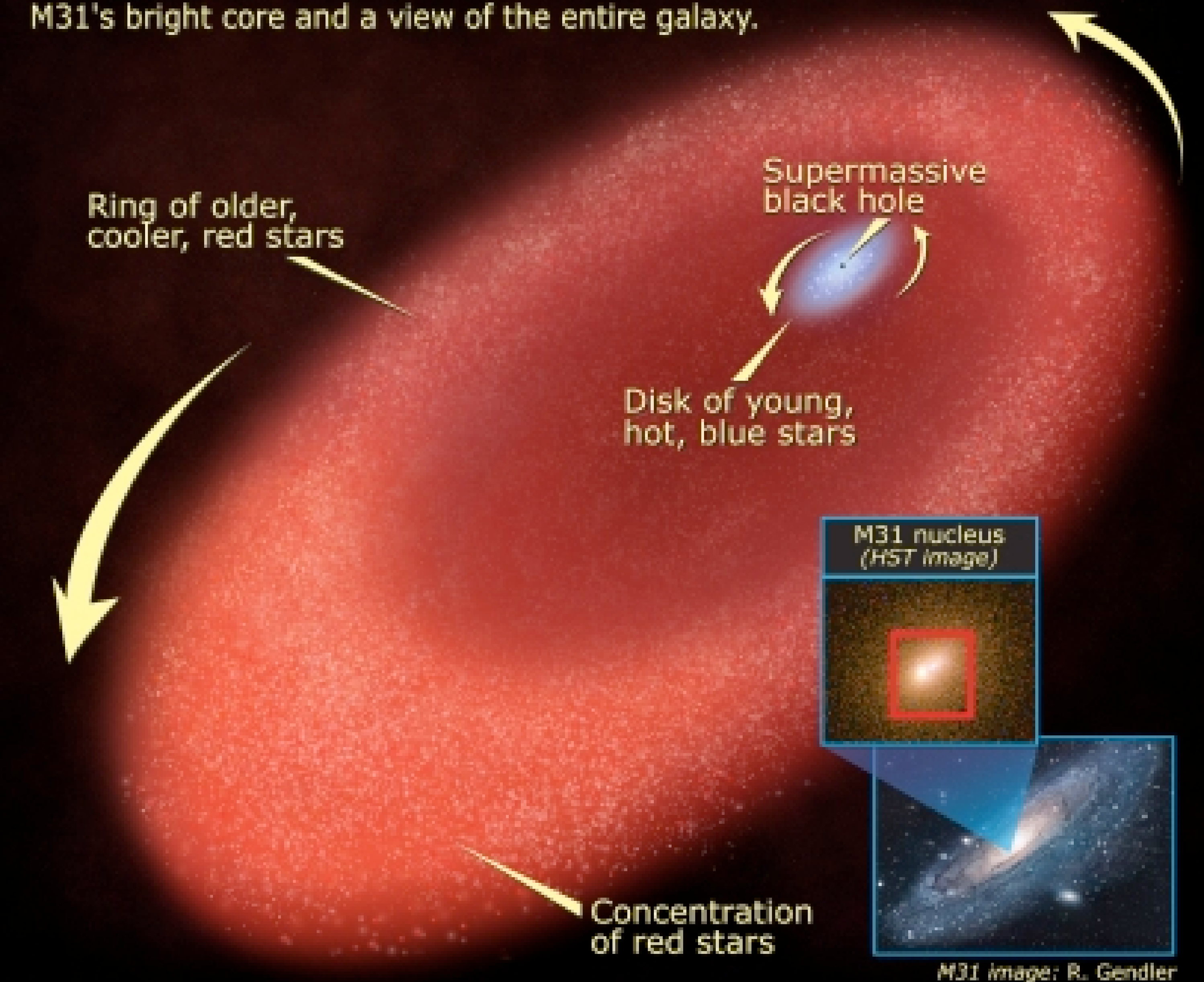
Unique laboratory

Embedded in central disk of HI gas:

- Densest star cluster
- Mini Spiral: Sgr A West
- Circumnuclear ring
- Expanding hot gas shell

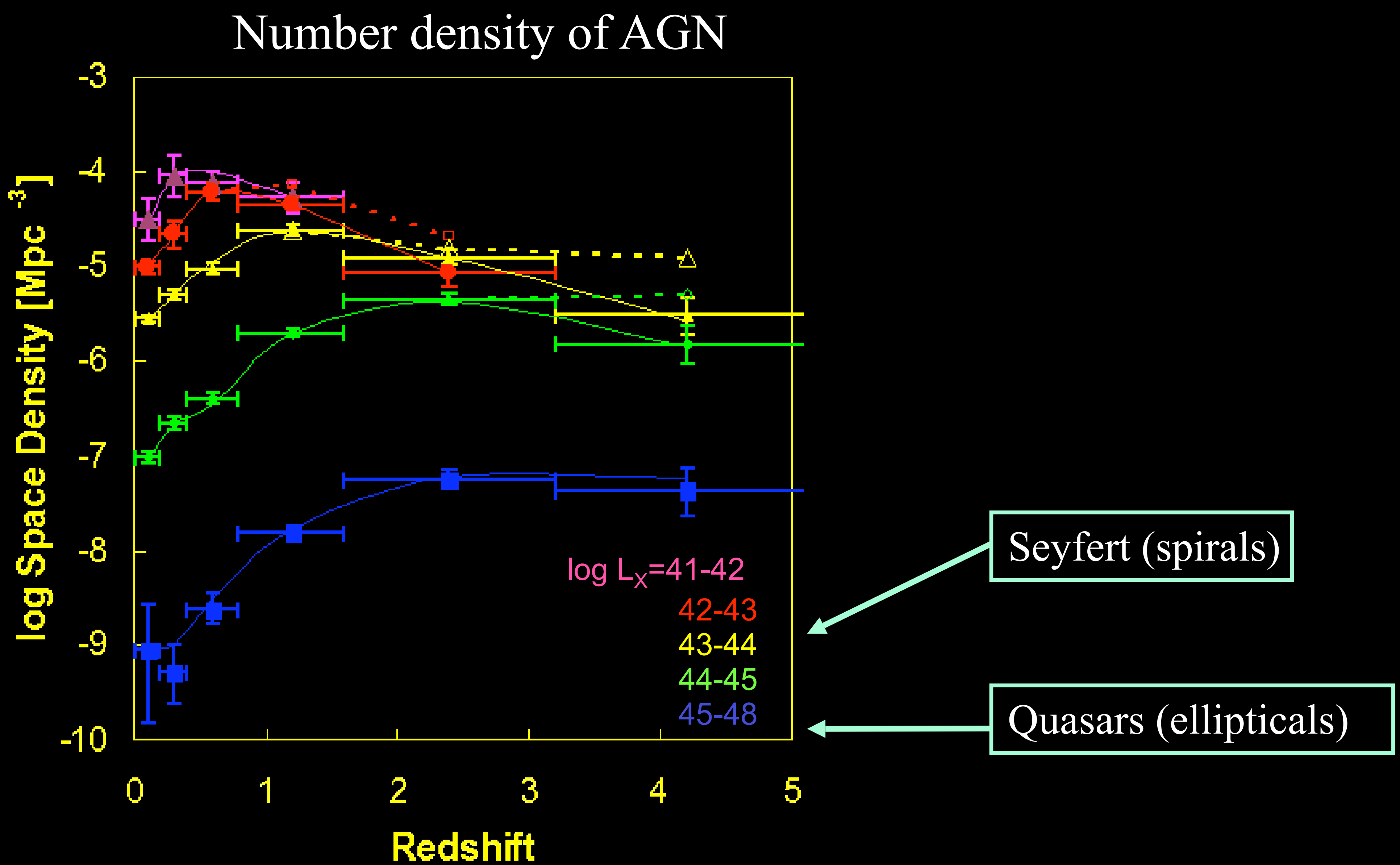
M31's intriguing nucleus

Hubble telescope observations have yielded insights into the Andromeda Galaxy's (M31's) complex nucleus. New images from Hubble uncovered a disk of young, hot, blue stars swirling around a supermassive black hole. The disk is nested inside an elliptical ring of older, cooler, red stars, seen in previous Hubble observations. The inset images show M31's bright core and a view of the entire galaxy.



(Bender et al. 2005)

The Puzzle of Anti-Hierarchical Black Hole Growth



(Hasinger et al. 05)

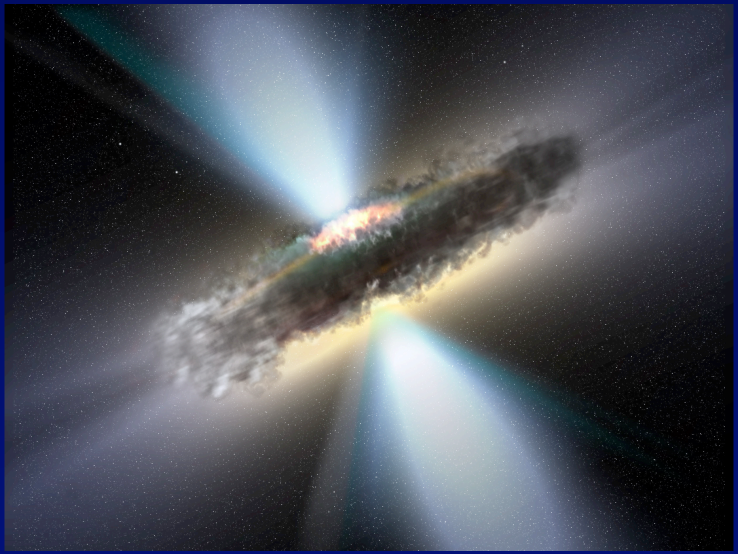
SINFONI observations of AGN

R. Davies et al. 06: Star formation and molecular gas dynamics

- Star formation during active phases of BH accretion is important.

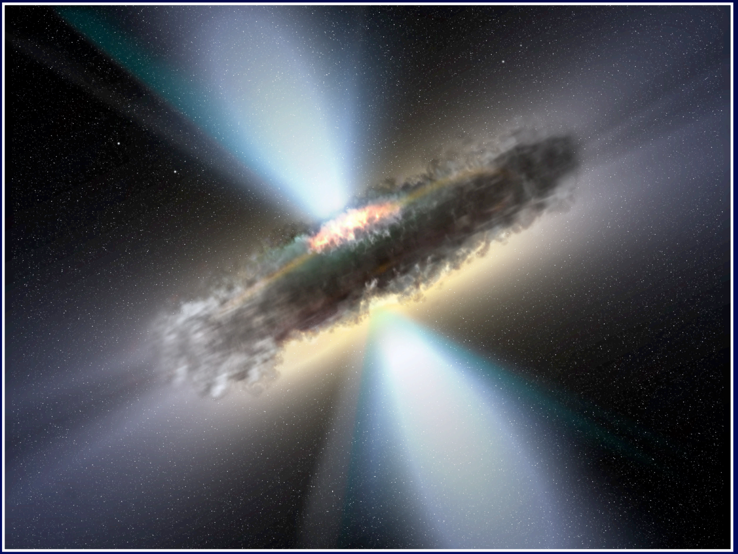
- Kinematics show ordered rotation but also high turbulent velocities

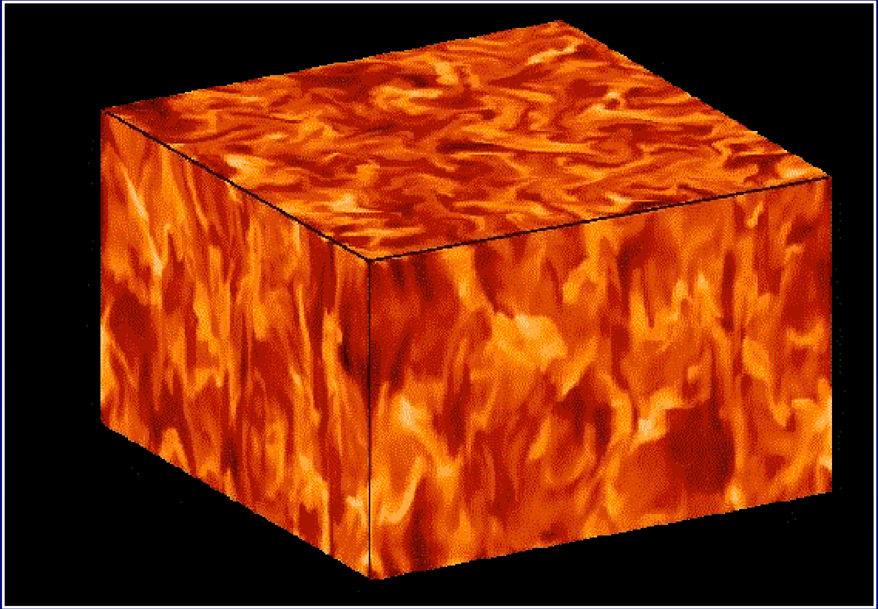
→ Physics of geometrically thick, turbulent, star forming gas tori

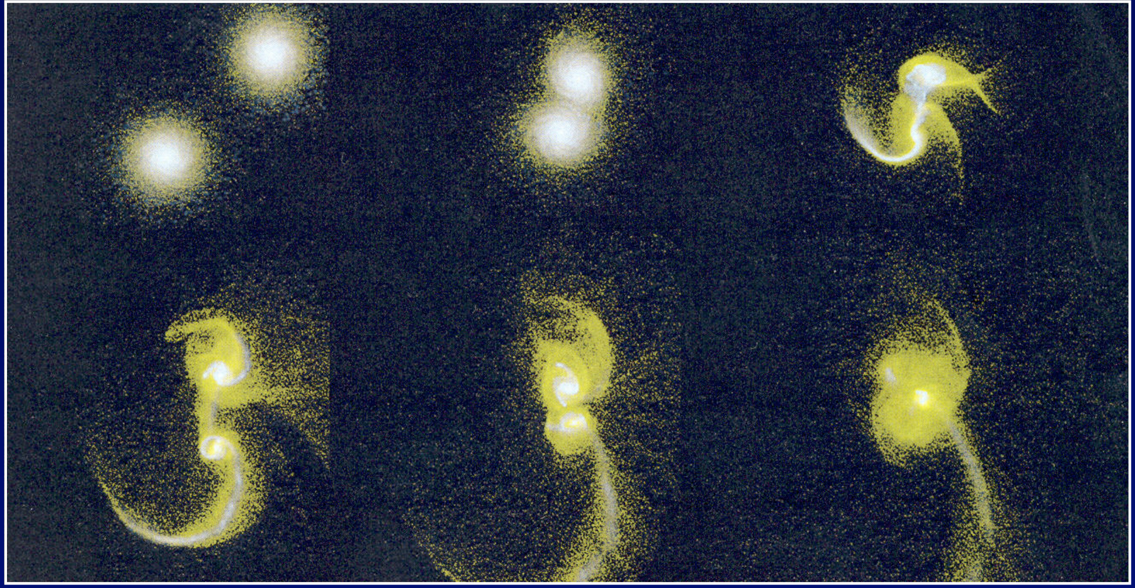


The Physics of Turbulent, Star Formation Gas Tori

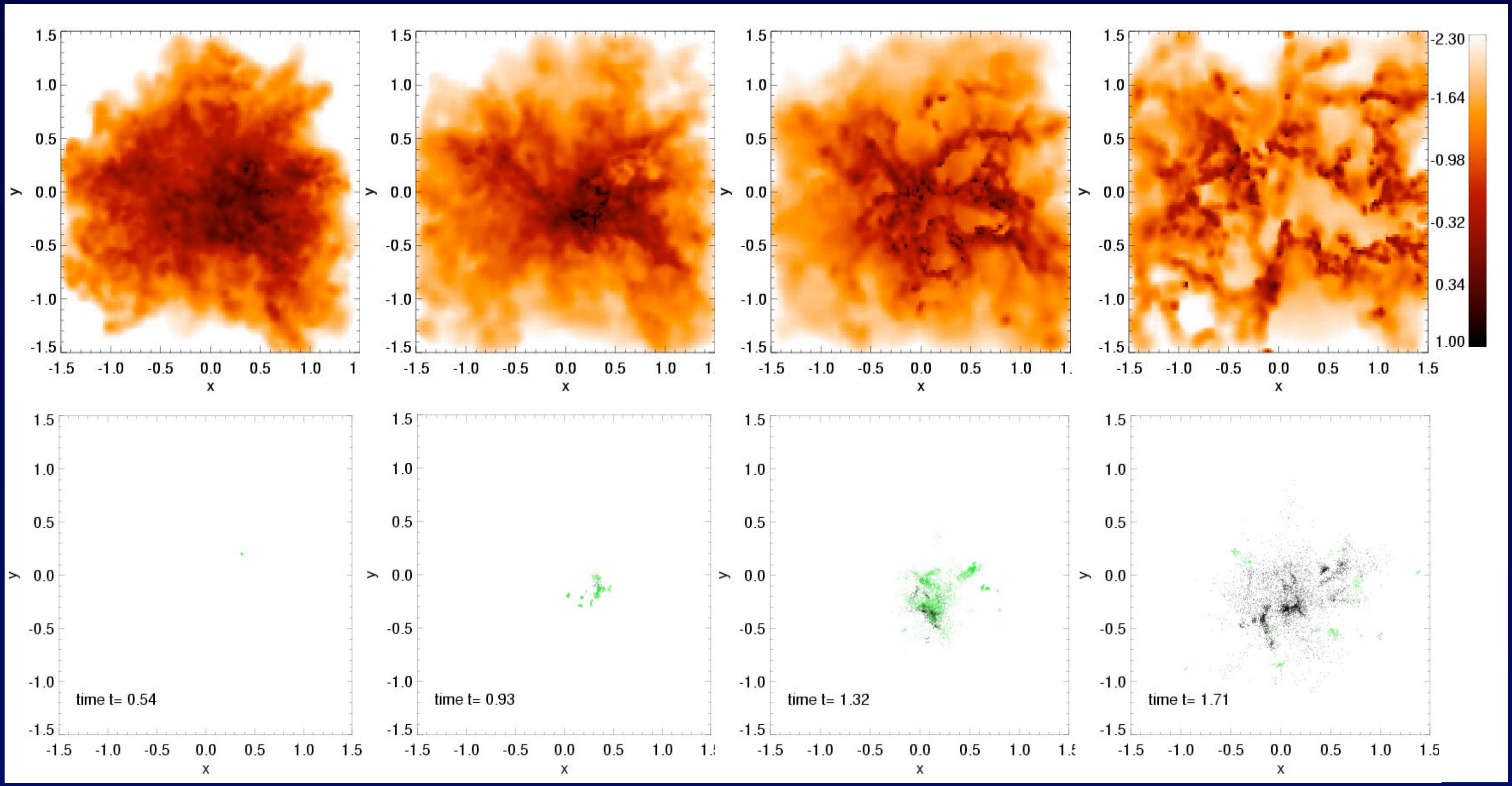
- What is the origin of gas tori?
- What is the driver of turbulence?
- How does turbulence affect the density distribution and geometry?







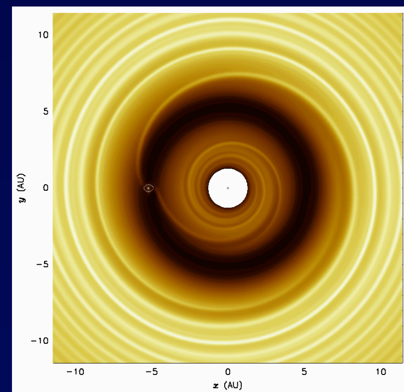
The Physics of Turbulent, Star Formation Gas Tori



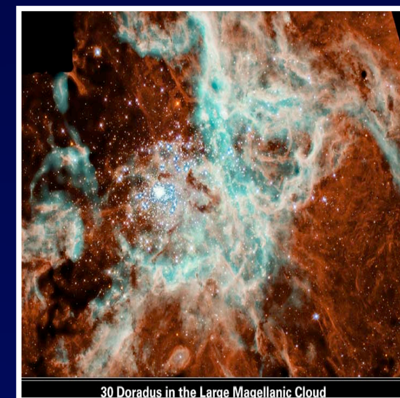
- When do gas tori become gravitational unstable?
- How does star formation (feedback) affect the physics of tori and the accretion onto central black holes?
- Does star formation in fast rotating tori lead to stellar rings as observed in the Milky Way and Andromeda?

Computational Astrophysics at USM (CAST)

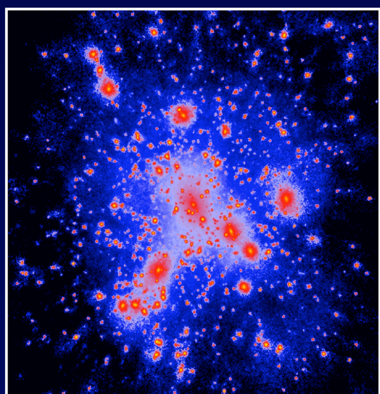
Planet



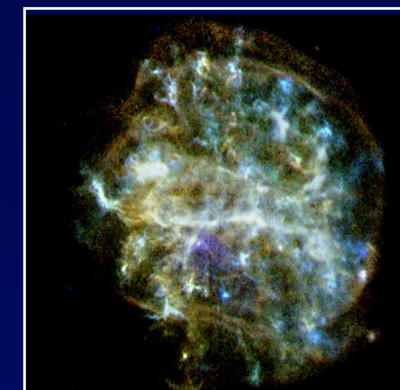
Star



Dark



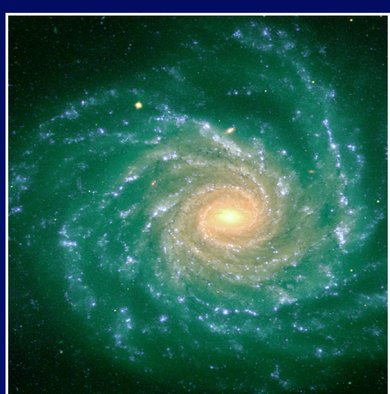
Nucleosynthesi



Formation of Galaxies

Formation of Stars and Planets

Spiral



Interstellar Medium

Galaxy Interaction

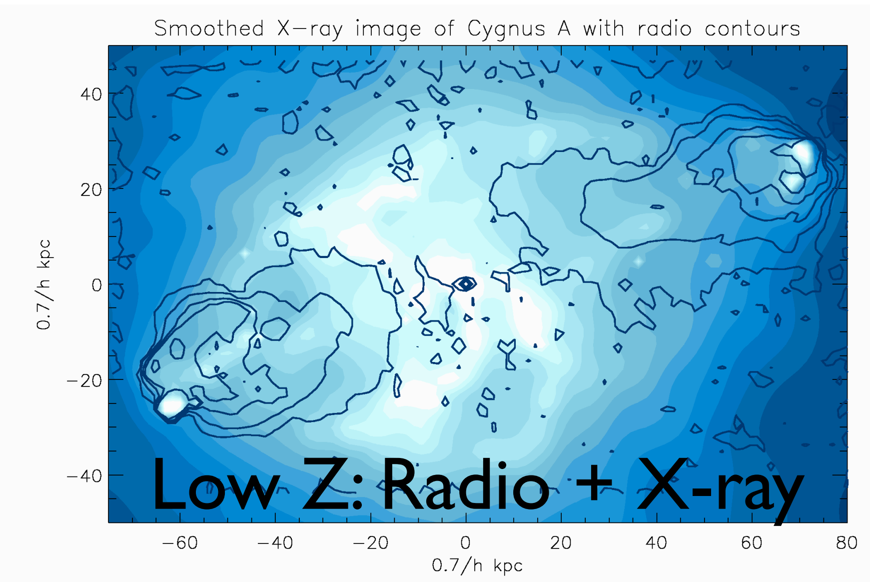
Elliptical

Radiation turbulence and active nuclei

Martin Krause

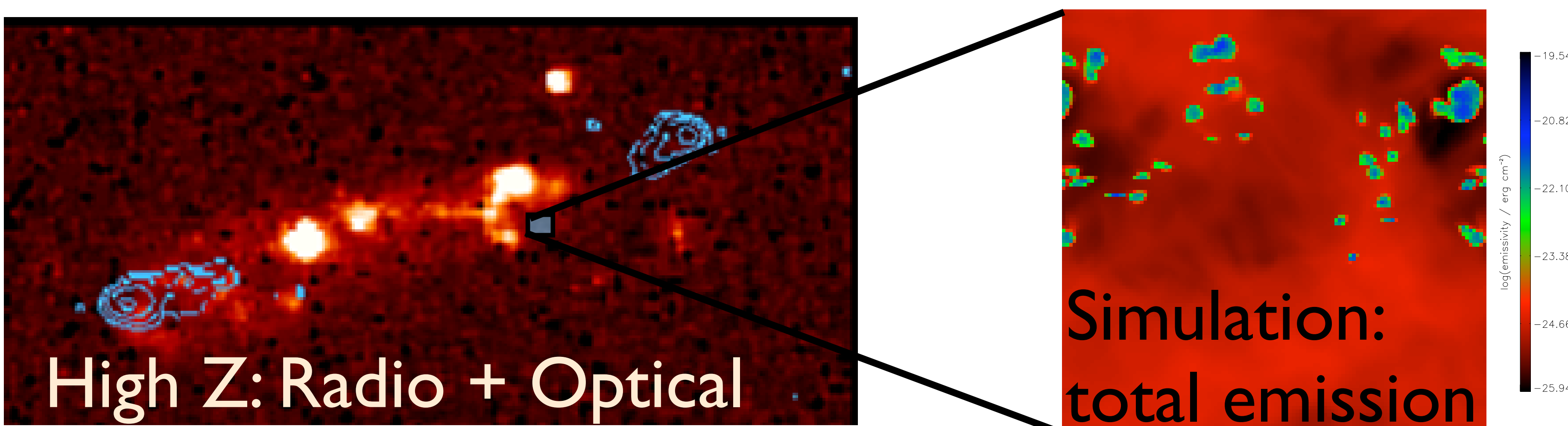
PhiGN startup workshop

Previous work:
multiphase turbulence for radio jet cocoons



- **3D hydrodynamics simulations**
- **Including opt. thin cooling**
- **Explains:**
  - **Presence of cool gas**
  - **Line kinematics**
  - **Radio - EL correlation**
- **Transferable to other MPT situations**

-> active nuclei



How to transfer this to active galactic nuclei?

New observations:

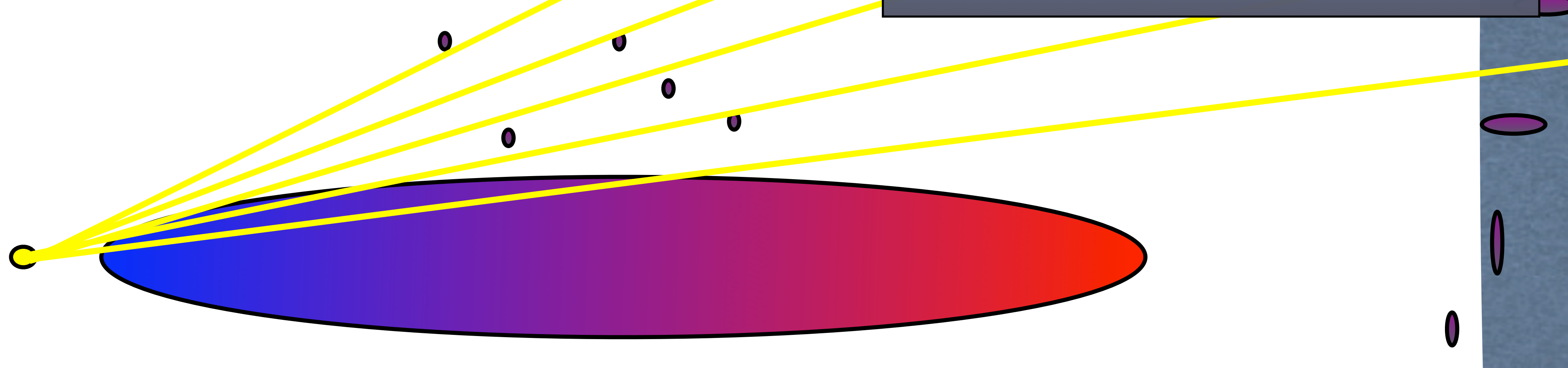
<u>X-rays</u>: L ~ Type I frac
Low/High Z modes

<u>Infrared</u>: Torus T & ρ distribution
only ~30% reradiated,
rest ?

Recent molecular torus modelling:

<u>Krolik et al.</u>: Radiation pressure from disk

<u>Quataert et al.</u>: Radiation pressure, new stars

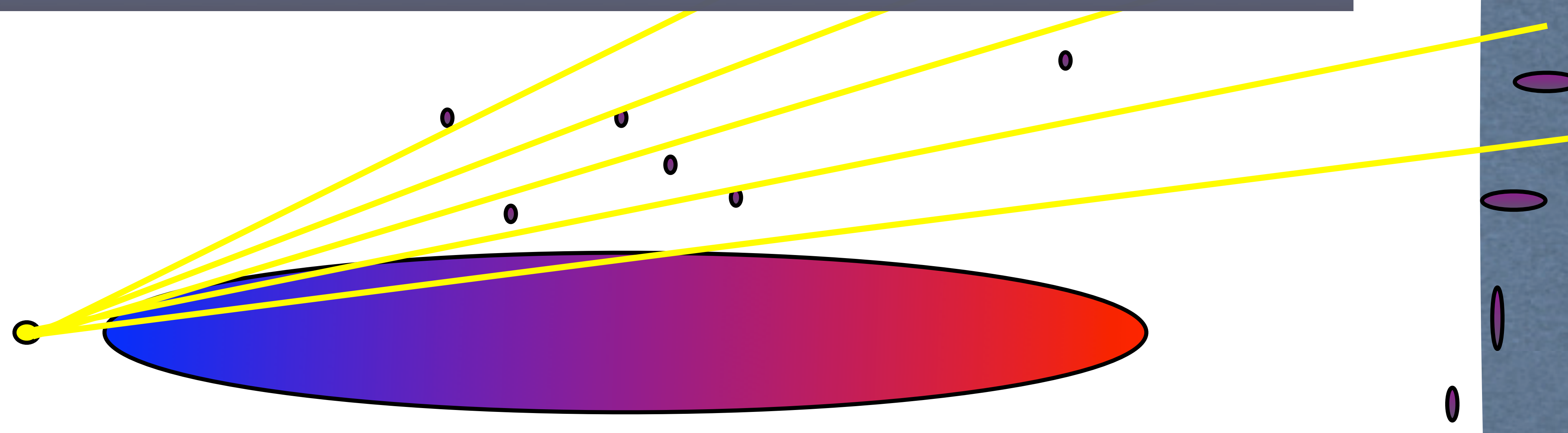


How to transfer this to active galactic nuclei?

Our aim: understand energy transport & dynamics of molecular tori & BLRs, coupling to host galaxy, role in galaxy evolution

Method: 3D hydrodynamics simulations with radiative transfer, first disk dominated

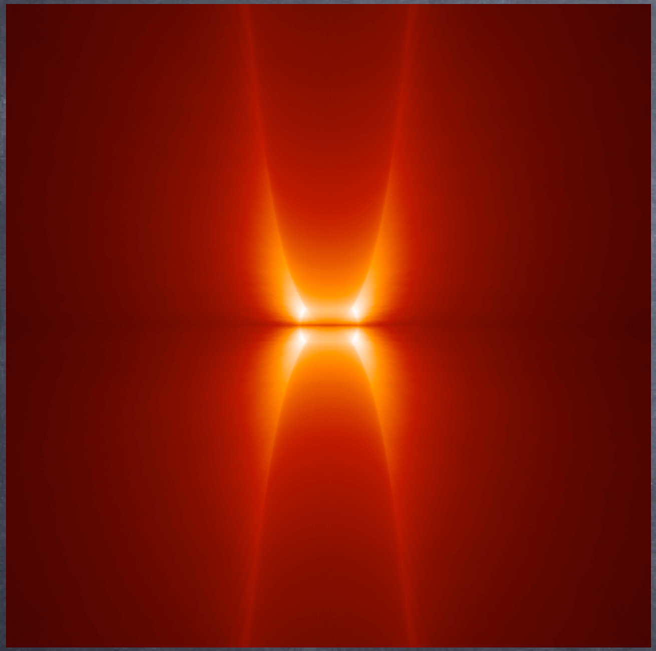
-> 1D rad. transfer



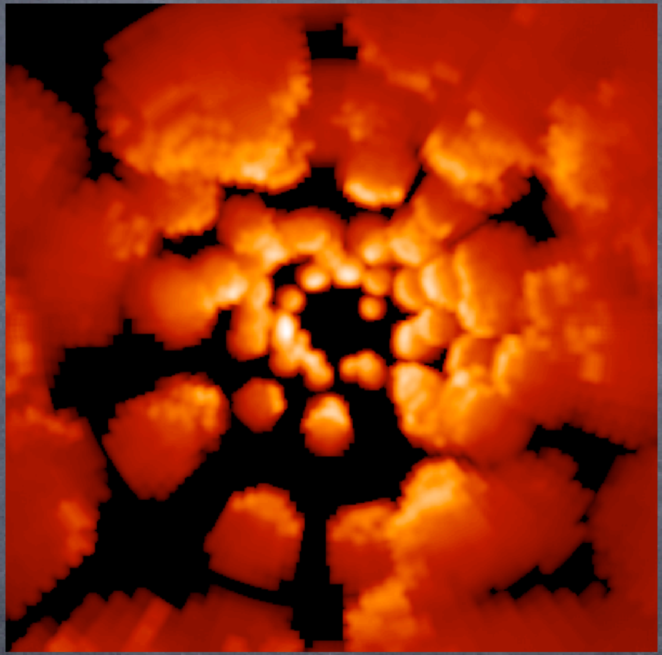
Large-scale torus modelling, turbulence and data comparison

Marc Schartmann

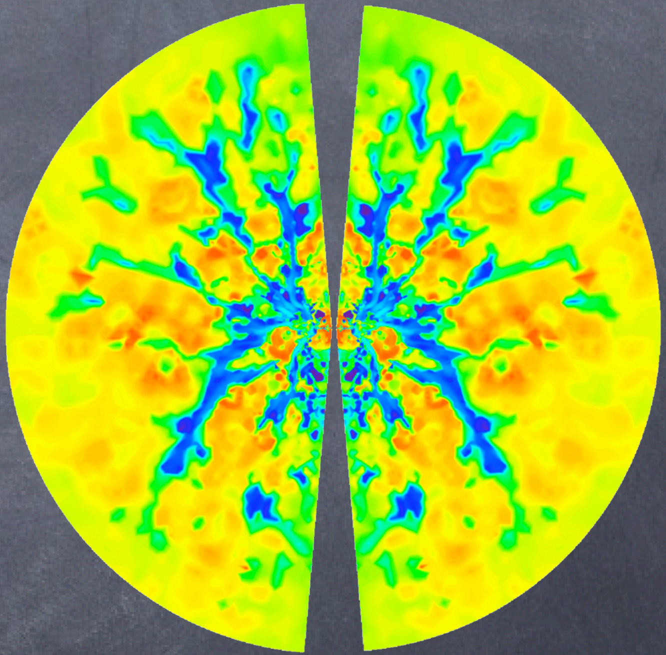
PhD @ MPIA: Meisenheimer, Camenzind, Klahr, Wolf, Henning, Tristram



Radiative transfer & high res. SED comparison: continuous tori



Radiative transfer & MIDI visibility / NACO comparison: clumpy tori

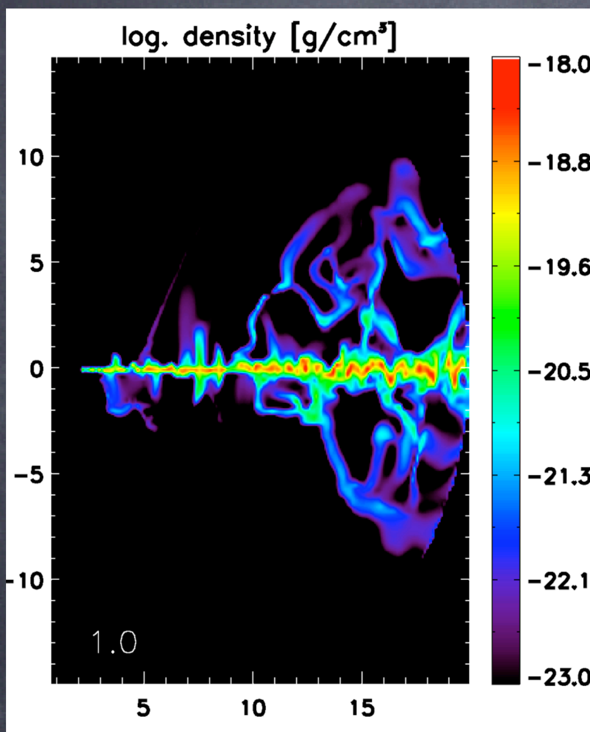


Hydrodynamics & Radiative transfer & Spitzer comparison

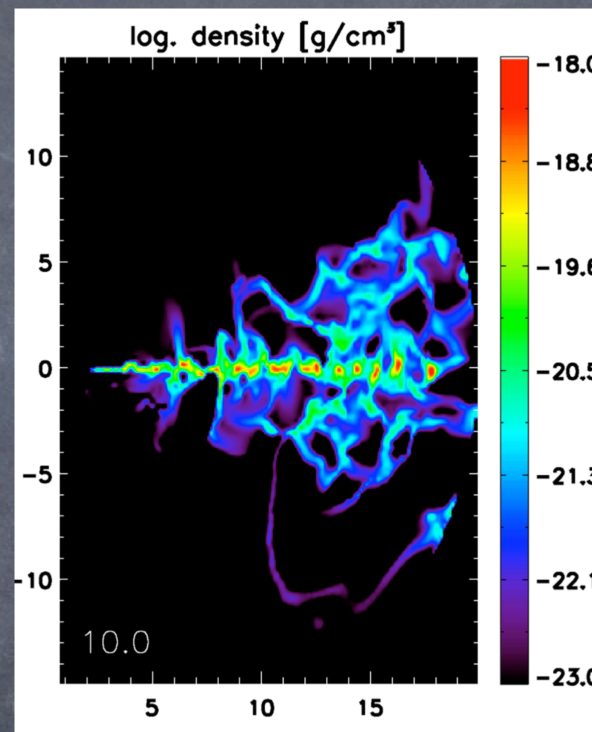
⇒ more about this: Area F seminar January, 23rd

Project A: turbulence in AGN tori on global scales

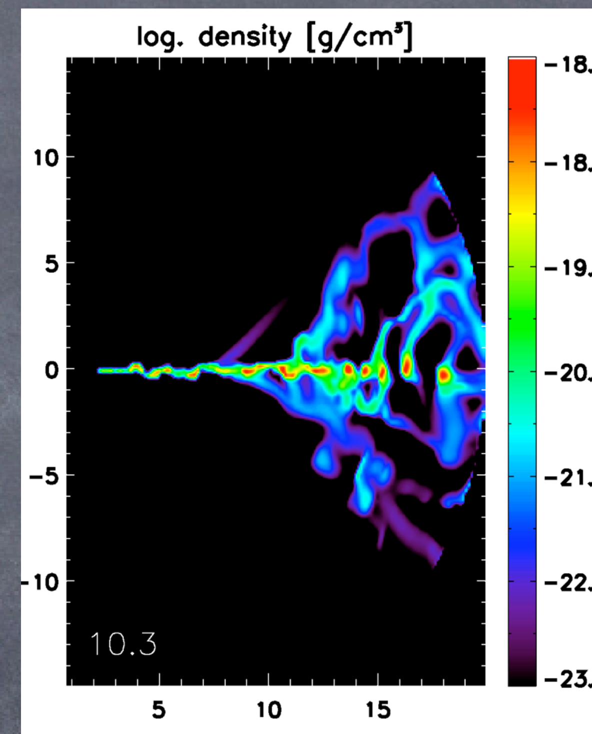
- perpetual stirring or single events to keep turbulence/scale height? ⇒ study decay time scales



drive turbulence with discrete energy injection



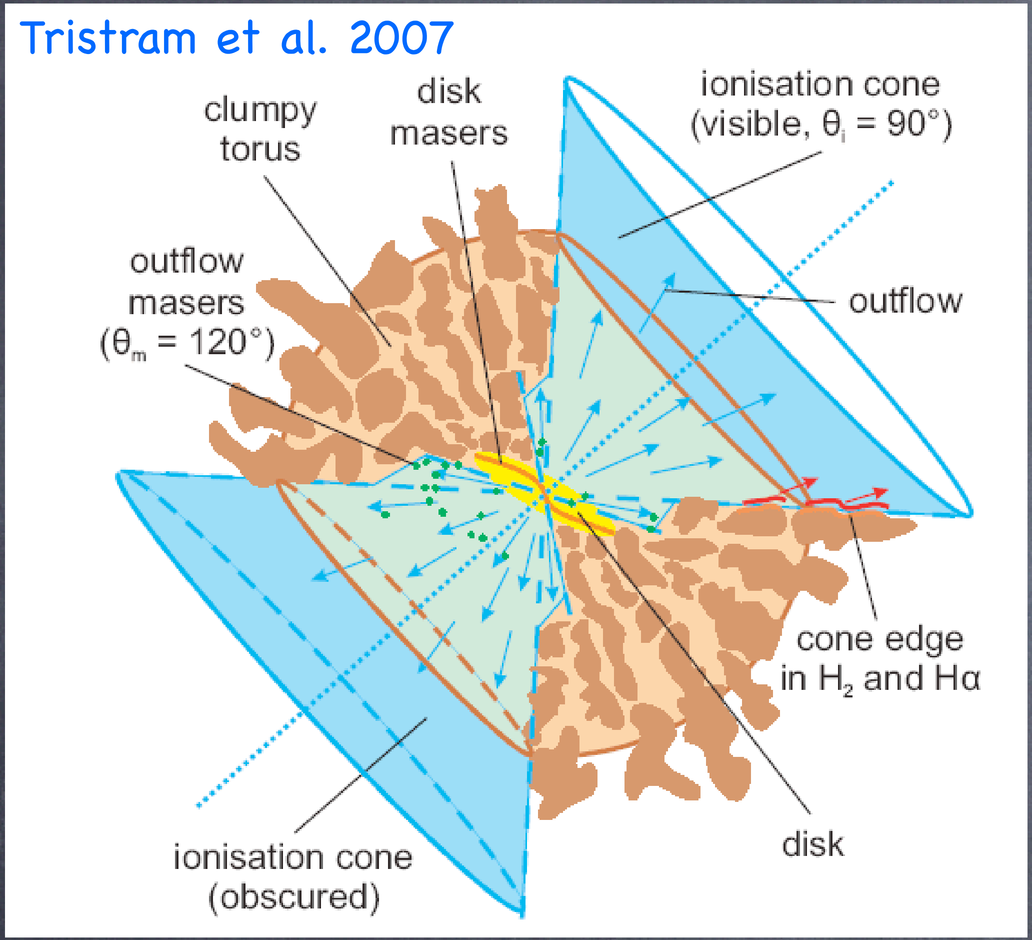
shut-off stirring mechanism



study time scale of decay

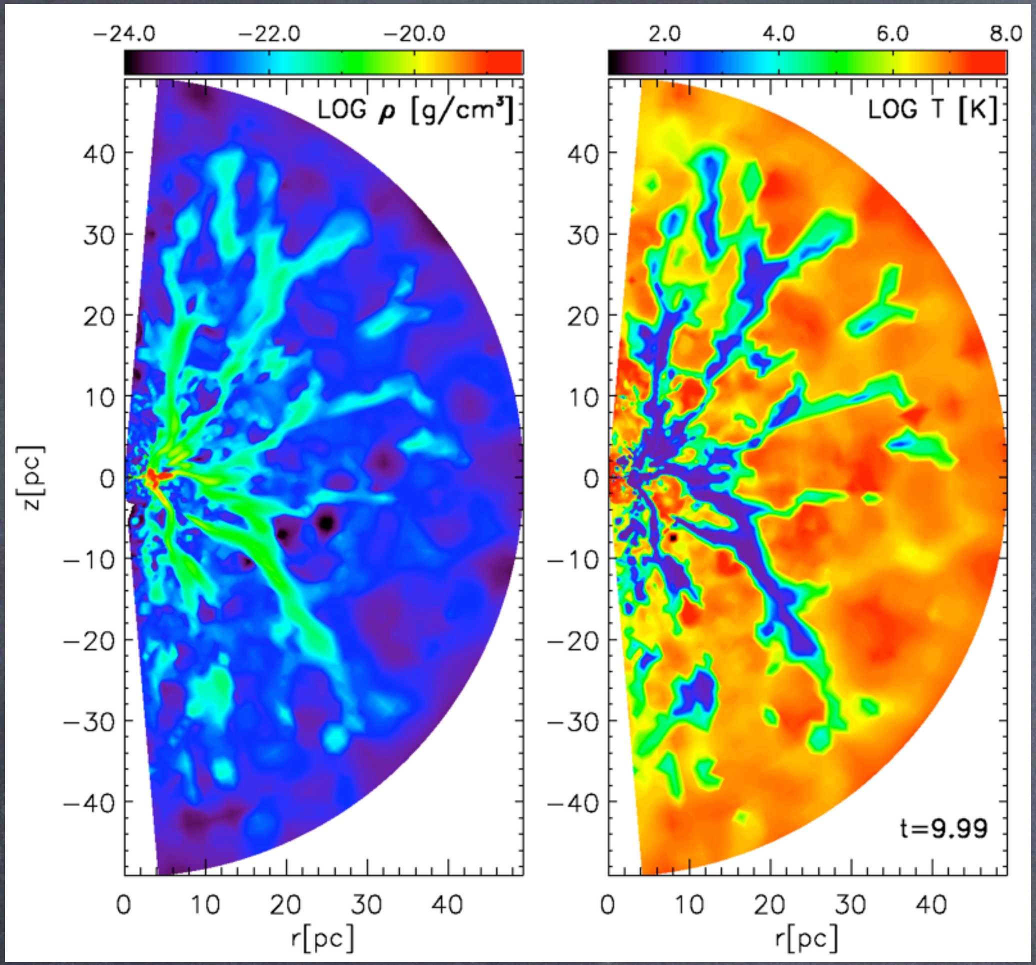
- next question: stirring mechanism?

Project B: global torus models & data comparison



- ⋆ wealth of data: SINFONI (IR-group), x-ray column densities (x-ray group), MIDI data (MPIA, MPIfR, Leiden, Markus Wittkowski's talk)

Project B: global torus models & data comparison



- wealth of data: SINFONI (IR-group), x-ray column densities (x-ray group), MIDI data (MPIA, MPIfR, Leiden, Markus Wittkowski's talk)
- evolution of young nuclear cluster (Ric Davies talk)
- successively ameliorate: rad. transfer, magnetic fields, ...
- compile „current best model" for data comparison

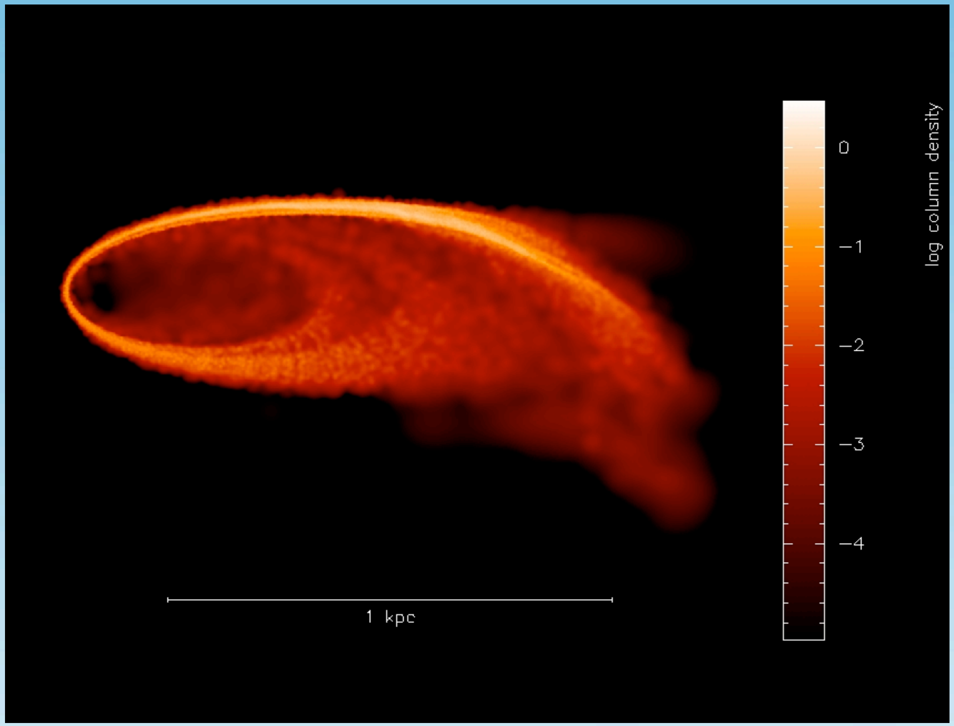
Star formation in the galactic center

Christian Alig
PhiGN startup workshop

Star formation in the galactic center

Current work:

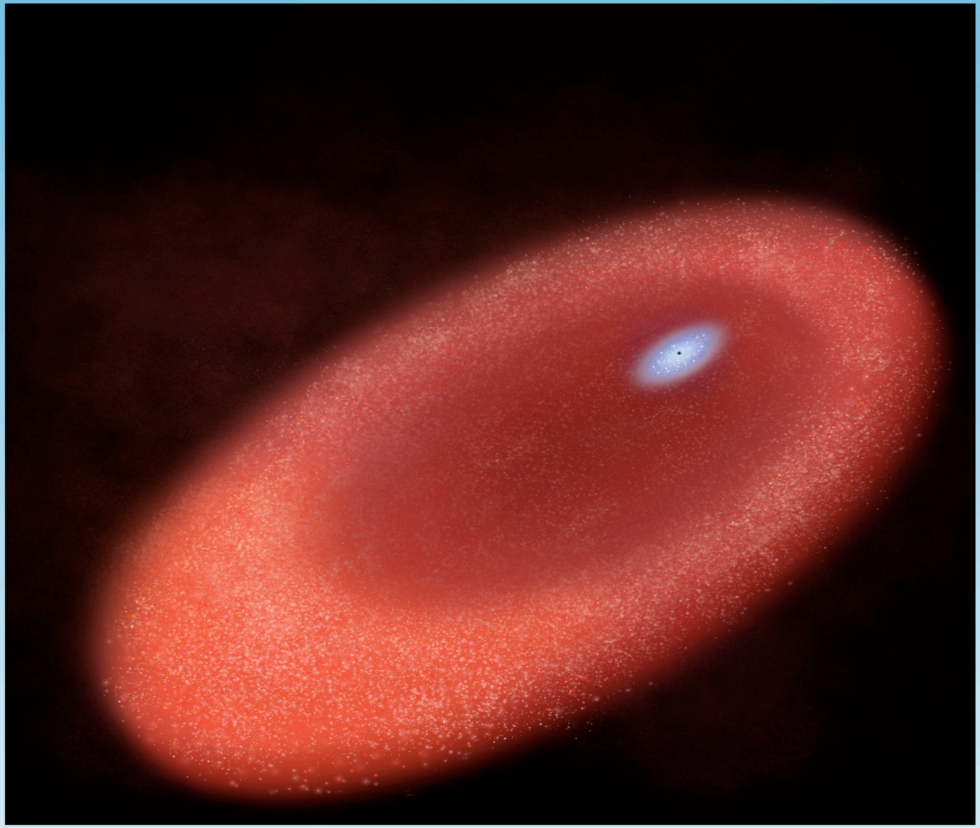
- Capturing, disruption and disk-phase of a molecular cloud by a SMBH.
- Accretion disk fragmentation.
- Excentric accretion disks.
- Multiple cloud infall.
- Cloud infall onto an accretion disk.



Star formation in the galactic center

Future goals:

- Comparison with the stellar disks in our GC (Genzel).
- Star-disk interaction and resulting orbital evolution.
- Comparison with the stellar disks in the Andromeda galaxy (Bender).

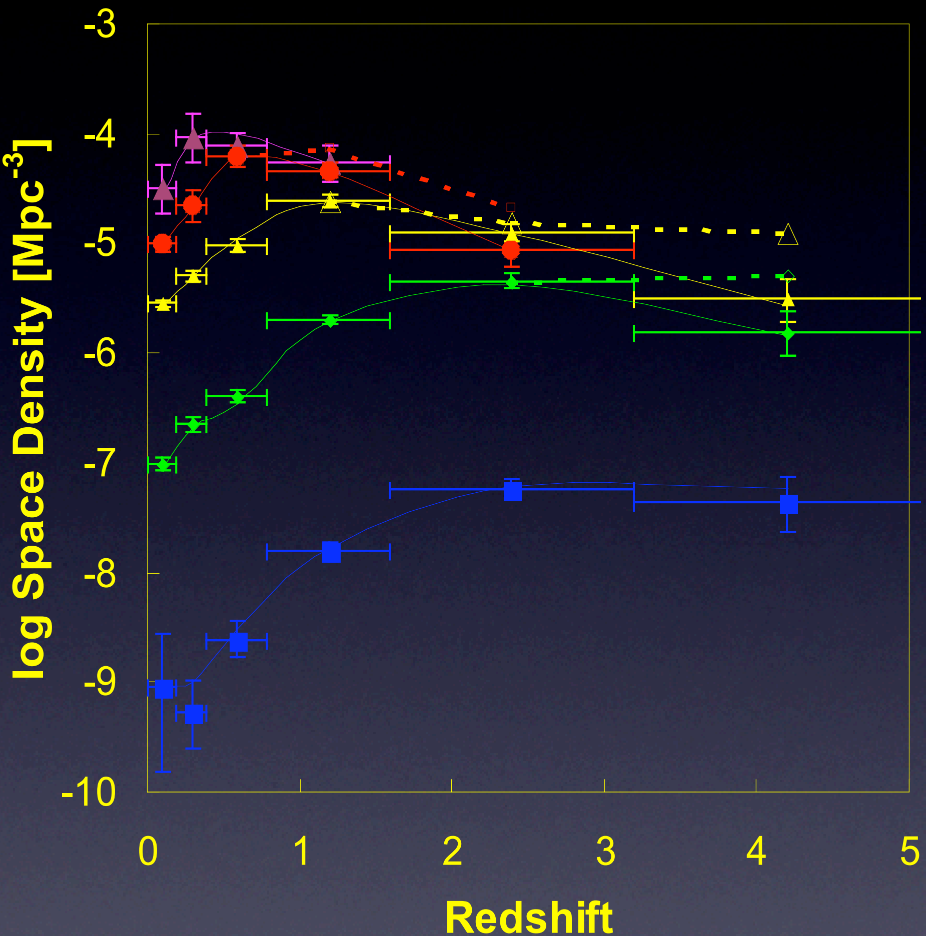


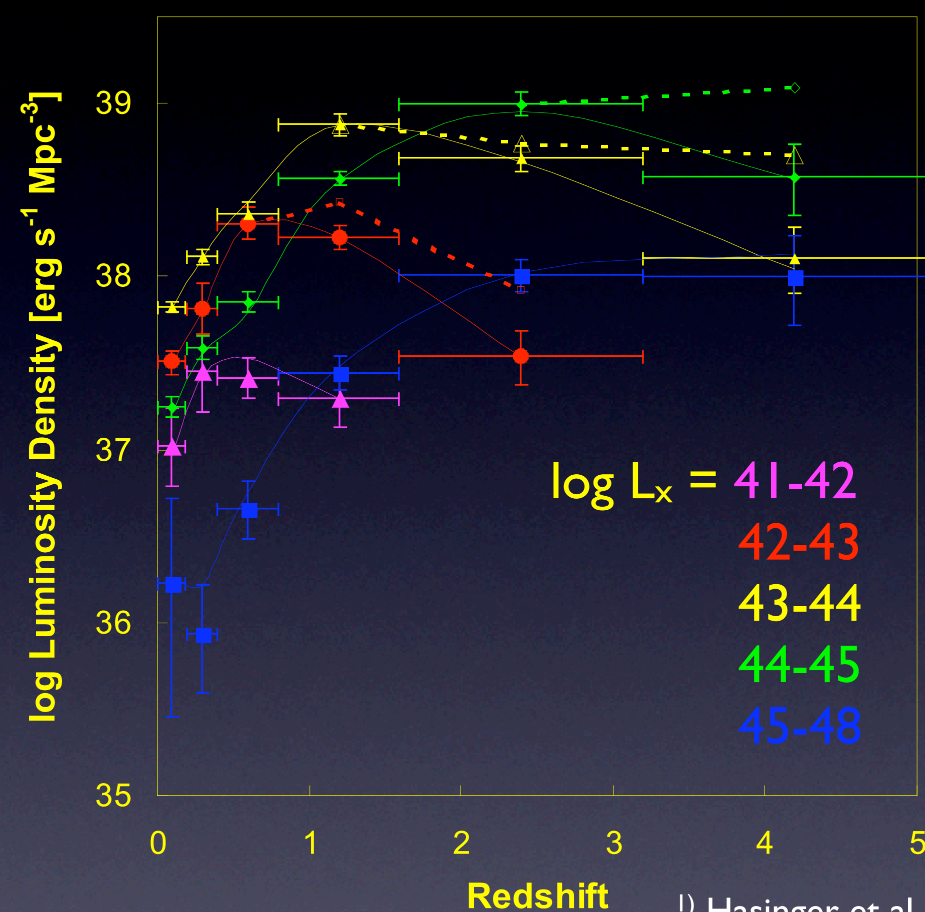
Anti-hierarchical growth of black holes

Michaela Hirschmann

14.12.2007, ΦGN-Workshop

Results from X-ray deep fields (Chandra, ROSAT, XMM-Newton[1]): Space and luminosity densities of type-1 AGNs as function of redshift





[1]) Hasinger et al., 2005

→ Luminosity density is dominated by Quasars at z = 2-3

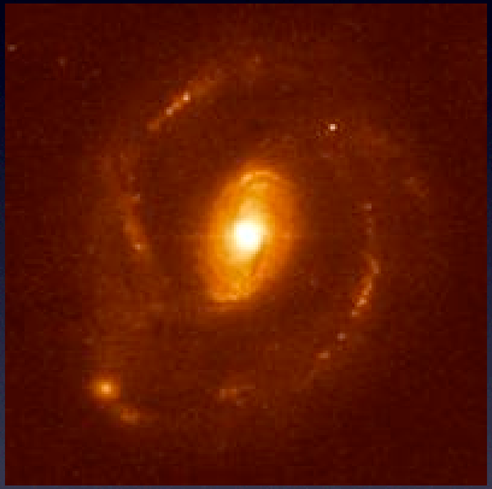
→ Background is dominated by intermediate AGN at z ~ 1

→ Space and luminosity densities of lower luminosity AGNs peak at significantly lower redshift than that one of higher luminosity ones

These observations imply an anti-hierarchical BH-growth:

Quasars with massive black holes grow early in cosmic history

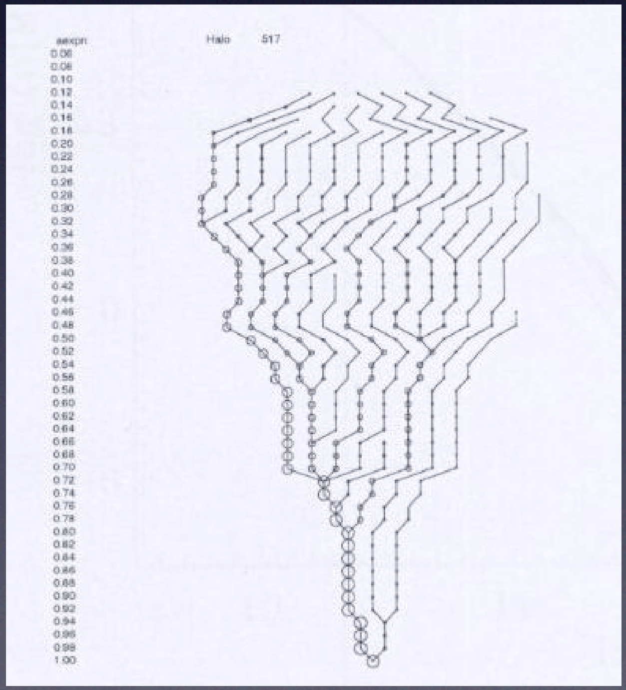
Seyfert galaxies with less massive black holes evolve much slower

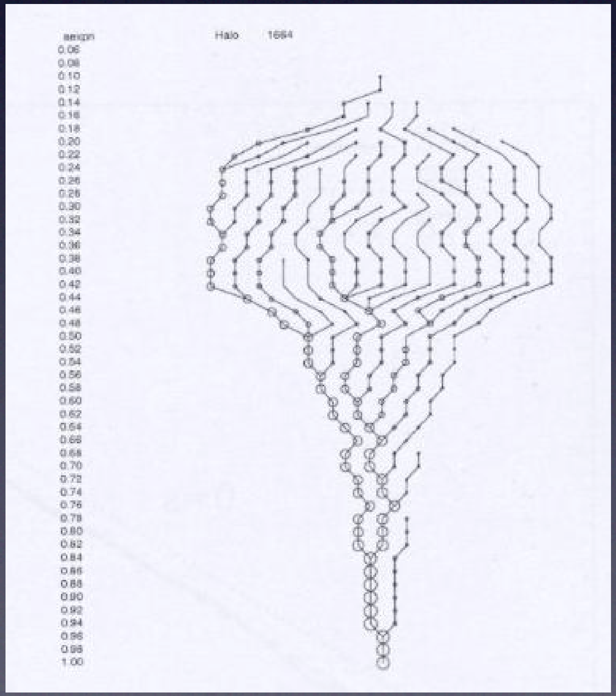


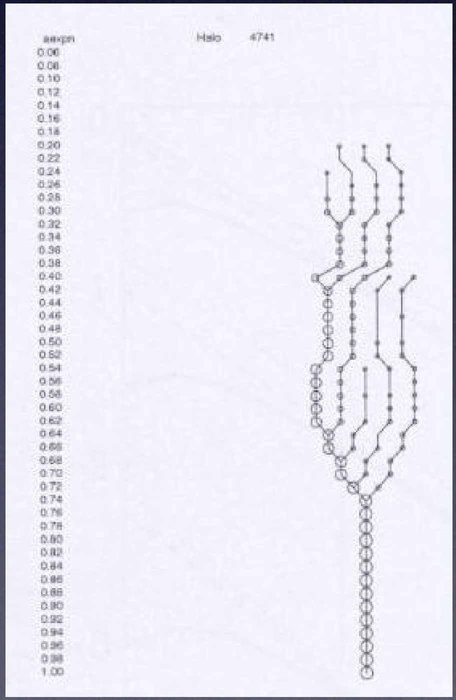
But within the context of a hierarchical evolution model:
Less massive objects form first, whereas more massive ones form only much later in the universe

→ Extended model for galaxy evolution and BH growth is needed!

- → Dark matter only simulations (done by CAST group): 512^3 particles in a comoving periodic cube of side L = 100 Mpc with the GADGET2-code (Springel et al., 2005)
- → Using the halo finder FOF and SUBFIND for identifying the dark matter halos in different redshift steps
- → Constructing merger histories with a program of Ch. Maulbetsch (Maulbetsch et al., 2007)







Based on these merger trees we assumed a simple model for getting the black hole growth rates:

1. Calculation of the aggregation rates of dark matter halos (includes both: Mass gain through accretion and merger)
2. In the framework of the cosmological model we can derive the aggregation rates for baryonic matter (85% dark matter and 15% baryonic matter)
3. Assumption that 50% of baryonic matter is used for star formation → Star formation rate (Madau-Plot)

Based on these merger trees we assumed a simple model for getting the black hole growth rates:

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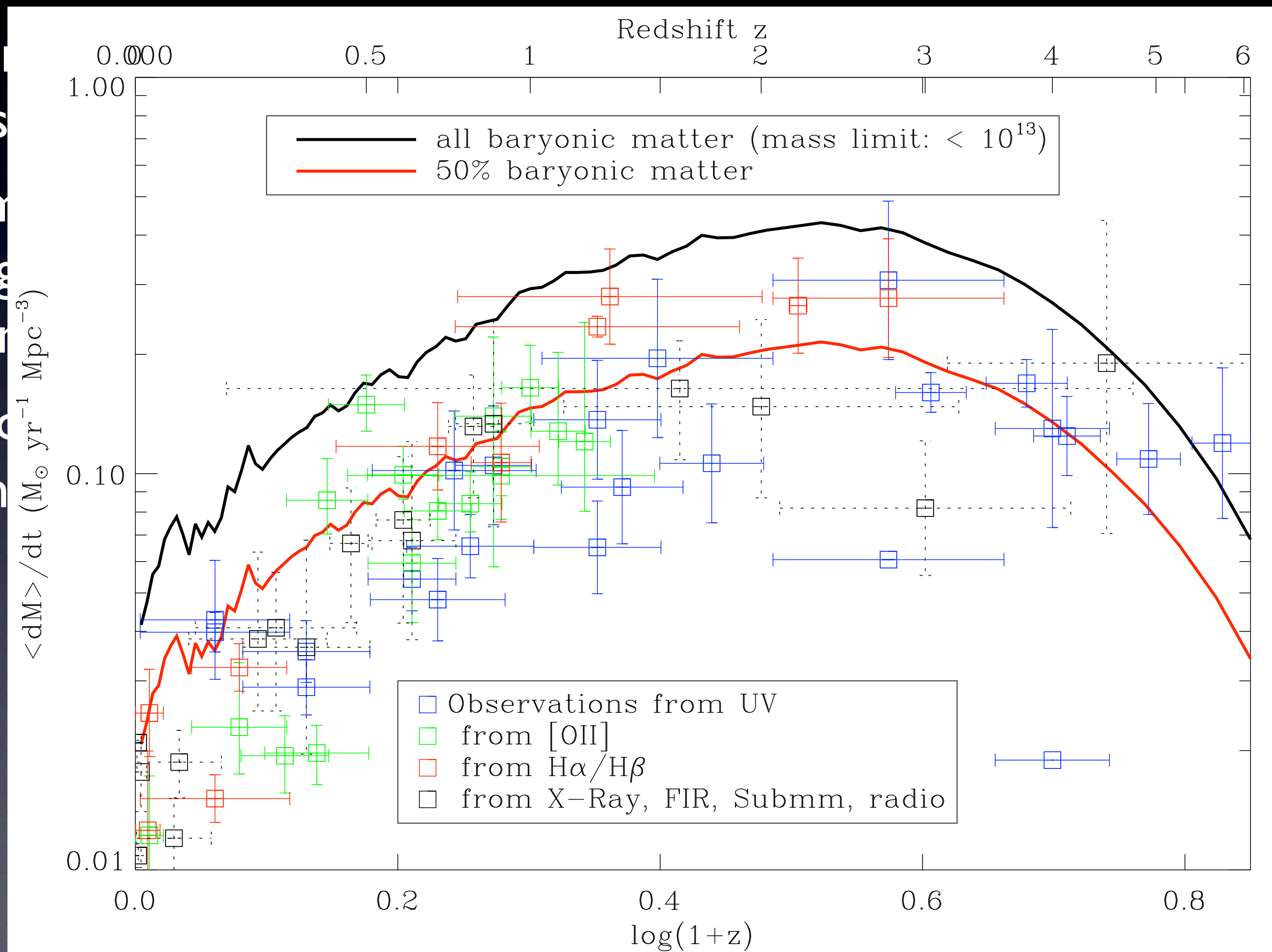

5%

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3. Assumption that 50% of baryonic matter is used for star formation → Star formation rate (Madau-Plot)
4. With the relation $M_\bullet = 0.0013\ M_{bulge}$ (Häring et al., 2004) we can estimate the black hole growth rate

Based on these merger trees we assumed a simple model for getting the black hole growth rates:

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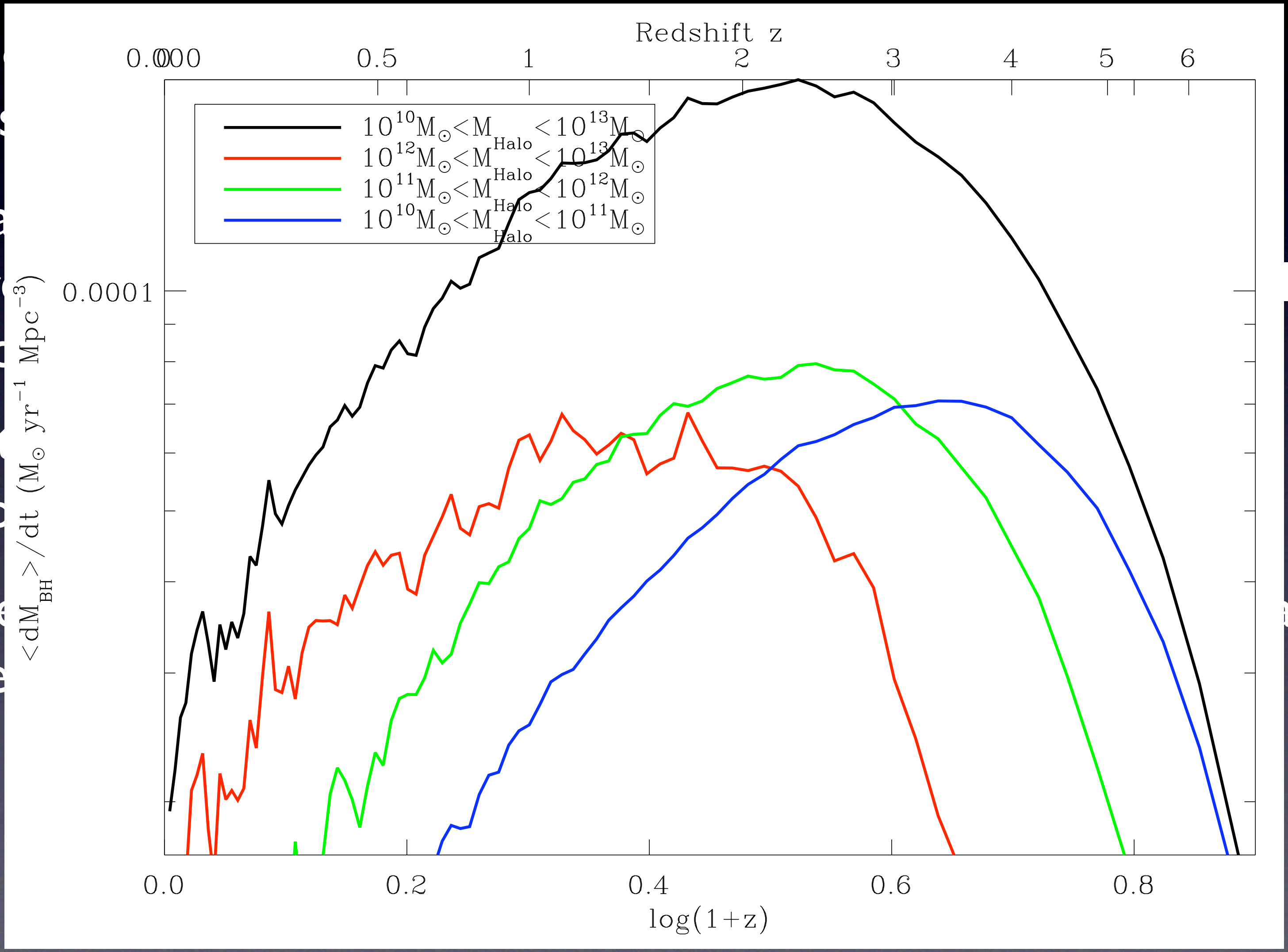

What we want to do in future:

- Get the bolometric luminosity with help of the relation $L_{bol} = \epsilon_r/(1-\epsilon_r) \cdot dM_\bullet/dt \cdot c^2$ → Comparison to measured luminosity functions and densities
- Further refinements of this simple model
- Consideration of the ‚microphysics' of AGNs, what will be investigated by other members of our group