

Sgr A* and Its Activity

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- **Sgr A***
 - 1 Overview: Mass and SED
 - 2 Time Variability
 - Plasma Expansion Model
 - Jet Model
 - 3 Structural Details near Sgr A*
 - The mini-cavity
 - Blobs
 - Continuous Linear Feature (1pc)
 - Jet Outflow?
 - 4 Large Scale Streamers (15pc)
 - Starburst Driven Outflow?

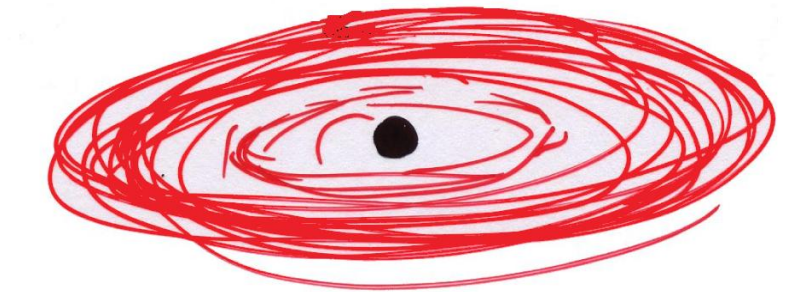
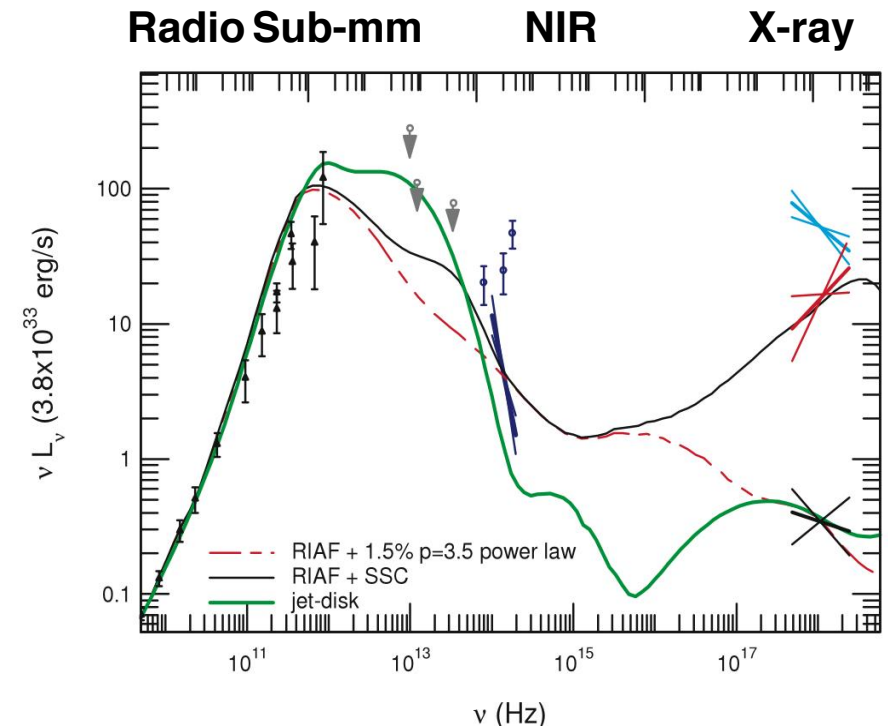
Spectral Energy Distribution

- Variable and Quiescent Components
- SED peaks in Submm
- Quiescent: Radio/ Submm (optically thick)
- Variable: IR/X-rays (optically thin)
- Underluminous:

$$\nu L_\nu \approx 100 L_\odot$$

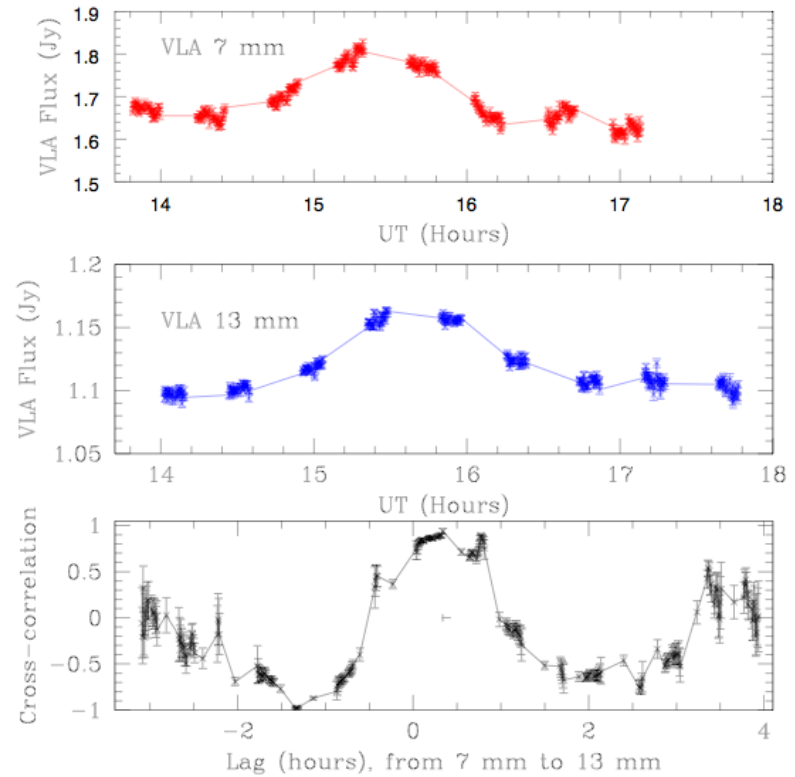
$$L_{\text{bol}} = \epsilon \dot{M} c^2 = 1.5 \times 10^7 \frac{\epsilon}{0.1} \left(\frac{\dot{M}}{10^{-5} M_\odot \text{ yr}^{-1}} \right) L_\odot$$

- The Steady Component: Two classes of Models
 - Accretion flow
 - Jet outflows
- Degeneracy

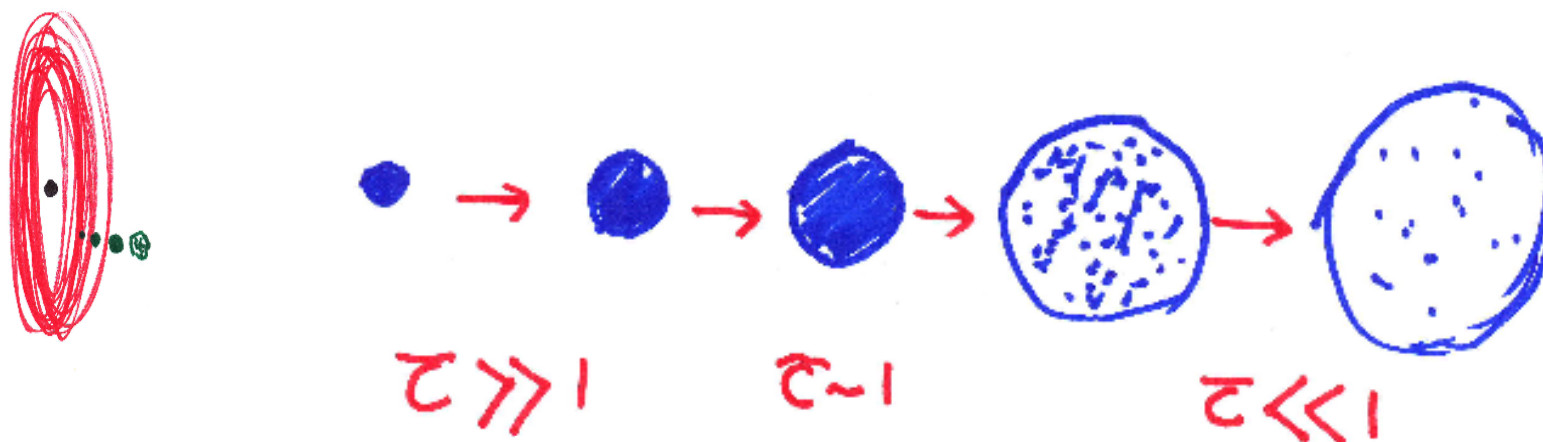


The Variable Component: Cross-Correlation

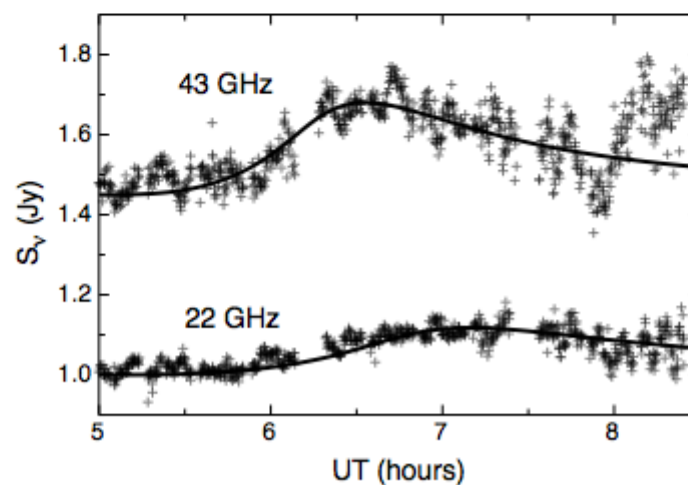
- Variability on Even Horizon length scale
- VLA Observations 43 and 22 GHz: Feb 2005, BnA array
- The cross correlation peaks:
 - 20-40 minute time delay led by 43GHz peak



Expanding Blob of Explain Synchrotron Light Curves



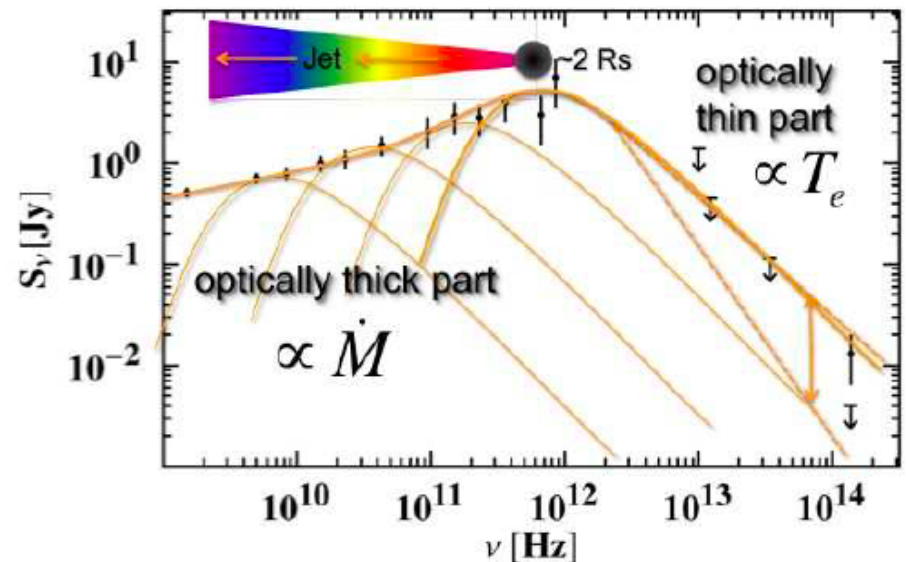
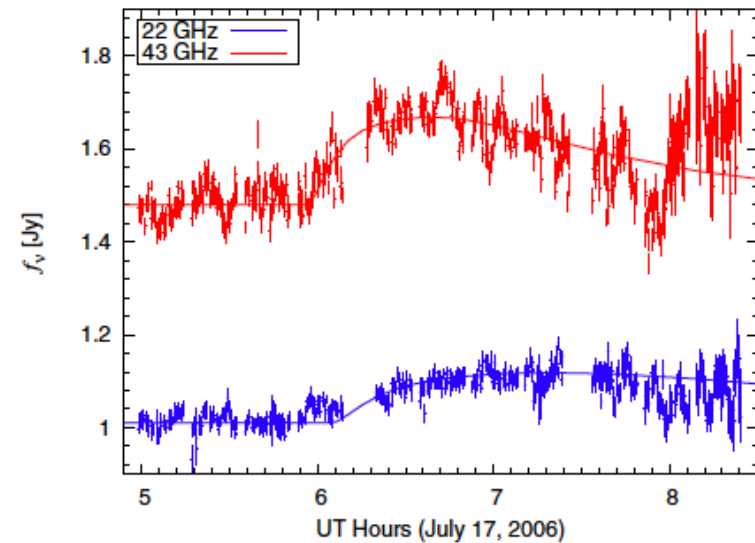
- Time delay is consistent with the expanding hot plasma model (Van der Laan 1964)
- Synchrotron optical depth
 $\tau \sim \nu^{-2.5}$
- Optically thick gas grows and then decays
- Particle spectrum E^{-3}
 corresponding to $\nu_c = 130$ GHz

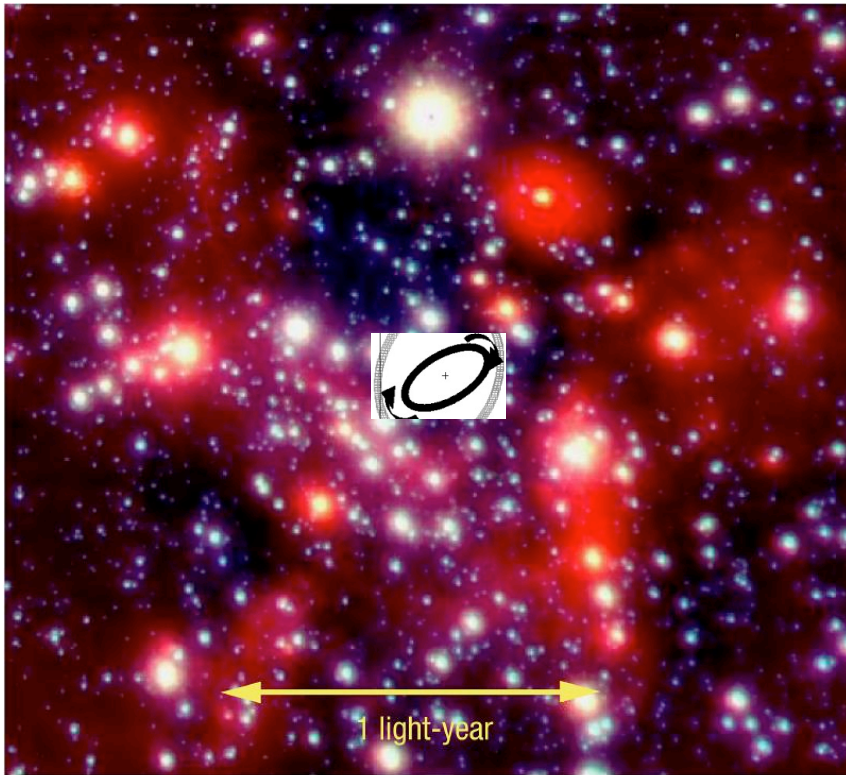


- $v/c = -0.15$
- $B = 11$ G
- Initial radius $= 2.2 R_s$
- $P = 1$

Jet Model Fitting of Light Curves

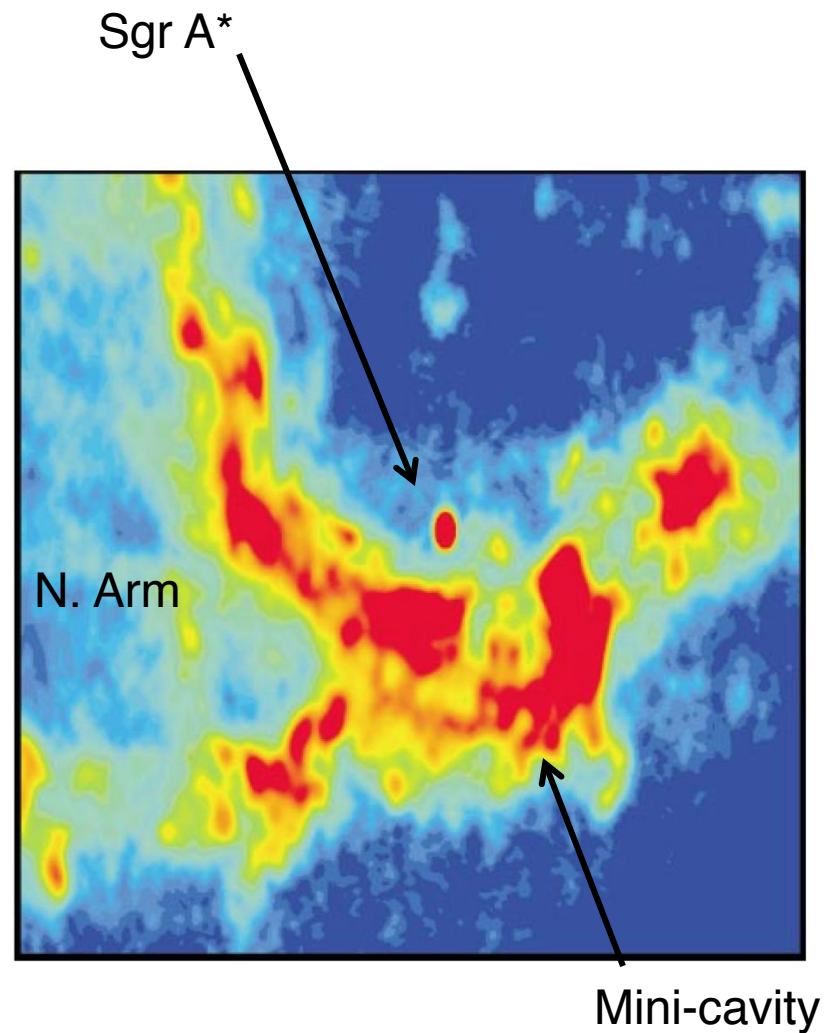
- Time Dependent Jet Model
(Maitra, Markoff and Falcke 2009)
- But. there is no evidence for a Jet on a VLBI scale
- Degeneracy again
- Is there a large scale Jet?



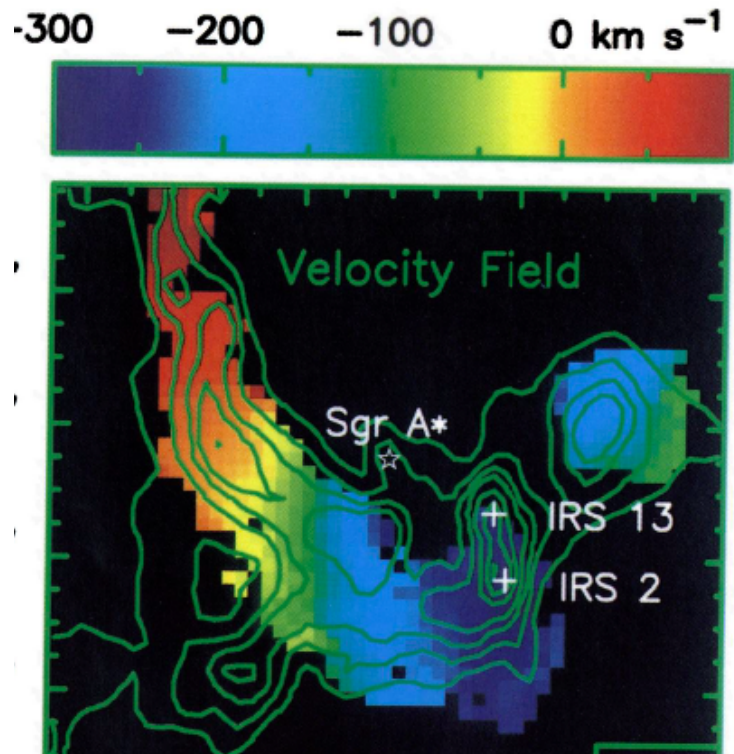


ESO PR Photo 23a/02 (9 October 2002)

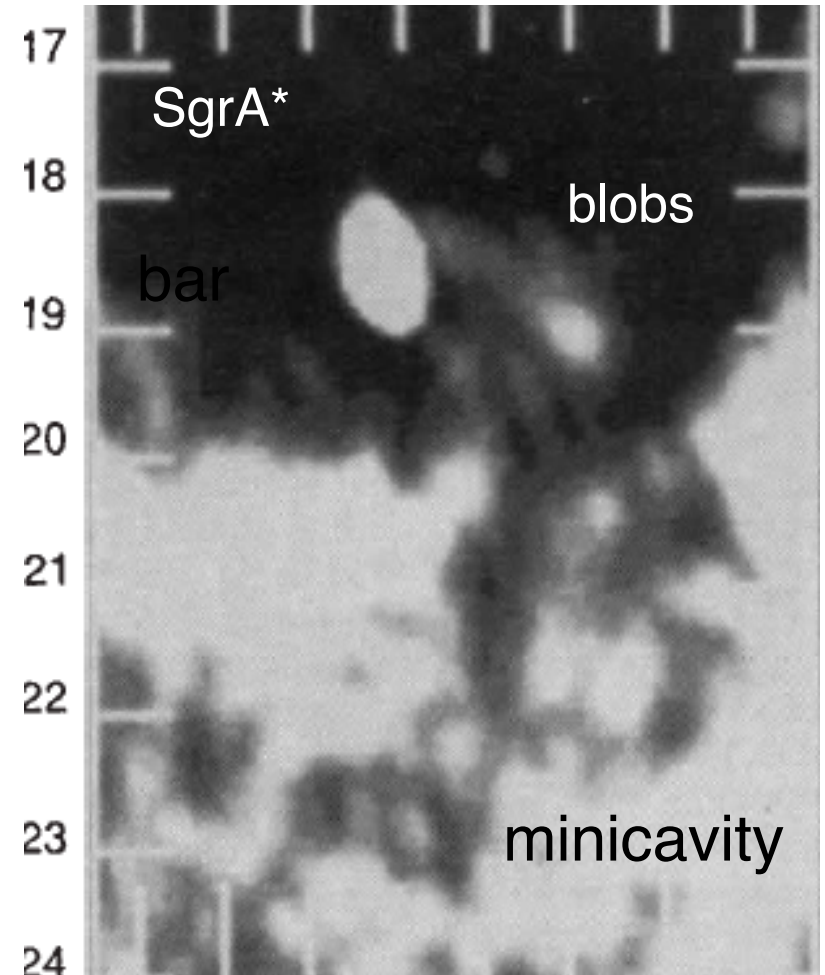
- Ionized mini-spiral structure (Sgr A West)
- A couple of light years across
- 2cm Continuum
- Young and evolved stellar clusters



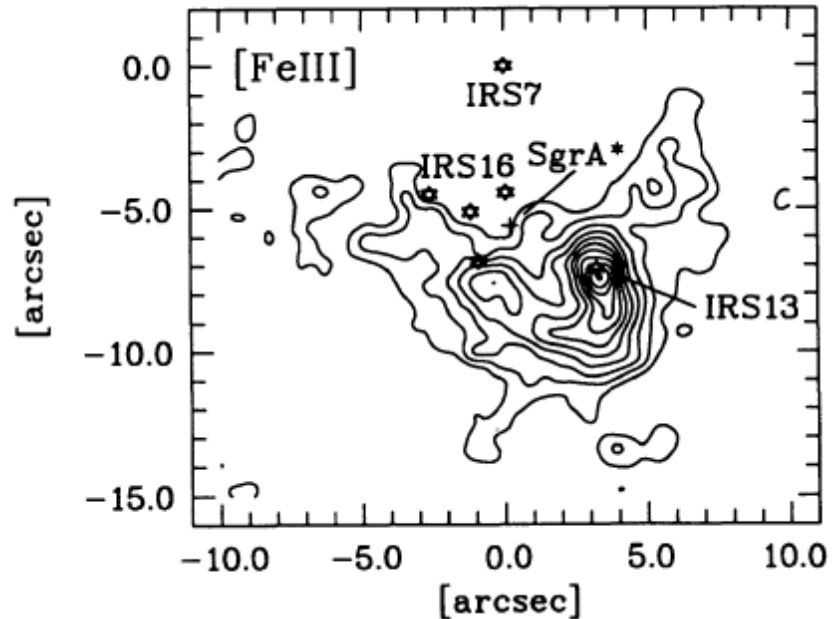
Min-cavity: Morphology & Kinematics



- Radio observations at 3.6cm
- Chain of blobs
- Cavity of $\sim 2''$ diameter
- Ridge of emission
- Kinematically disturbed
- Low L/C ratio

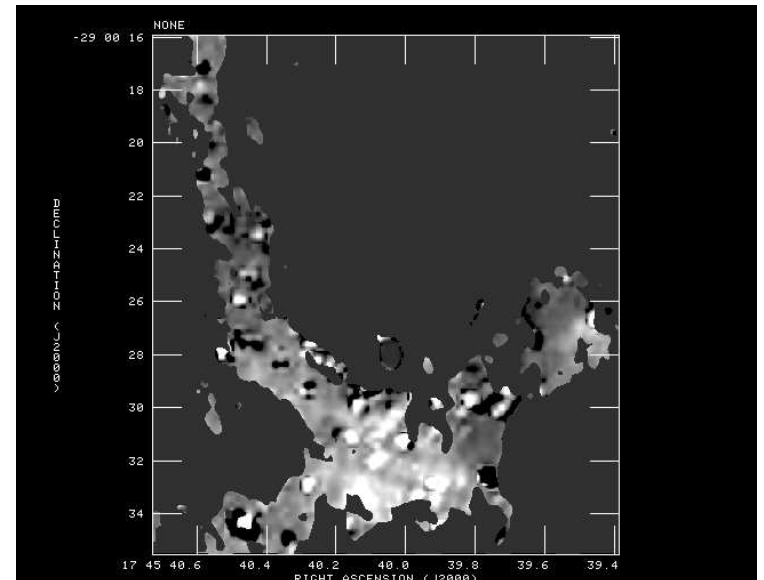
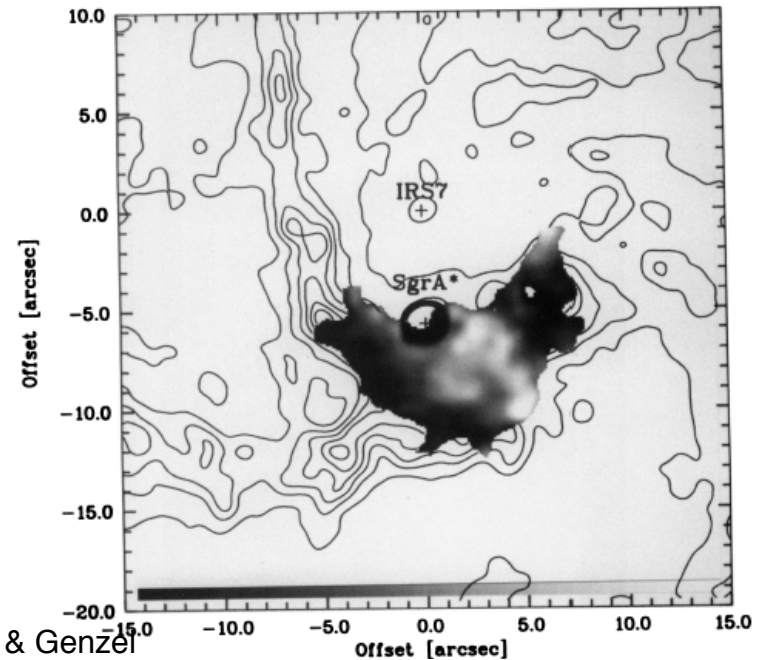


Mini-cavity: Shocked gas



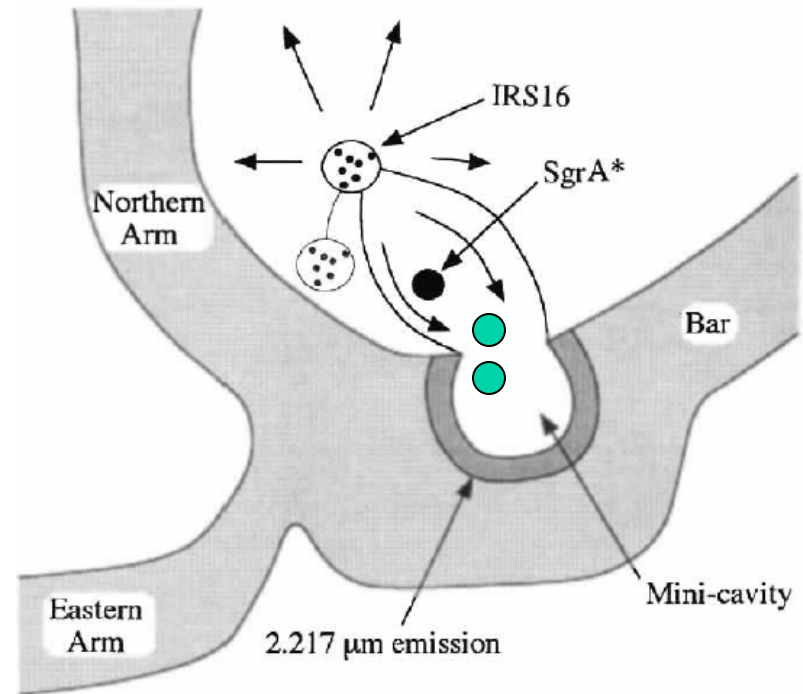
- FeII and FeIII emission from the mini-cavity
- Bow-shock structure
- High FeIII/ratio
- Shocks to enhance Fe abundance
- Photoionized by UV photons

Lutz, Krabbe & Genzel
1993



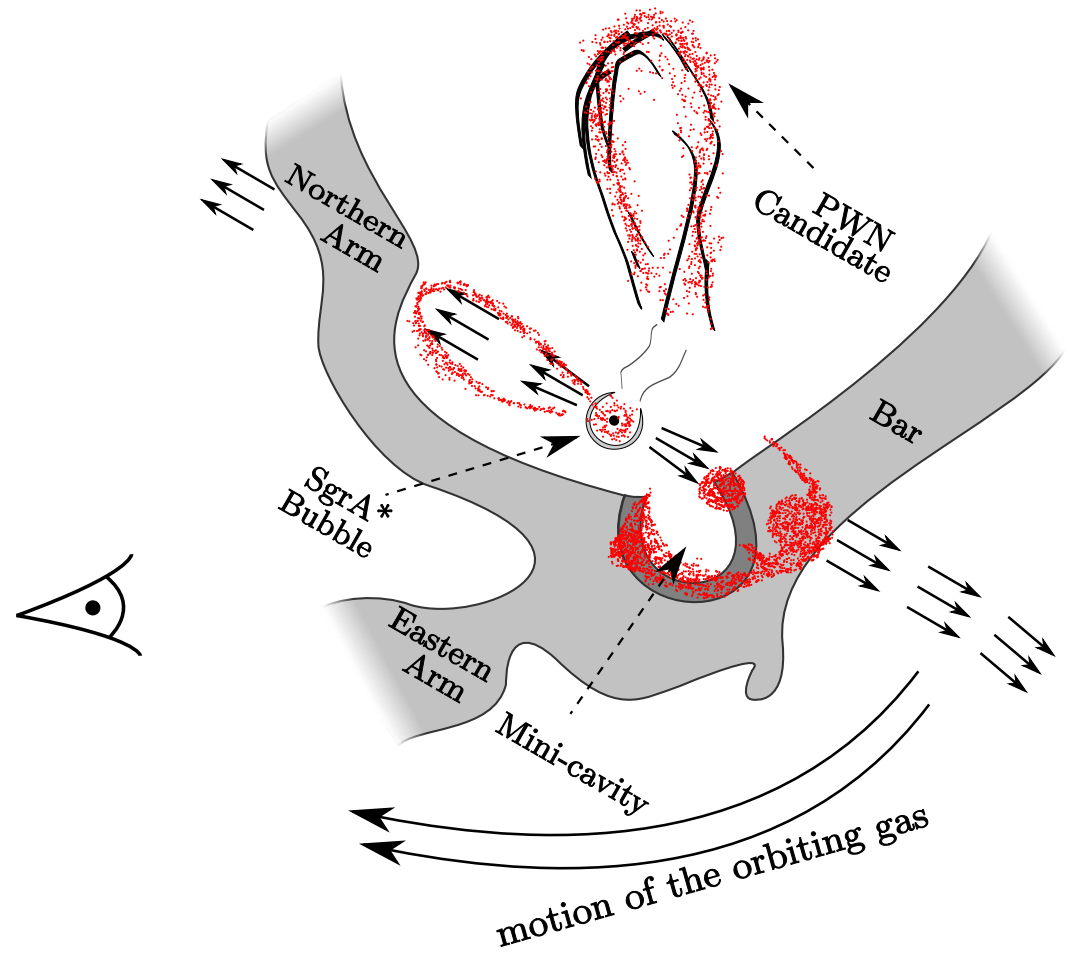
Mini-cavity and Blobs: Origin and Formation

- Morphology
 - Expanding bubble
- Kinematically disturbed
 - Expanding bubble
- Thermal
 - High L/C ratio in RRL
 - High Fe abundance
 - Low 12micron/2cm
 - X-rays
 - High FeII/2cm
- Focused Winds vs, Jet outflow from Sgr A*?



Relativistic or Sub-relativistic Jet Outflow?

- Highly collimated Jet
- Has to be fast not be bent by tidal effects
- Dynamically young (~ 100 years)
- Enough ram pressure to punch through 10^4cm^{-3}
- $L_{\text{kinetic}} \sim 10^{38} \text{ erg/s}$
- $L_{\text{mini-cavity}} \sim 10^{34} \text{ erg/s}$



Radio

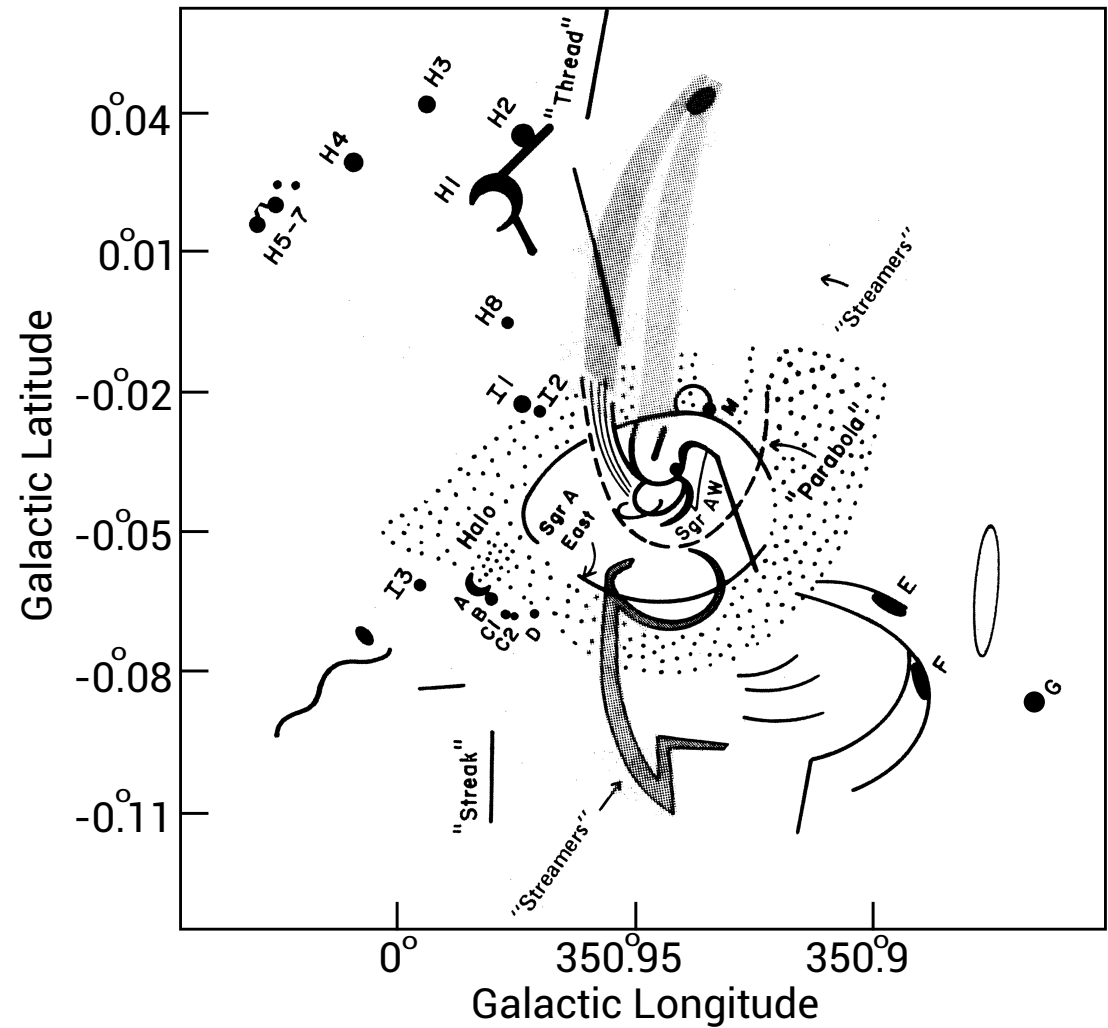


X-ray



II. NGC 4258: Mega Maser Disk

- Application: Engulfing Cloud
- Keplerian dominated regime
- $M_{\text{disk}} < 1\text{-}15\% M_{\text{bh}}$
- Thin disk: $h/r < 2\%$ (NGC 4258)



- **Conclusions**

- 1. Preliminary Measurements: Outflow from Sgr A***

- ☐ Accretion disk
 - ☐ Orientation of clockwise stellar disk
 - ☐ Interaction with the mini-cavity
 - ☐ Support the jet mode

- 2. Streamers: Thermal X-rays and Nonthermal radio Emission**

- ☐ Mixture: Hot, warm and cold phases
 - ☐ Collimation by the 2pc molecular ring