Variable Infrared and Radio Emission from the Galactic Black Hole

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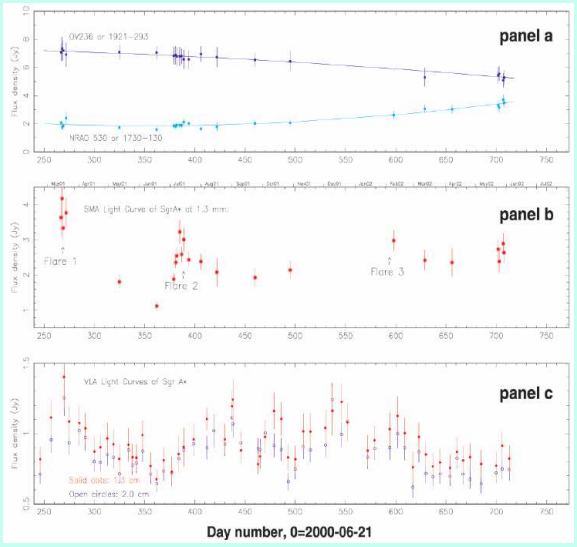
It is well established that SgrA* varies in the radio on time scales from ~days to hundreds of days (Brown & Low 1982; Zhao et al. 1989; Zhao & Goss 1993; Zhao, Bower & Goss 2001).

Long wavelengths --> interstellar scintillation contributes

Short wavelengths to 1mm --> intrinsic variations: “flares” at the rate of about 3 per year …

Zhao et al. 2003 -->



Zhao & Bower have lately argued for a 130-day periodicity, and maybe a longer cycle with a period about 2.5 times longer.

SgrA* variability at 100 & 140 GHz

Miyazaki, Tsutsumi, & Tsuboi 2004

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

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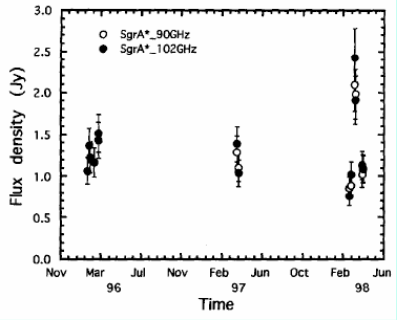
are needed to see this picture.

2000

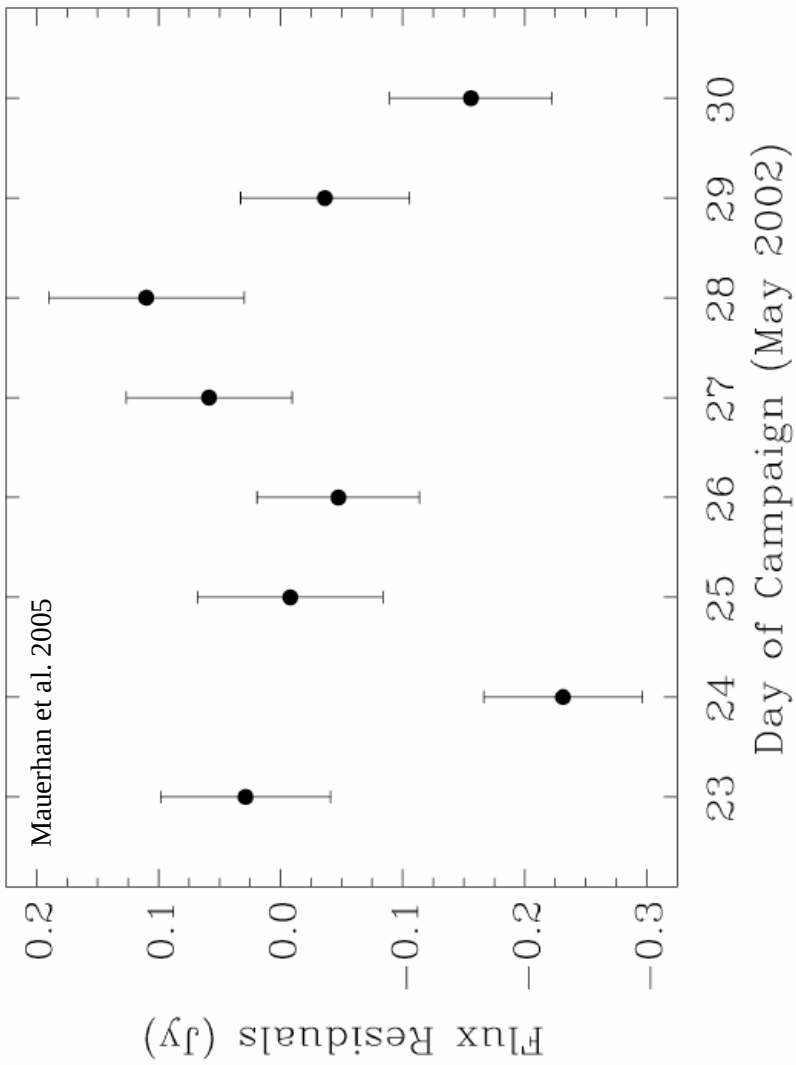
1999

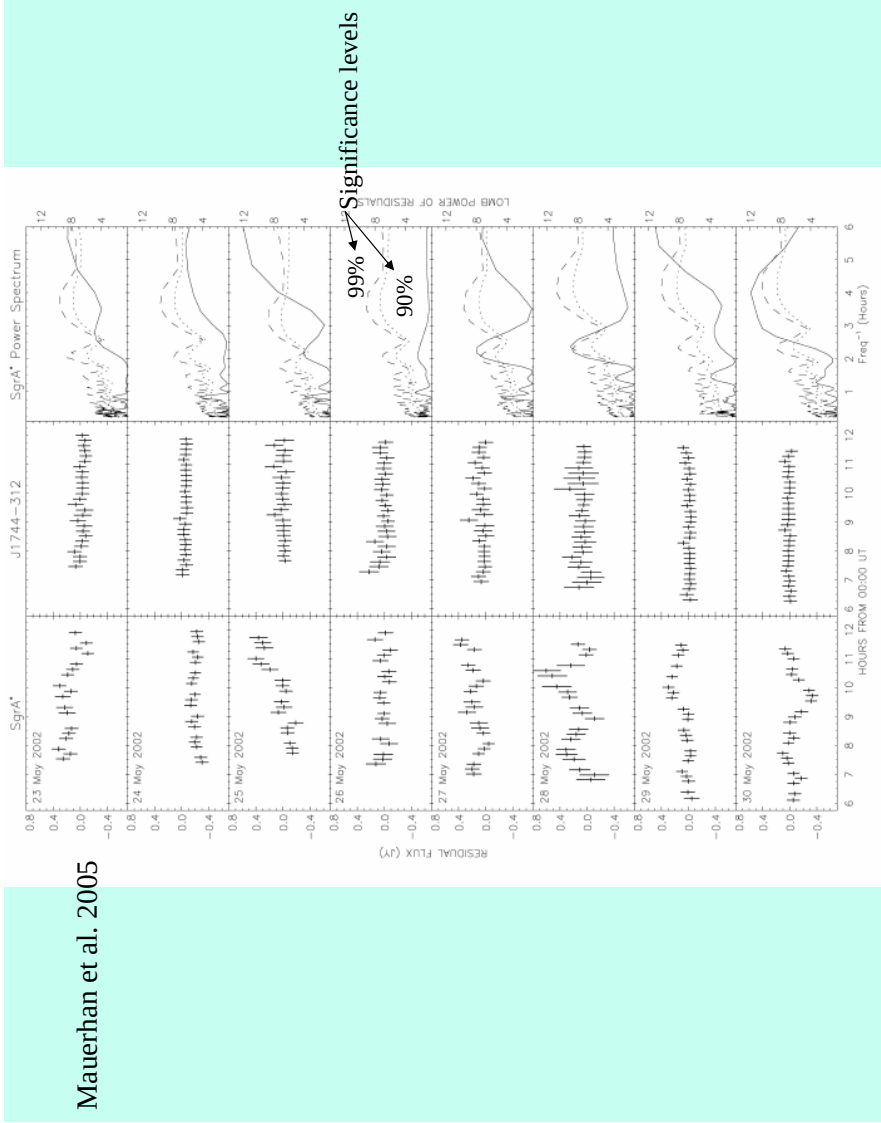


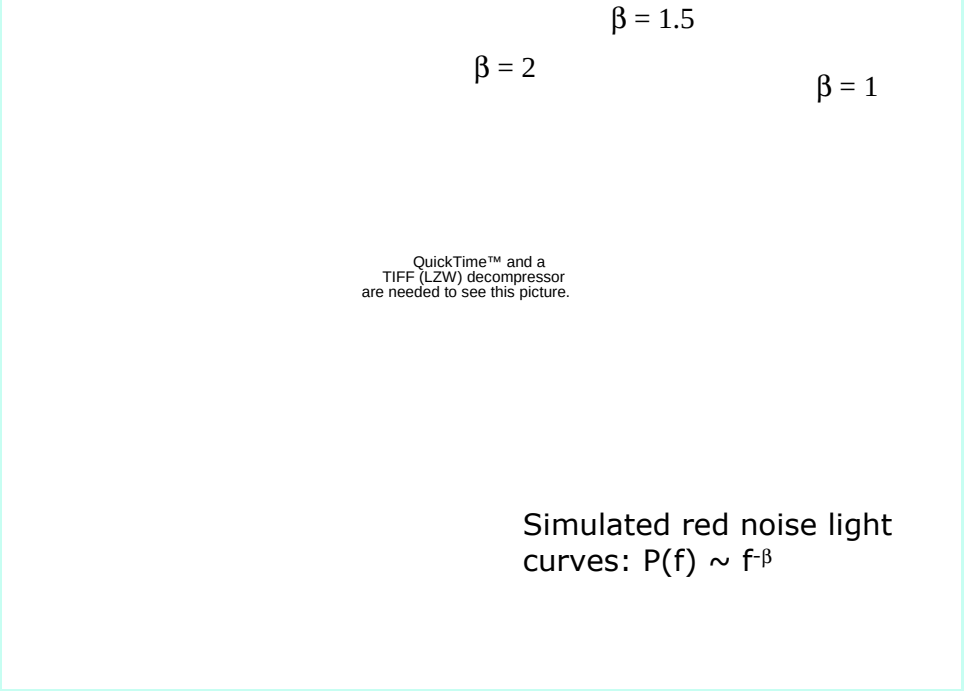
Jon Mauerhan, Morris, Walter & Baganoff 2005 -->

While searching for radio counterparts to X-ray flares, 8 full tracks were obtained with the Owens Valley Interferometer at 3-mm on SgrA*, allowing a study of shorter-time-scale variations.

Details --> Mauerhan poster


Flux Residuals (Jy)
0.2
0.1
0.0
−0.1
−0.2
−0.3
23 24 25 26 27 28 29 30
Day of Campaign (May 2002)
Mauerhan et al. 2005


Significance levels
99%
90%
SgrA*
J1744−312
SgrA* Power Spectrum
RESIDUAL FLUX (Jy)
HOURS FROM 00:00 UT
Freq⁻¹ (Hours)
Mauerhan et al. 2005



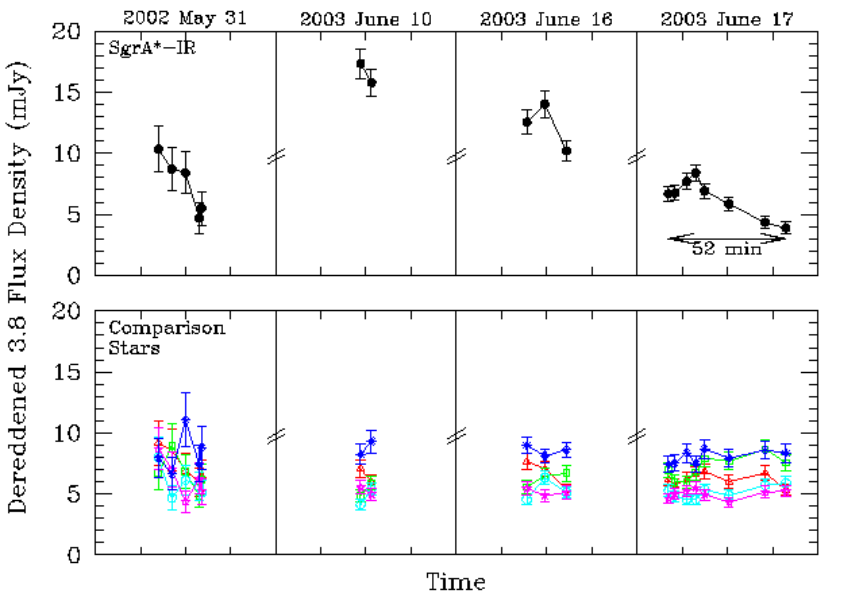
Simulated red noise light curves: $P(f) \sim f^{-\beta}$

Conclusions from 3mm study:

- Significant variability on time scales of >~ 1 hour, with a possible peak at 2.6 hours.
- Aside from the possible peak, the variations are consistent with a 1/f noise spectrum.
  Afterthought: can the long-term variability be similarly characterized?
- The 2.6-hr peak, if real, would correspond to the dynamical time at a characteristic radius of ~10 R_s. Is this the 3-mm photosphere? It does correspond well with the VLBI-determined size at 3-mm (Doeleman, Bower, et al.) Jet or disk?

Infrared: Time-variable 3.8-μm emission from SgrA* …

Ghez et al. 2004



factor of 4 intensity change over 1 week
& factor of 2 change in 40 minutes at 3.8 μm

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

The issue of confusion is critical for these studies, especially the measurement of the near-IR emission of SgrA* itself.

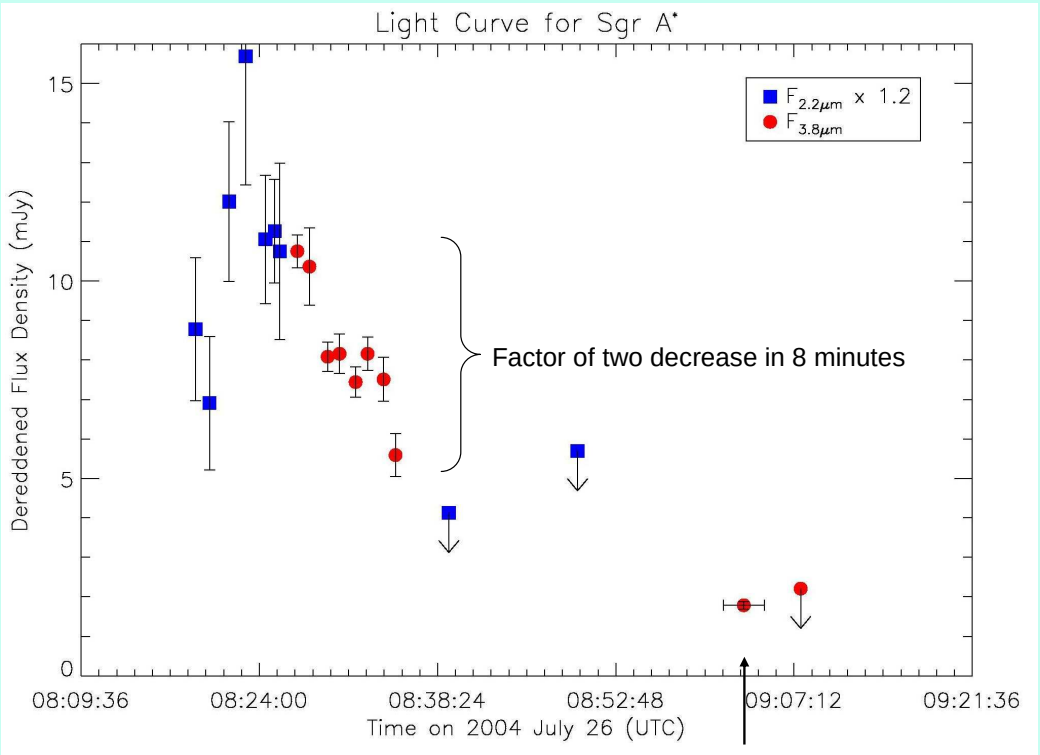
Every year since 1995, except 2003 & 2004, there has been a star within one resolution element of SgrA*.

The presence of a nearby stellar source can alter the centroids of both SgrA* and the nearby star.

Measuring a quiescent source at the position of SgrA* is problematical, given the rise in projected stellar surface density all the way in to at least 0.1" = 0.004 pc.

Aperture photometry on SgrA* requires a still unknown and difficult correction.

2004 Keck result using laser guide star adaptive optics:

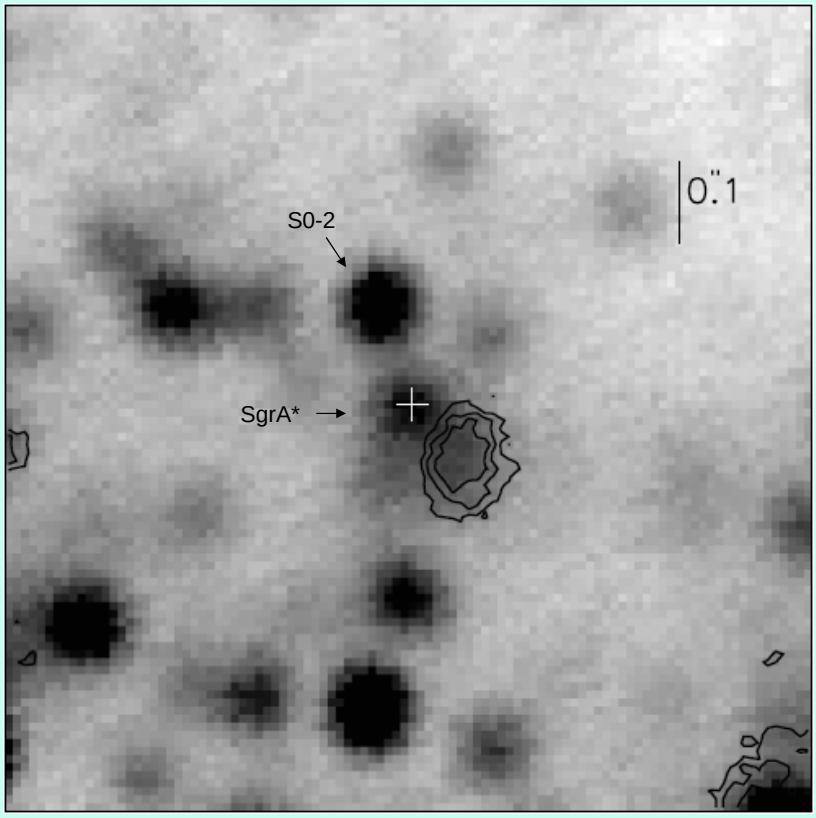


See Seth Hornstein poster

Some conclusions from the near-IR studies:

- Clear and dramatic variations on time scales as short as 8 min.
- Variations appear to be irregular, stochastic, although the sampling is not yet adequate to statistically characterize them.
- The near-IR light curve might ultimately be characterizable as a succession of 1 - 2 hour “flares”, or high states, occuring at the rate of 4 to 8 per day.
  Nomenclature: what is a flare?
- No evidence for a steady, quiescent state. At best, during any given time interval of a day or two, there may be an “interim quiescent” level.
- No evidence in the Keck data for a periodicity.

The extended red emission near SgrA*



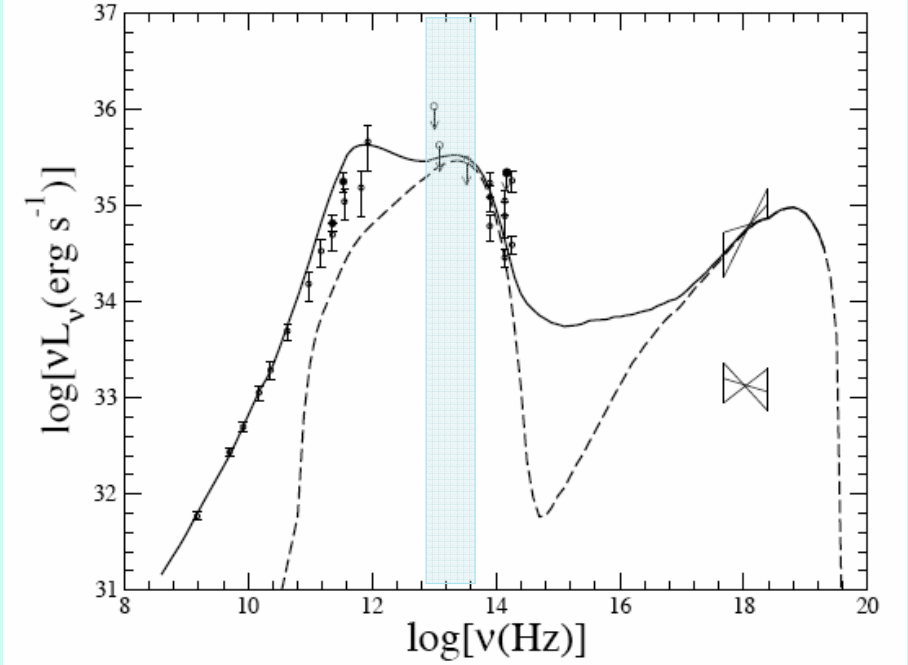
Keck LGS image

Infrared color of Sgr A* ...

Eisenhauer et al. 2005 --> “The 1.7 - 2.45 μm spectral energy distributions of these flares are fit by a featureless “red” power law of spectral index $\alpha = -4 \pm 1$ ($S_\nu \sim \nu^\alpha$).”

Our K - L color (3.0 ± 0.2) from 7/2004 gives $\alpha = -0.3 \pm 0.2$

This has strong implications for the mid-infrared, since the Eisenhauer slope would place the flux well above current limits at 10 μm, while our flatter (but still rather red) slope is consistent with those limits.

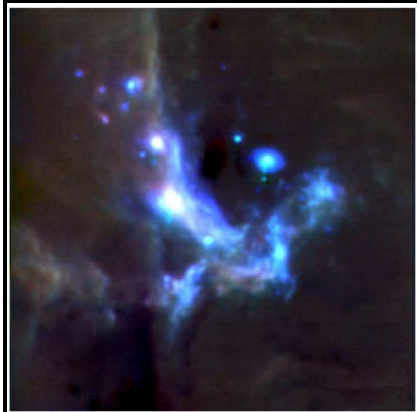


Sgr A West with Keck/MIRLIN
3-color, 8 - 21 μm
(deconvolved)

Morris, Ressler, Ghez, Becklin,
Tanner, Cotera, Werner

6" = 0.25 pc

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.



Colour Composite of the Galactic Centre
(VLT Melipal + VISIR)

ESO PR Photo 16d/04 (12 May 2004) © European Southern Observatory

2”

ε

Mini-cavity

11 μm Keck LWS observation, 2002 May

IRS3

Northern Arm

Mid-IR conclusions:

- It will be difficult to improve on the steady-state limit because of the background spatial fluctuations, but
- the fluctuating component is within reach, although there is no evidence for it at a level of ~ 5 mJy.
- the mid-IR reveals dust features that may be interacting with SgrA* and its entourage.