Title: Review of Astro

Speakers: Charles Gammie

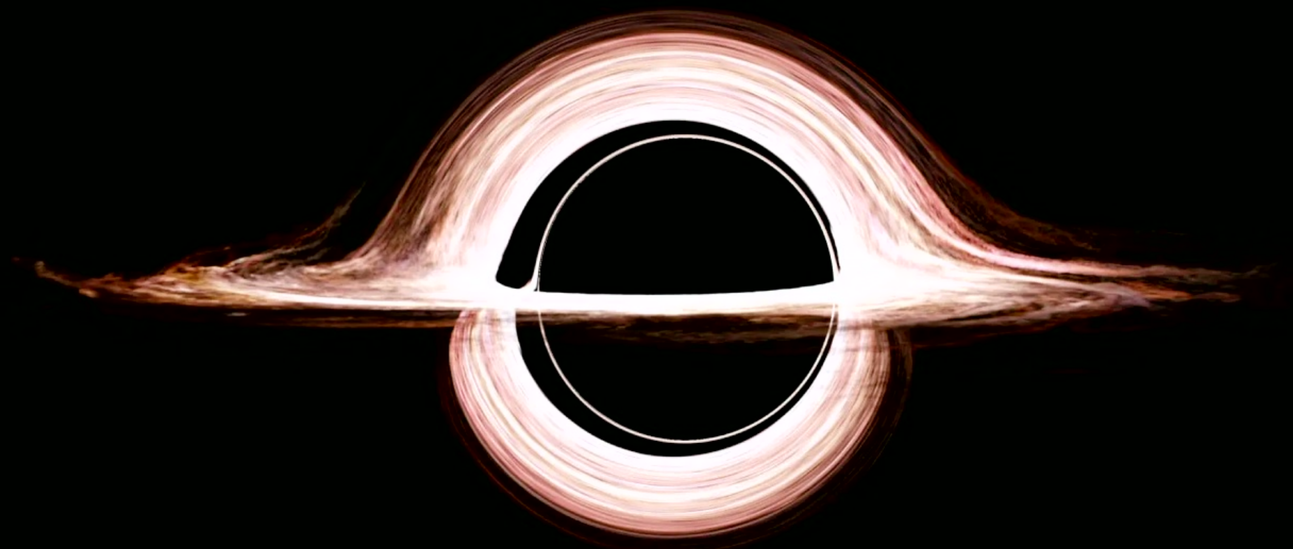
Collection/Series: Future Prospects of Intensity Interferometry

Subject: Cosmology

Date: October 31, 2024 - 1:00 PM

URL: https://pirsa.org/24100104

Astrophysical Applications of Intensity Interferometry



Charles F. Gammie

Perimeter, 31 Oct 2024

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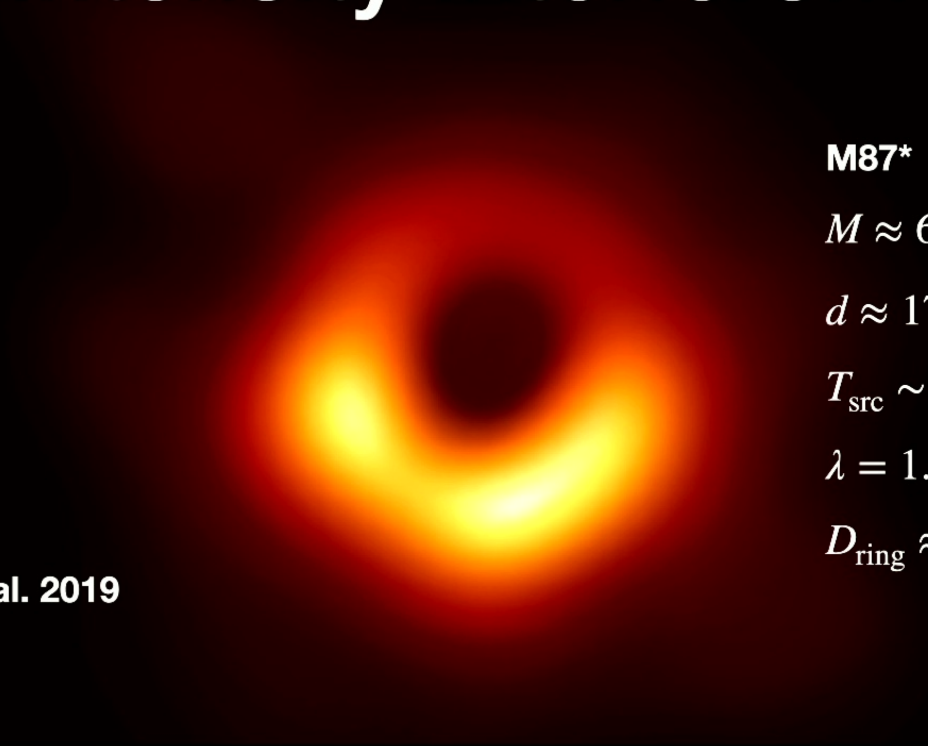
Astrophysical Applications of Intensity Interferometry



M87*

$M \approx 6 \times 10^9 M_\odot$

$d \approx 17\,\mathrm{Mpc}$

$T_{\mathrm{src}} \sim 10^{10}\,\mathrm{K}$

$\lambda = 1.3\,\mathrm{mm}$

$D_{\mathrm{ring}} \approx 40\mu\mathrm{as}$

EHT et al. 2019

Perimeter, 31 Oct 2024

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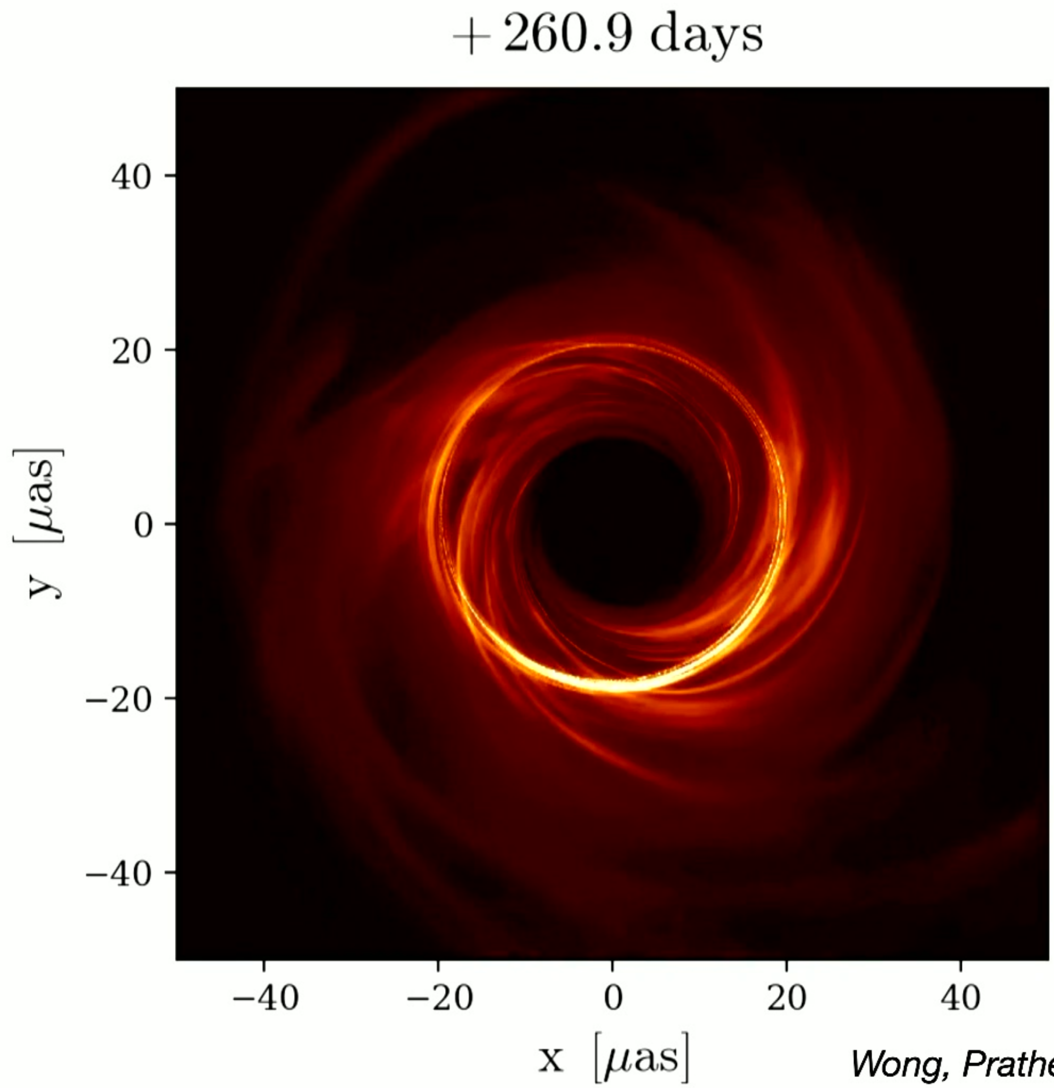
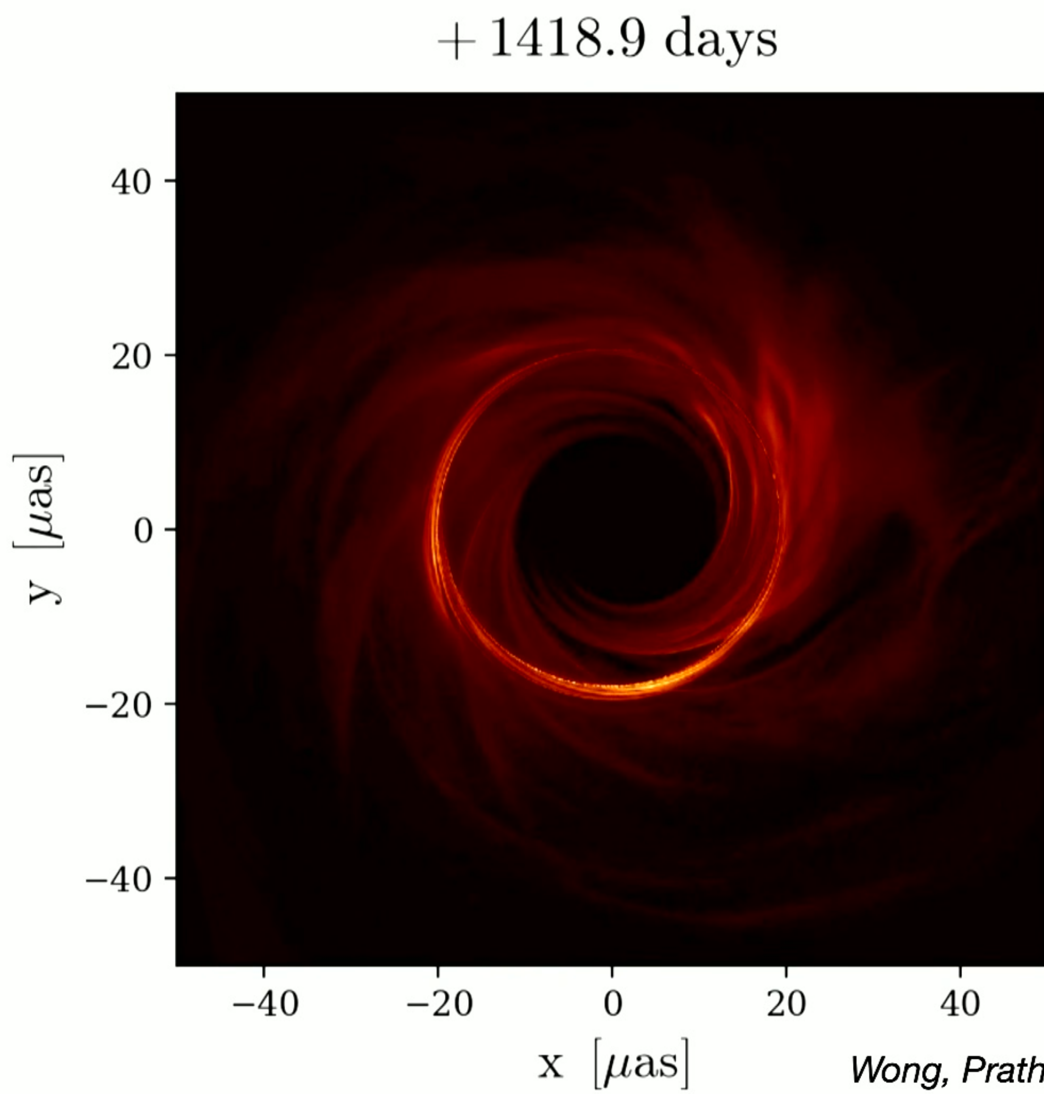


Wong, Prather, Gammie (Illinois)



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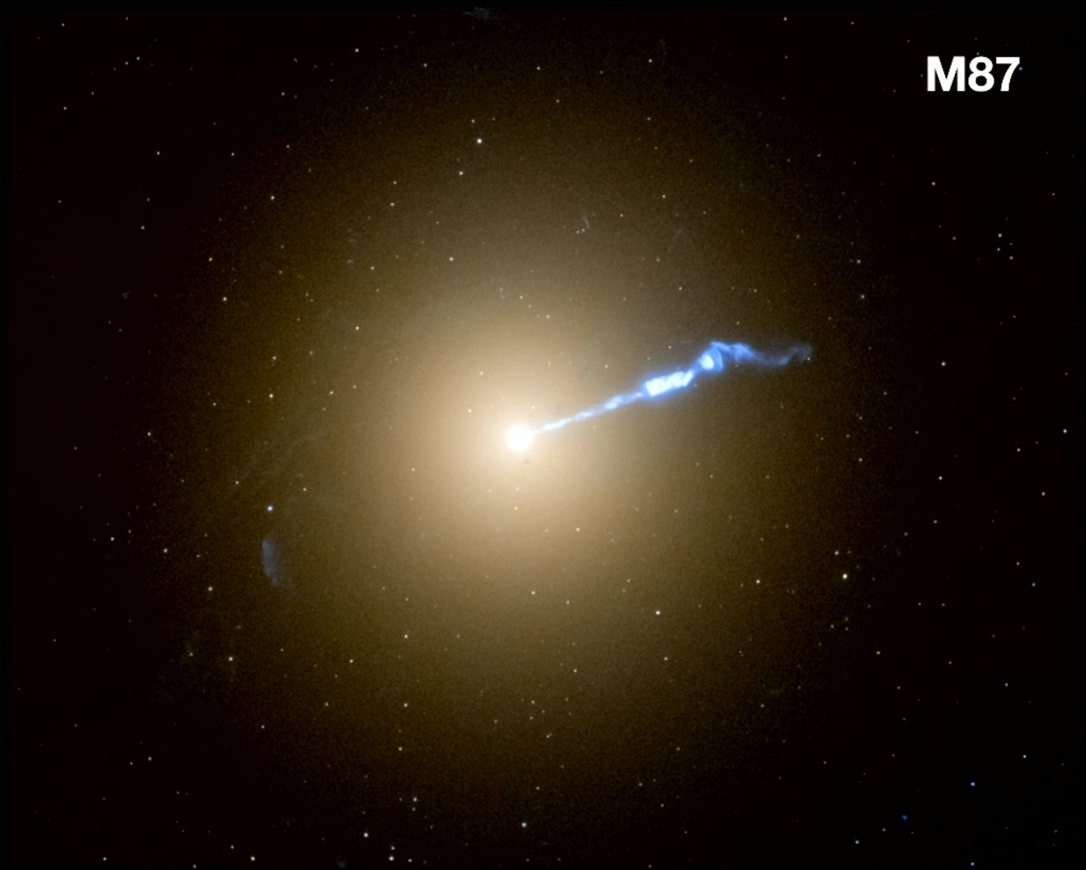

credit: NASA, ESA, STScI, Alec Lessing (Stanford University), Mike Shara (AMNH)

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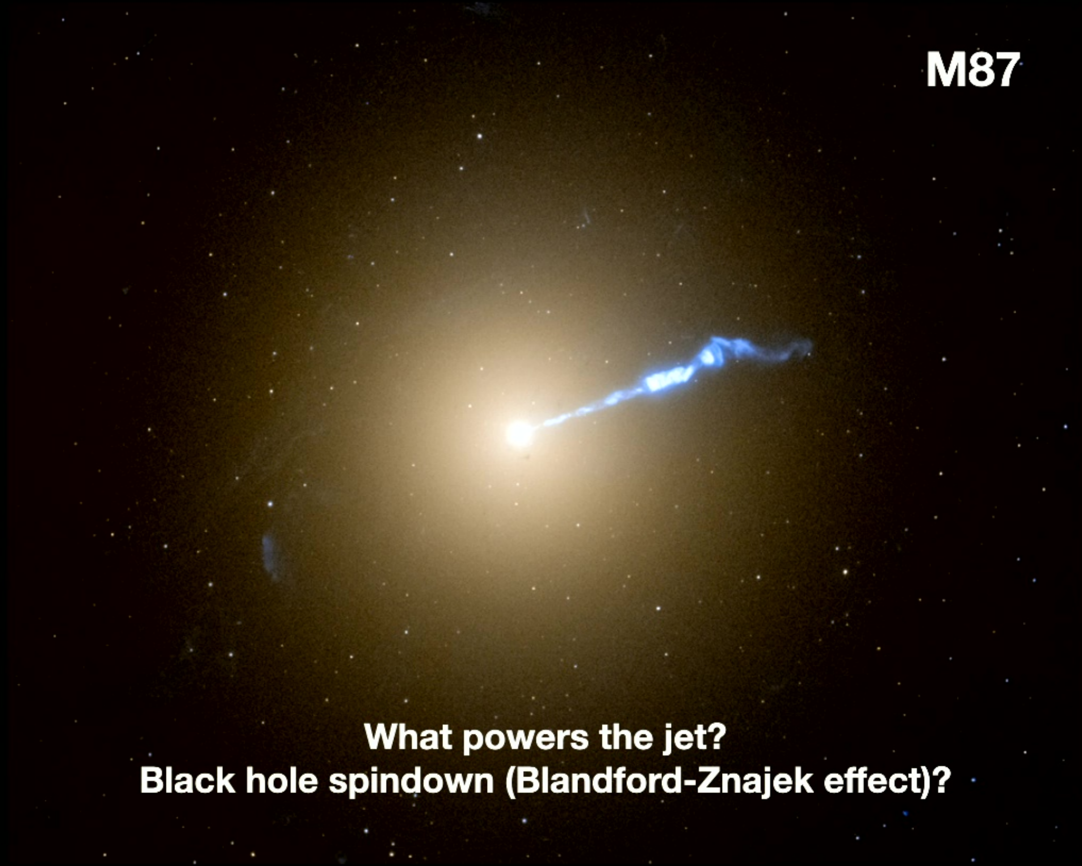

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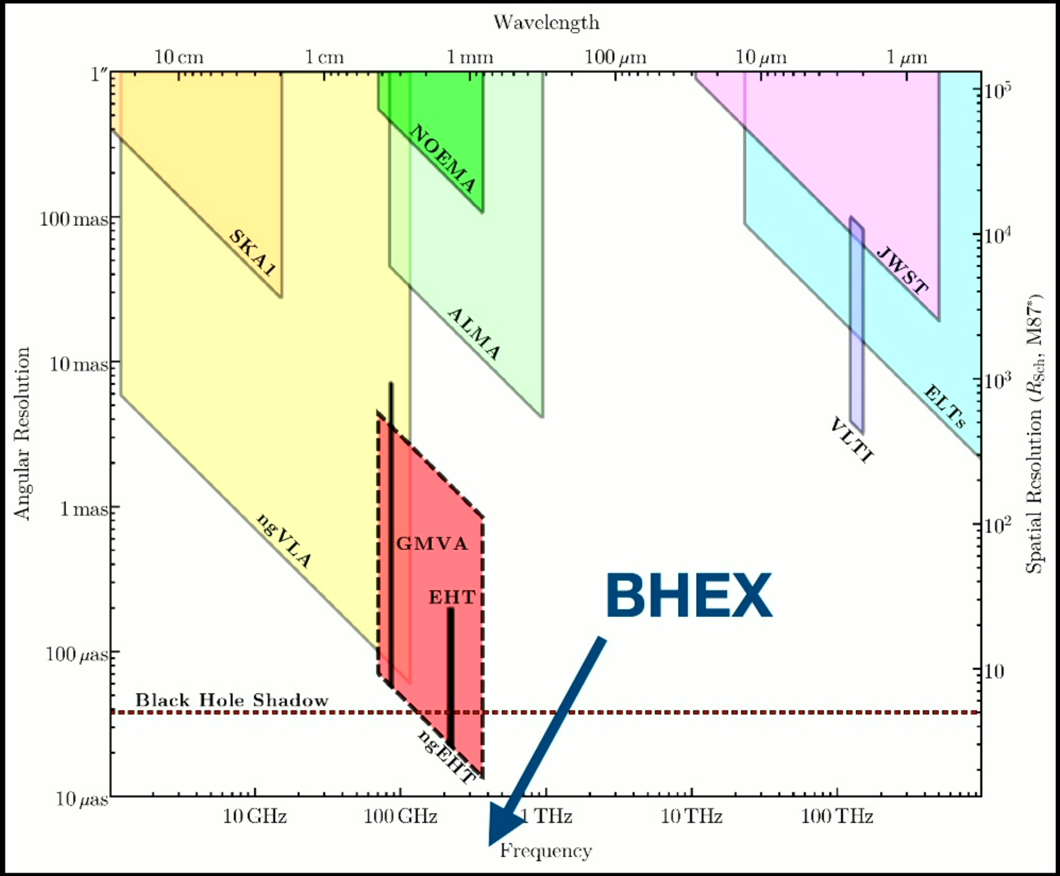
The Resolution Frontier



Johnson et al. 2023

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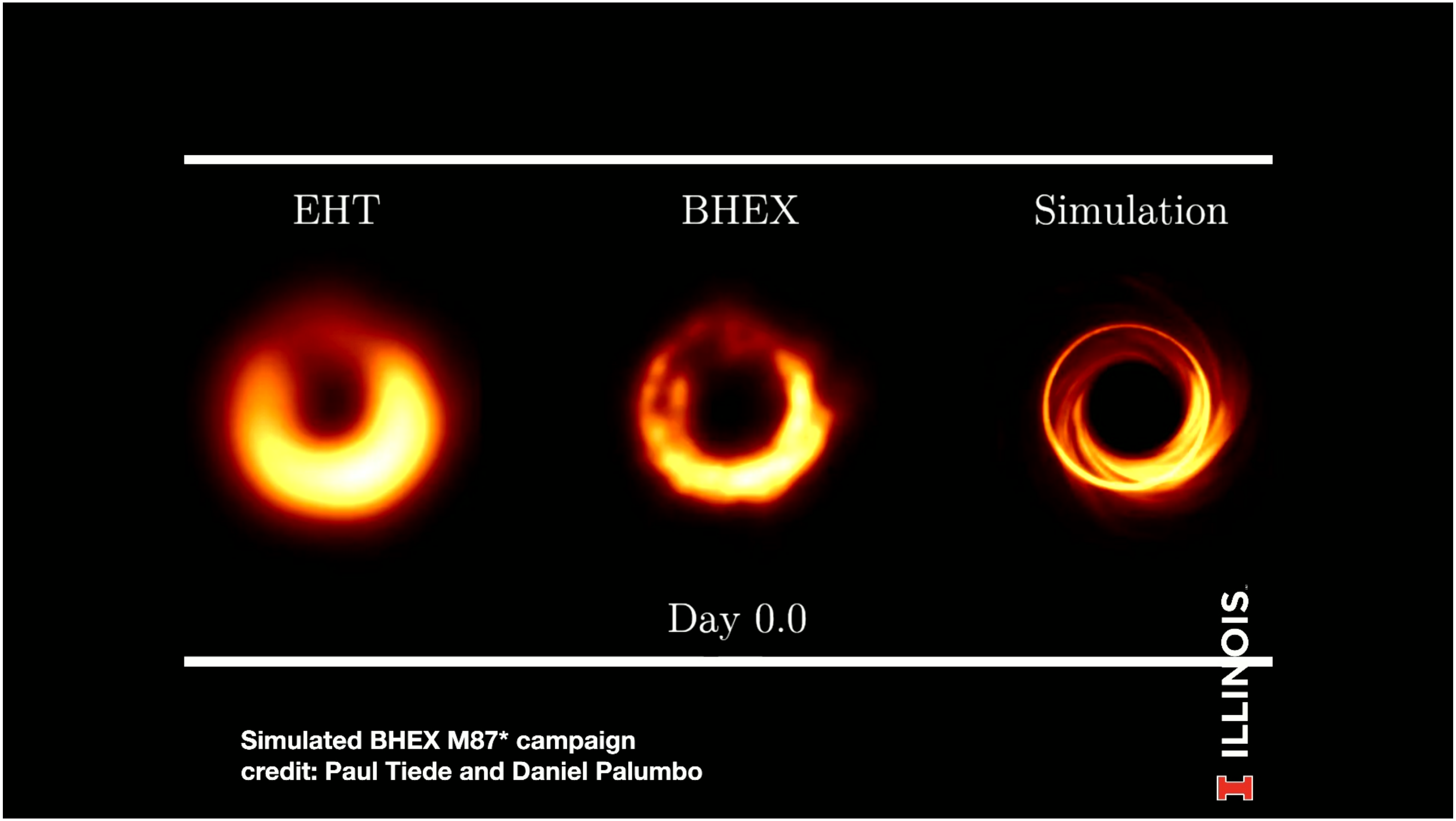
EHT
BHEX
Simulation
Day 0.0
Simulated BHEX M87* campaign
credit: Paul Tiede and Daniel Palumbo
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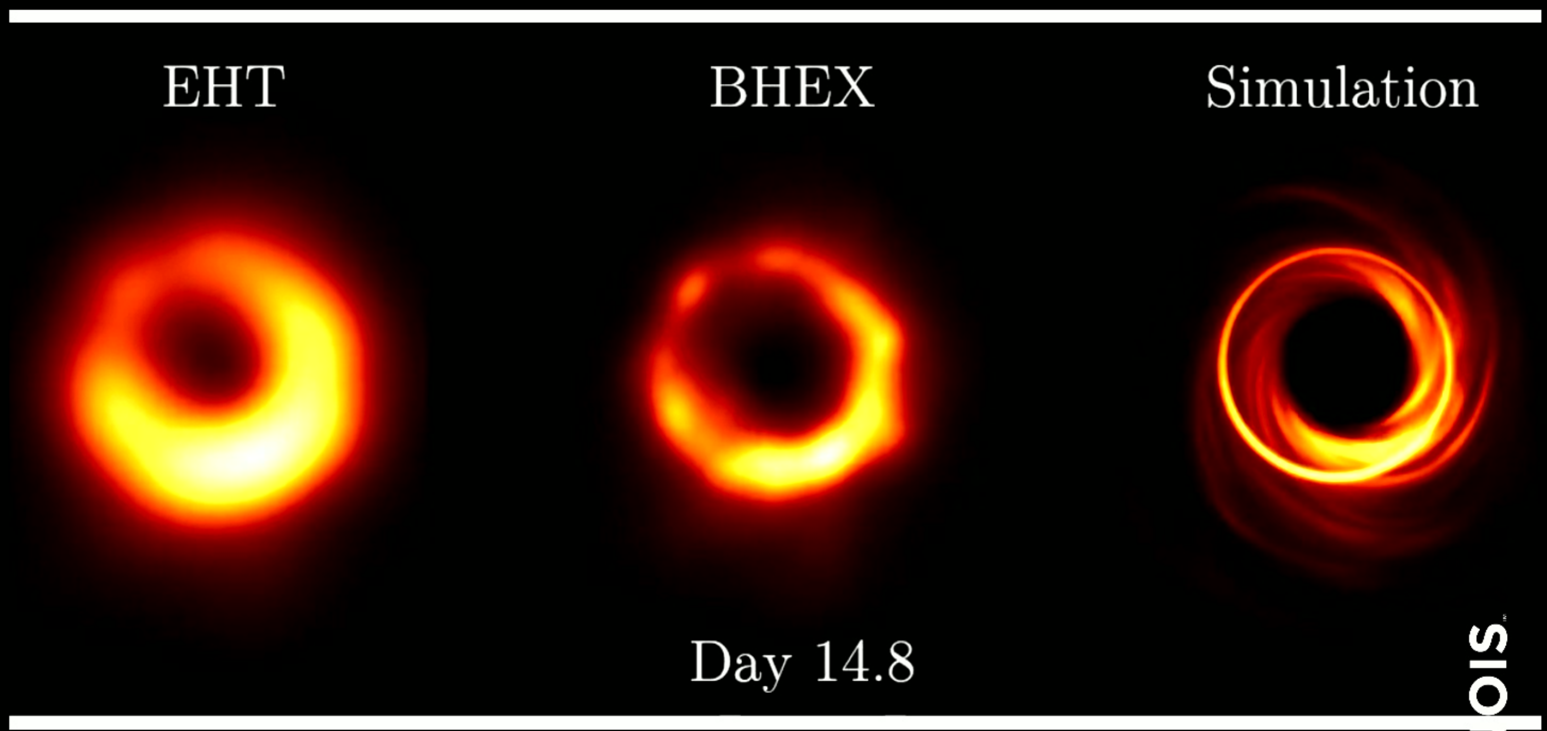

Simulated BHEX M87* campaign
credit: Paul Tiede and Daniel Palumbo

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Plan

The resolution frontier

The signal and the noise

Supermassive black holes

Binary supermassive black holes

Accreting white dwarfs

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The Signal and the Noise

Two-Element intensity interferometer (from Dalal, Galanis et al. 2024)

$$SNR = \eta\,|\mathscr{V}|^2 \left(\frac{AF_\nu}{h\nu_0}\right)\left(\frac{T_{obs}}{\sigma_t}\right)^{1/2} (128\pi)^{-1/4}\, n_{\rm chan}^{1/2}$$

$$= 0.38\eta\,|\mathscr{V}|^2 \left(\frac{A}{100{\rm m}^2}\right)\left(\frac{T_{obs}}{\rm hr}\right)^{1/2}\left(\frac{\lambda}{\mu{\rm m}}\right)^{-1}\left(\frac{T_{\rm src}}{10^5{\rm K}}\right)\left(\frac{\sigma_t}{13{\rm ps}}\right)^{-1}\left(\frac{\Delta\theta}{1\mu{\rm as}}\right)^{2} n_{\rm chan}^{1/2}$$

Two-Element amplitude interferometer

$$SNR = \eta\,|\mathscr{V}| \left(\frac{AF_\nu}{kT_{\rm sys}}\right)\left(T_{obs}\Delta\nu\right)^{1/2}$$

$$= 28\eta\,|\mathscr{V}| \left(\frac{A}{100{\rm m}^2}\right)\left(\frac{T_{obs}}{\rm hr}\right)^{1/2}\left(\frac{\Delta\theta_{\rm src}}{1\mu{\rm as}}\right)^{2}\left(\frac{T_{\rm src}}{10^9{\rm K}}\right)\left(\frac{\Delta\nu}{\rm GHz}\right)^{1/2}\left(\frac{\lambda}{\rm mm}\right)^{-2}$$

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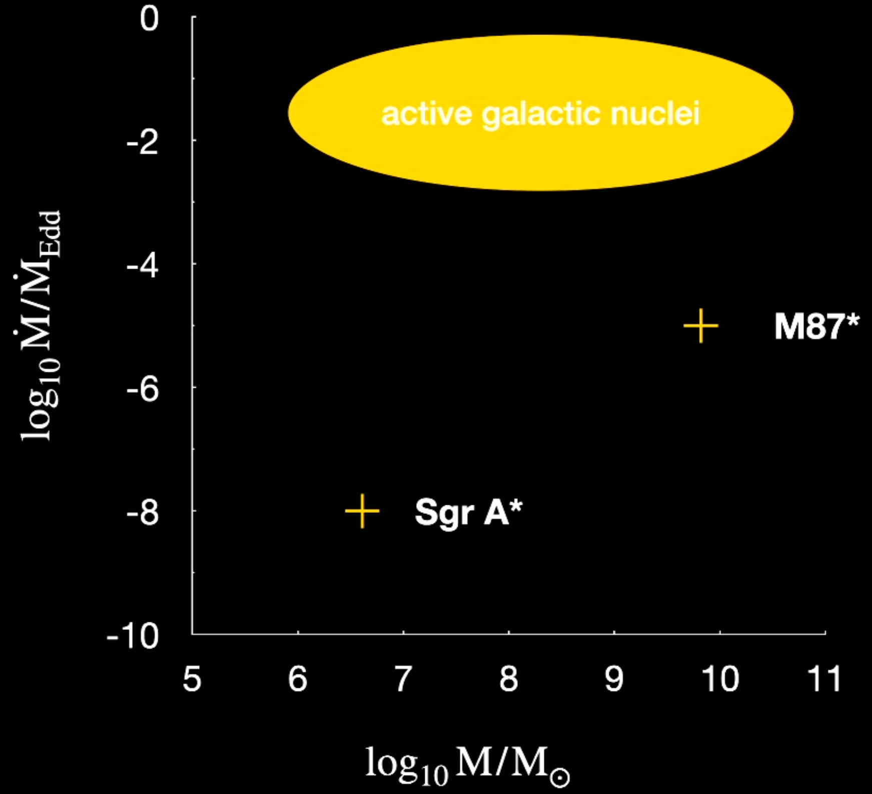
Accreting Supermassive Black Holes



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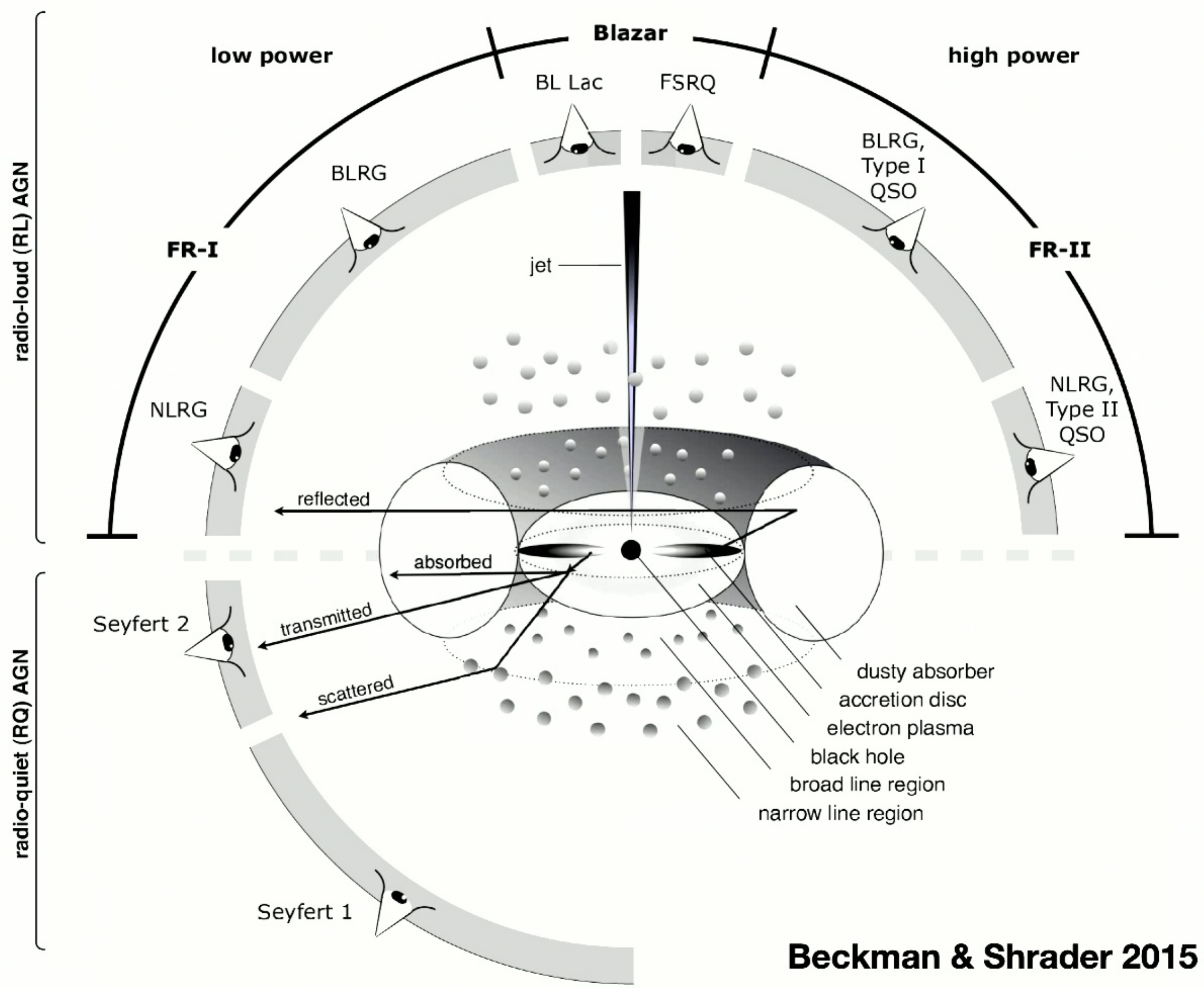

Beckman & Shrader 2015

$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$; $\lambda = 5000\text{Å}$

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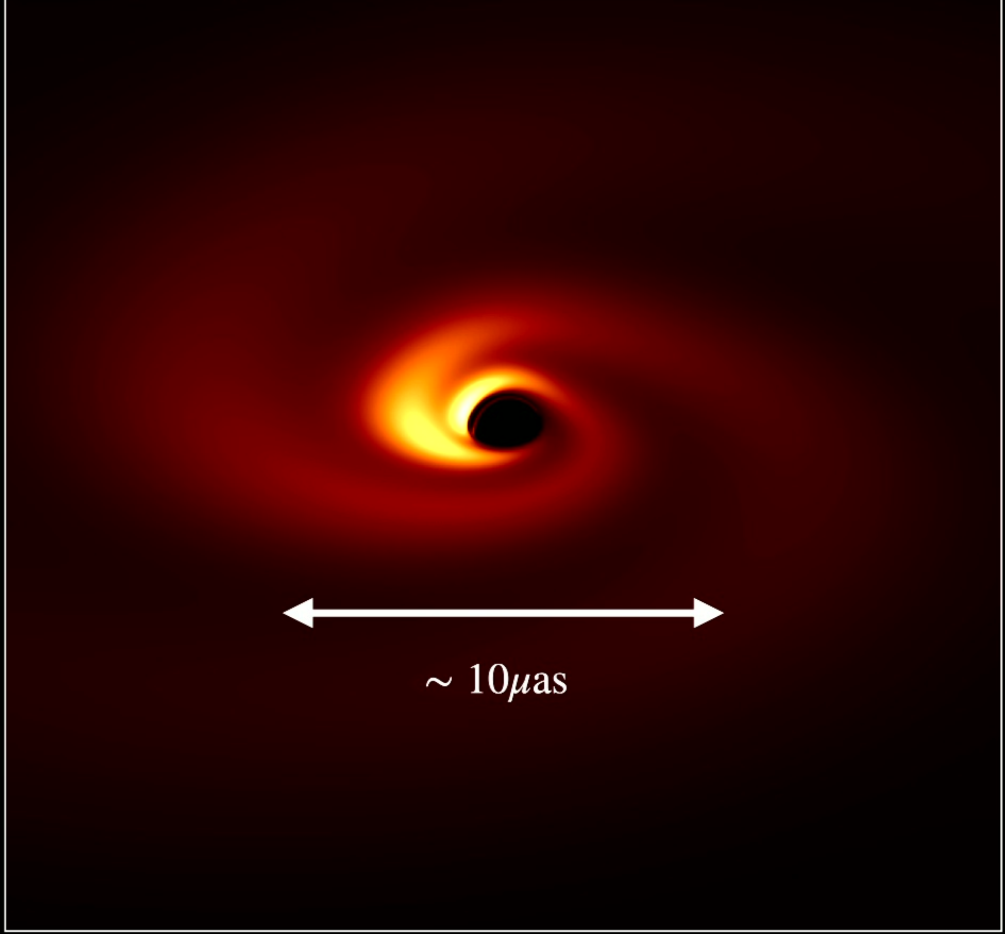
toy image of direction emission from AGN disk



$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$; $\lambda = 5000$Å

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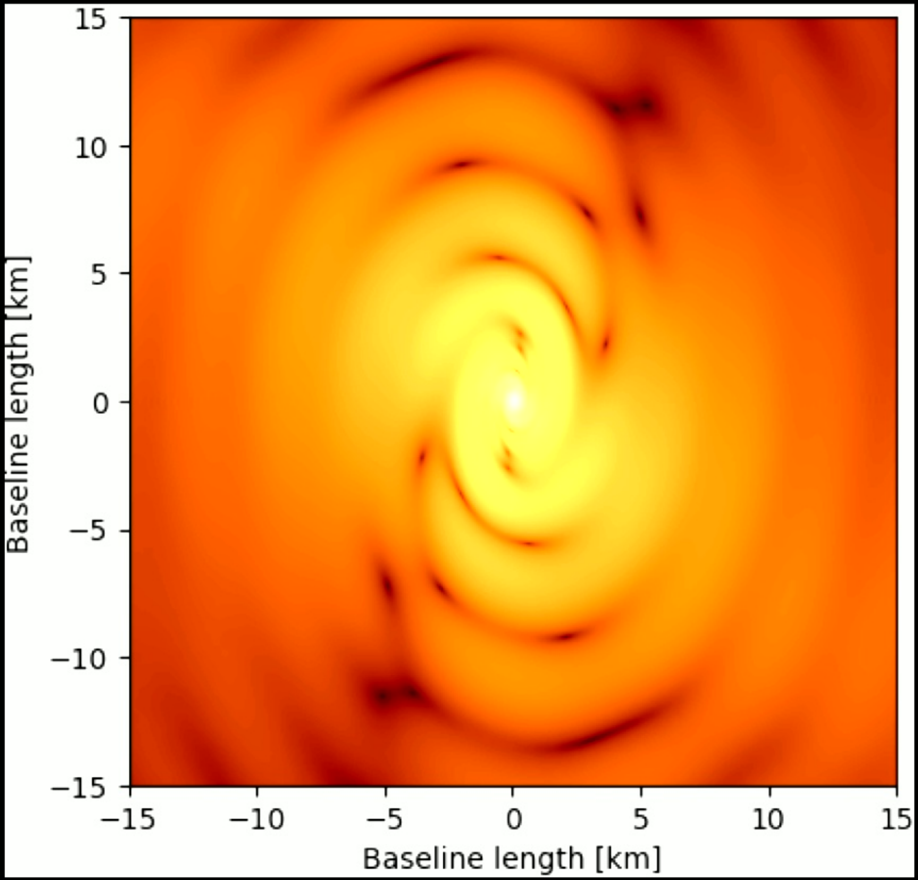
toy image of direction emission from AGN disk

$$T_{\rm eff} \simeq 10^6 \left(\frac{L}{L_{\rm Edd}}\right)^{1/4} \left(\frac{M}{10^8 M_\odot}\right)^{-1/4} \left(\frac{r}{r_g}\right)^{-3/4} \mathrm{K}$$

$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$; $\lambda = 5000$Å toy image of direction emission from AGN disk



$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$**;** $\lambda = 5000\text{Å}$

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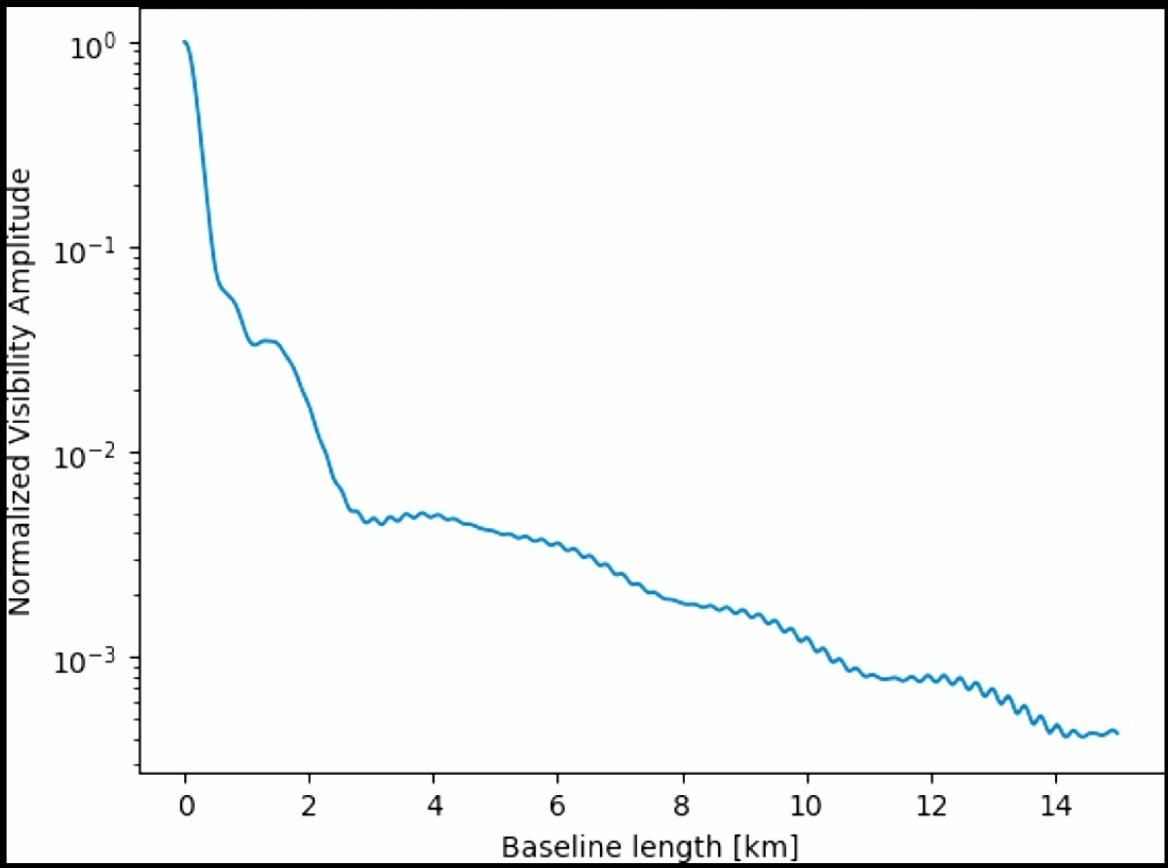
toy image of direction emission from AGN disk



$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$; $\lambda = 5000\text{Å}$

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Supermassive Questions

What is the structure of $r \sim GM/c^2$ flows when $L \sim L_{\rm Edd}$?

What is the size of AGN disks? Inconsistent with naive disk model (Morgan et al. 2010 microlensing constraint)

How inhomogeneous are AGN disks? May explain size inconsistency (Dexter & Agol 2011)

Are AGN disks flared, warped, twisted?

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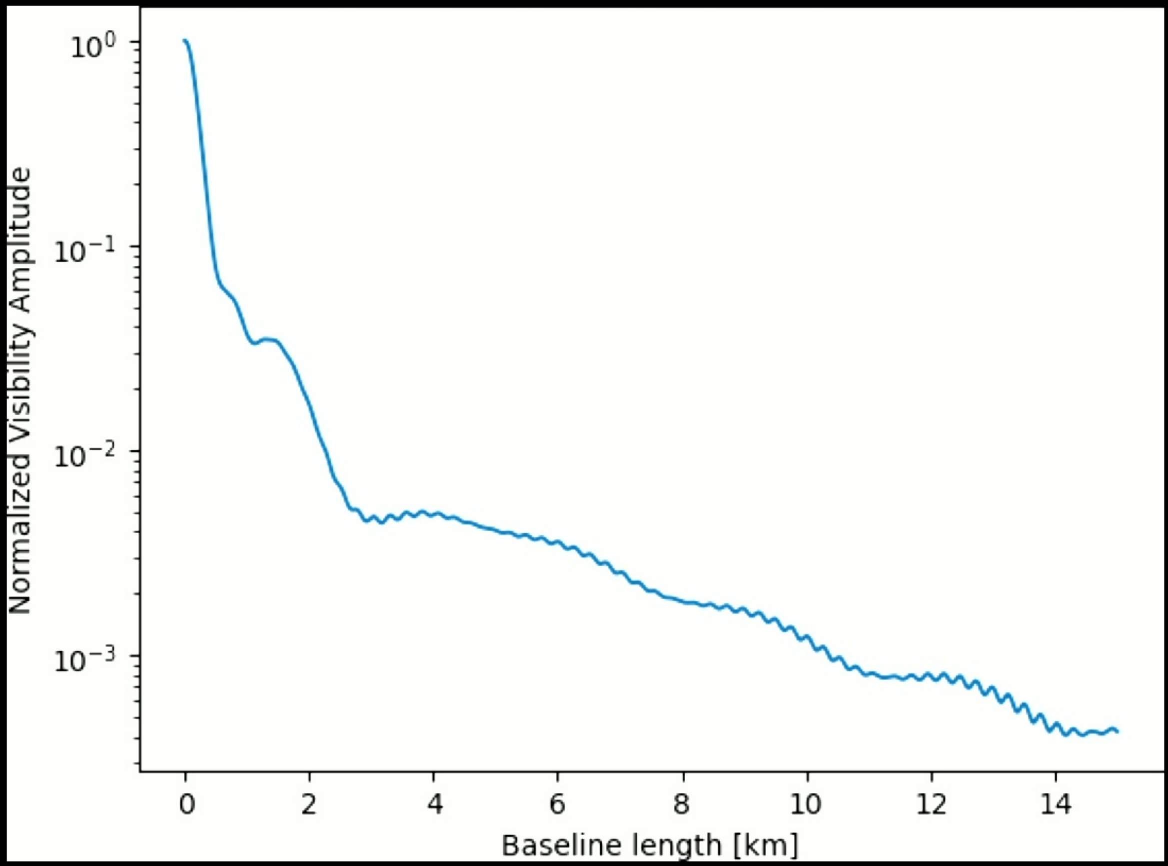

$10^8 M_\odot$ **black hole at 10 Mpc;** $L/L_{Edd} = 0.1$; $\lambda = 5000\text{Å}$

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Equal mass black holes, total mass M, separation a, gravitational radius $r_g \equiv GM/c^2$

$$\Delta\theta = 0.1 \left(\frac{a}{r_g}\right)\left(\frac{M}{10^8 M_\odot}\right)\left(\frac{d}{10\mathrm{Mpc}}\right)^{-1} \mu\mathrm{as}$$

Example:

OJ 287, candidate black hole binary, $M \sim 10^{10} M_\odot$

$d \sim 1$ **Gpc**
$a \sim 10^4$ **AU**
$\Delta\theta \sim 10\mu\mathrm{as}$

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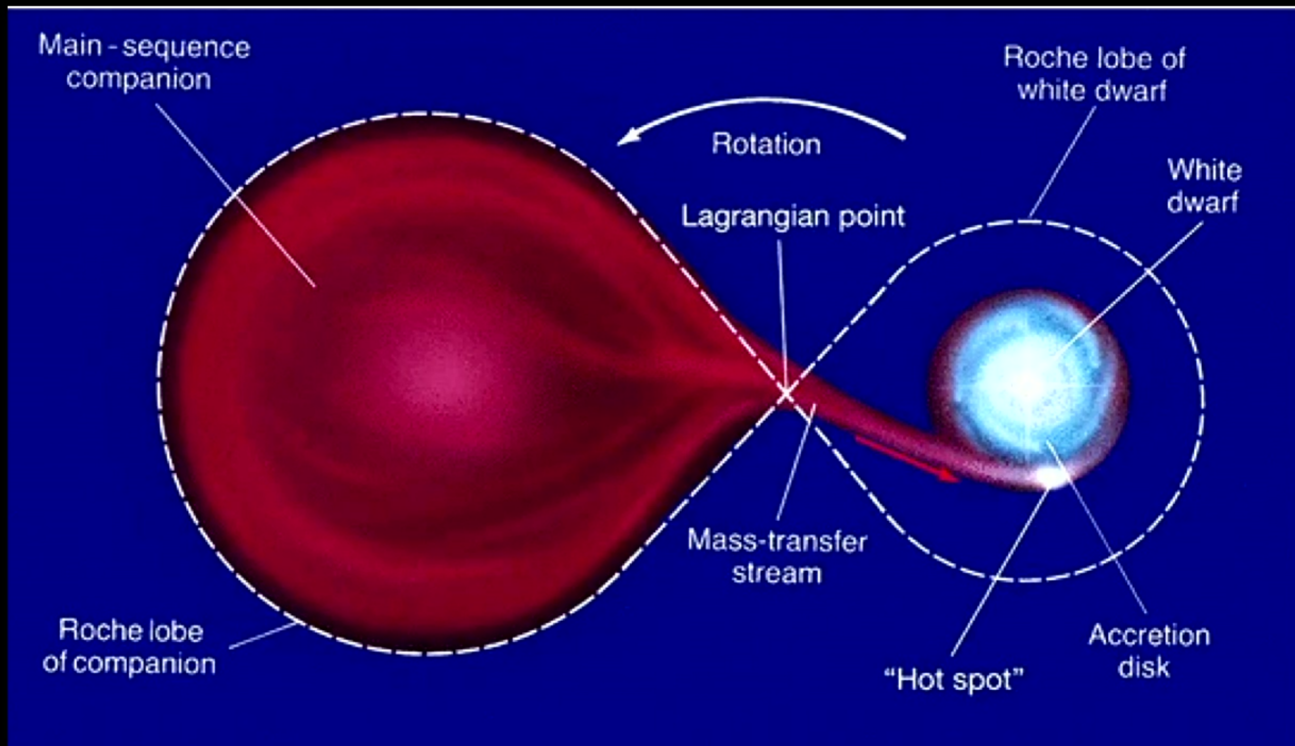
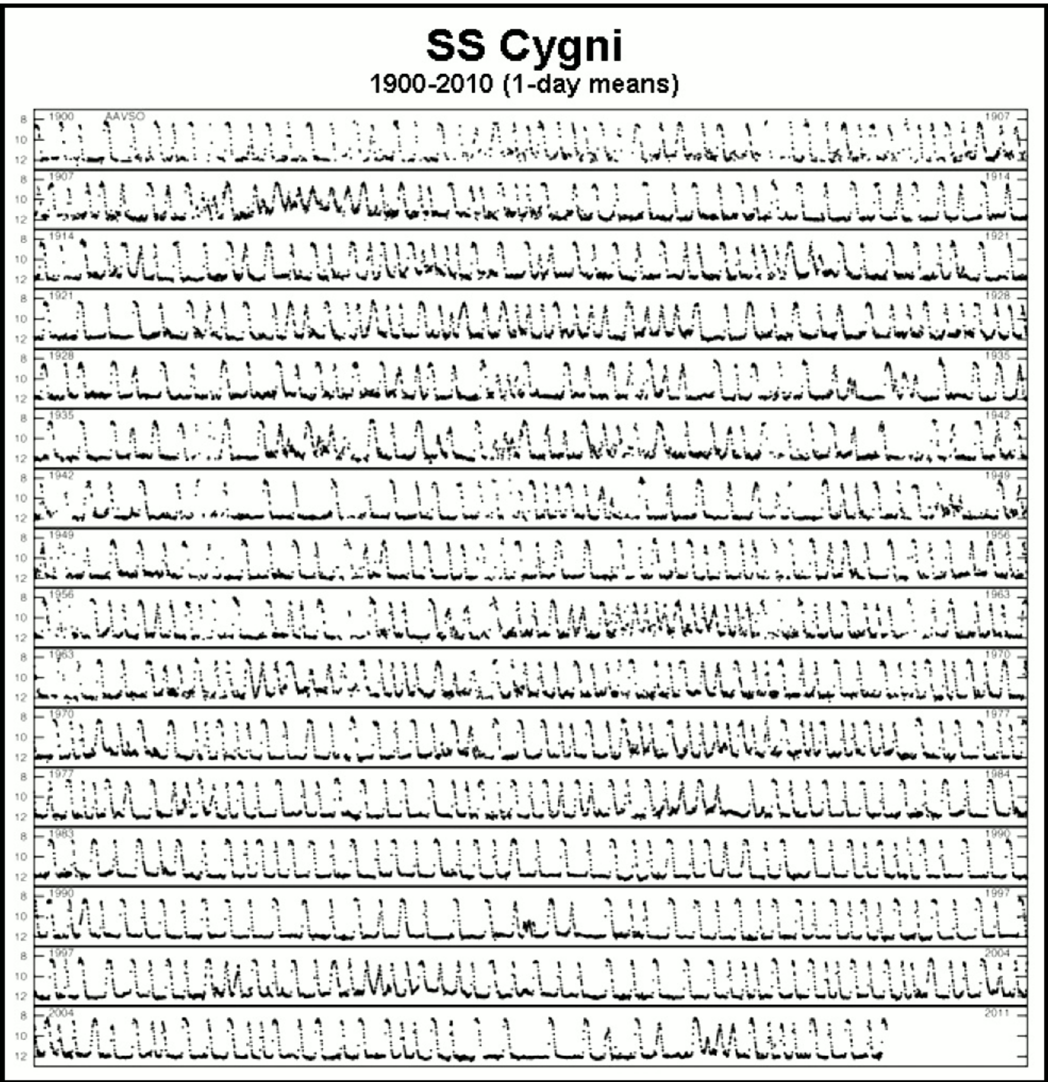


Credit: Pearson Prentice Hall, Inc



AAVSO

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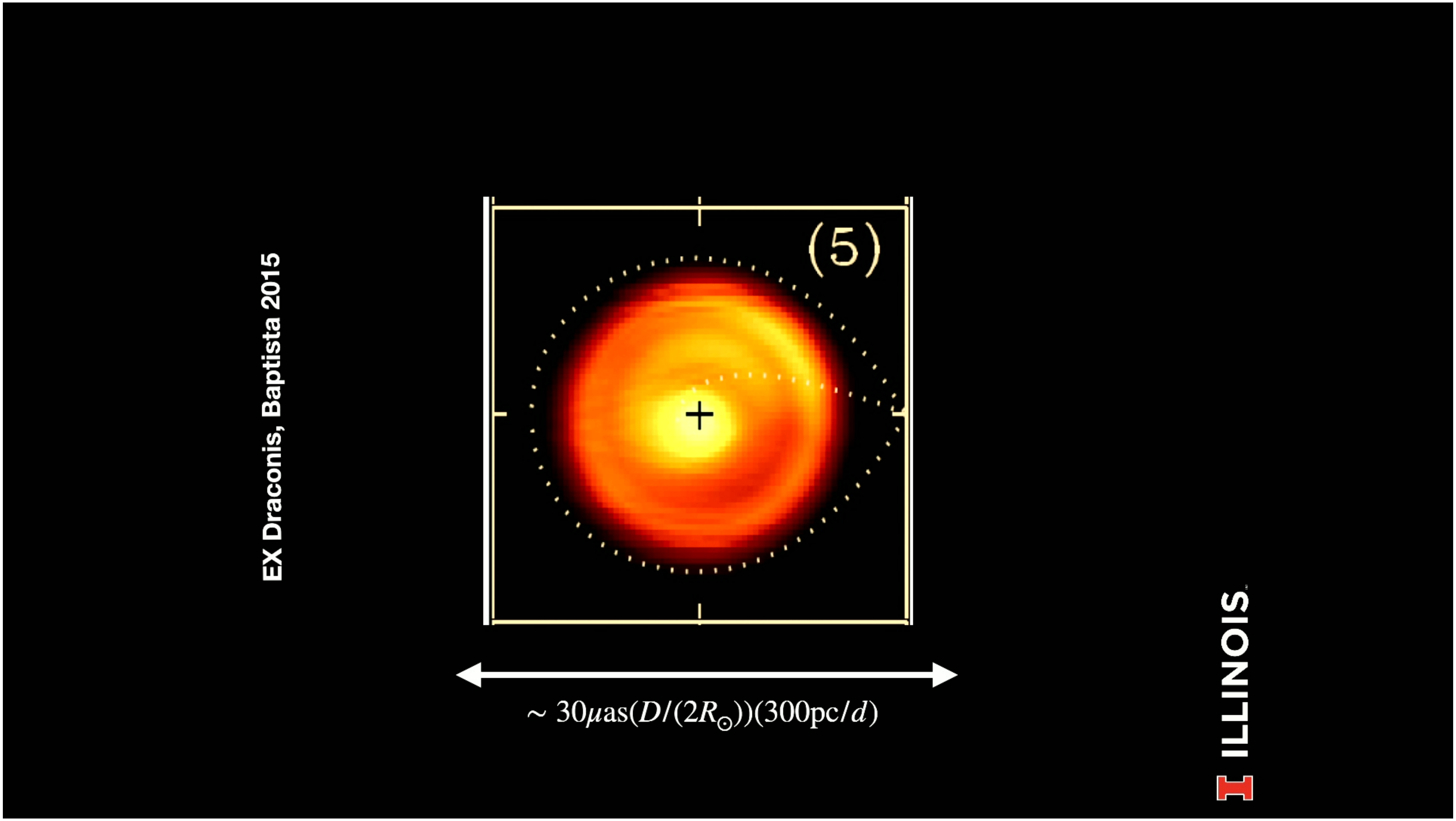

EX Draconis, Baptista 2015
(5)
$\sim 30\mu as(D/(2R_\odot))(300pc/d)$
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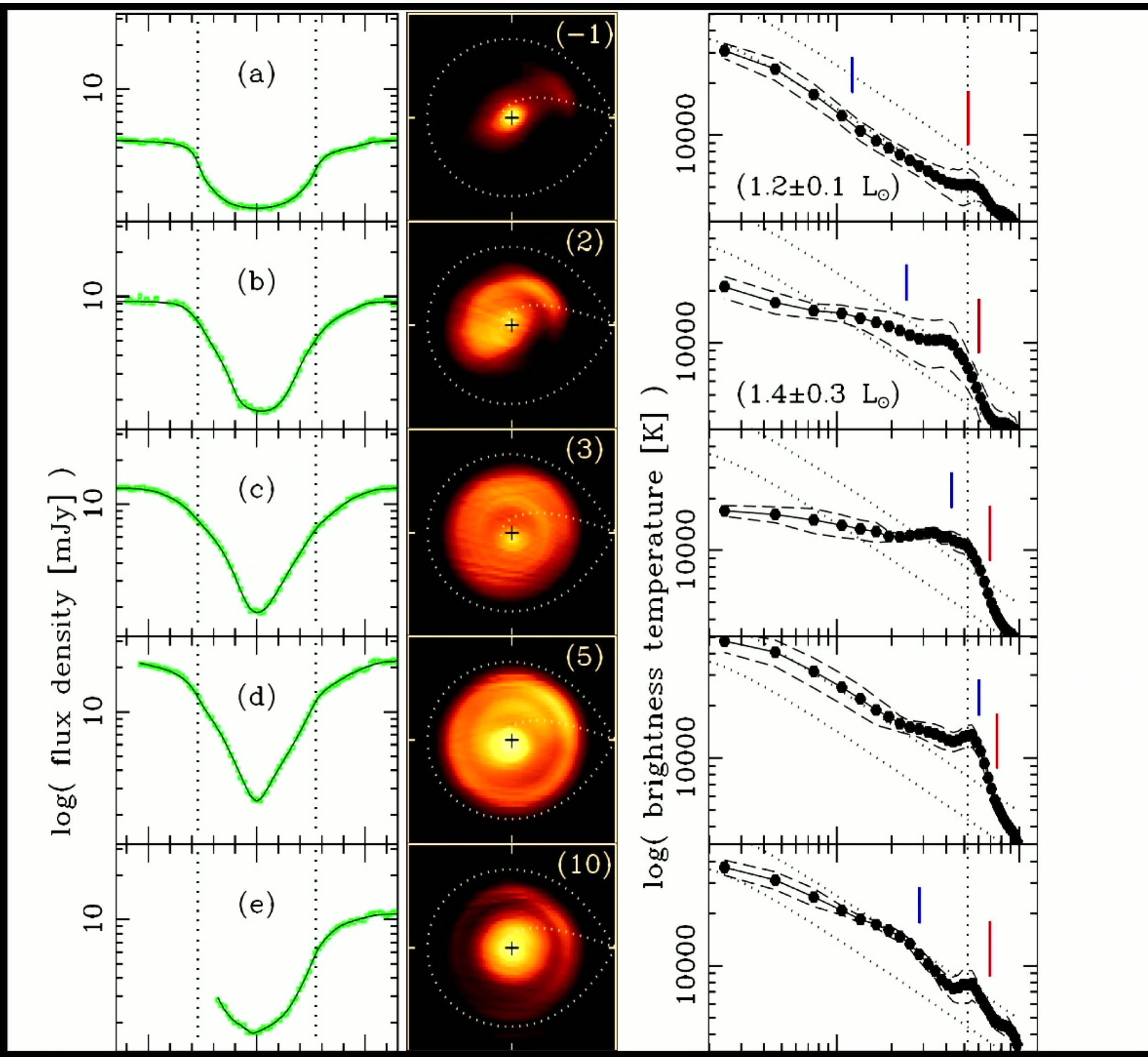
EX Draconis, Baptista 2015



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Summary

The resolution frontier: EHT + BHEX

The signal and the noise: AGN, CVs : $m_V \gtrsim 8; \quad F_\nu \lesssim 3\,\mathrm{Jy}$

Supermassive black holes: probing relativistic inner disk

Binary supermassive black holes: separating binaries

Accreting white dwarfs: model accretion disks

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