AGN at the Dawn of the Multi-Messenger Era

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CUNY BMCC/AMNH

For MMA SAG

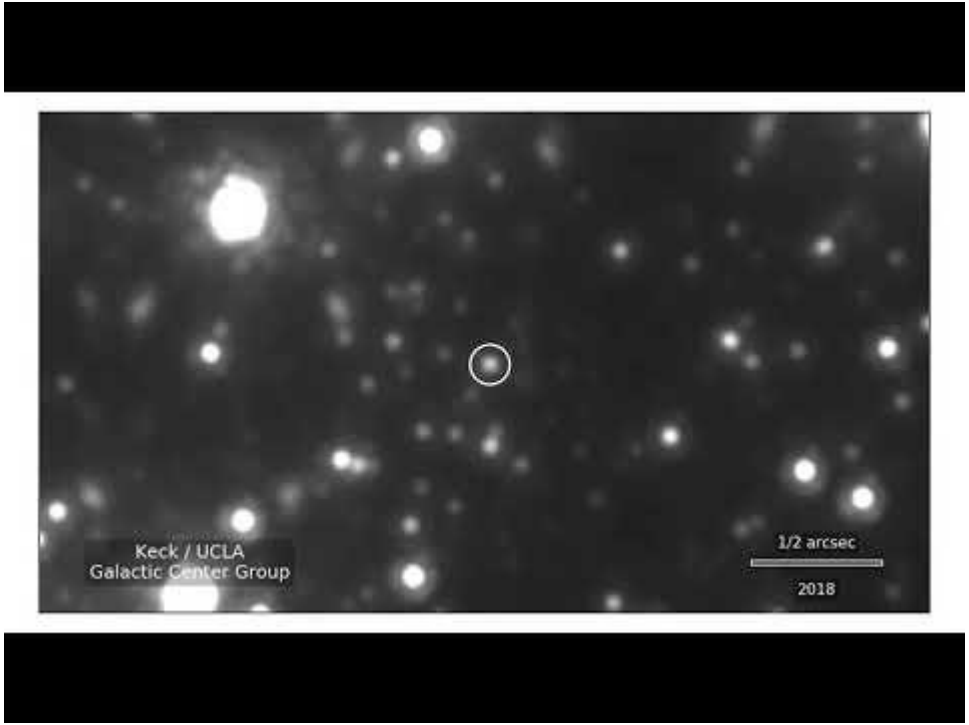
Our nearest galactic nucleus

Pericenter ~few 1000r_g

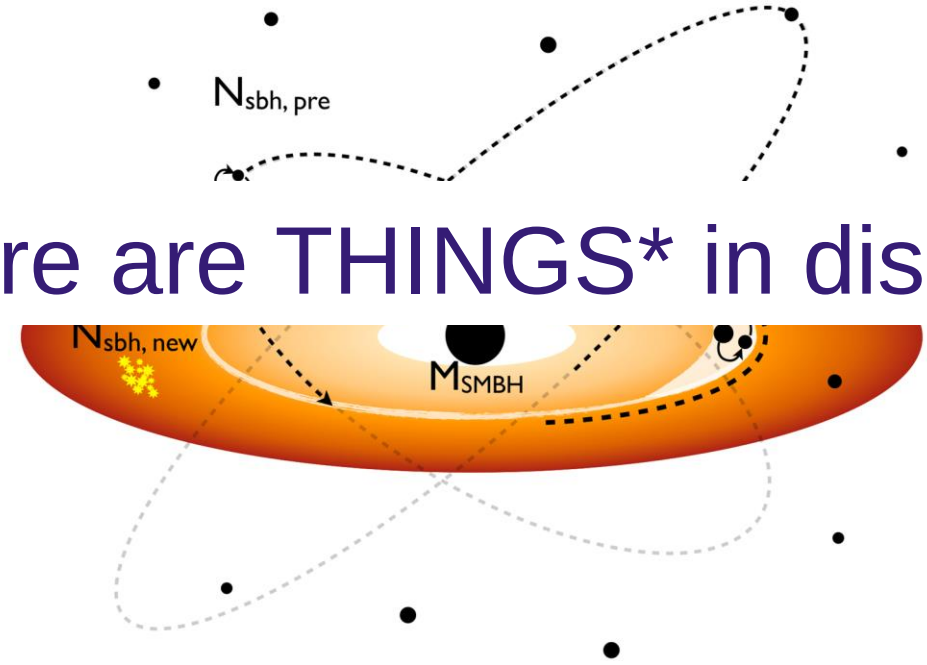
Genzel++ 2018

N_{sBH} ~2x10^4

Hailey++ 2018



A cartoon AGN



There are THINGS* in disks!

McKernan, Ford++ 2012
McKernan, Ford++ 2014
Bellovary++ 2016
Bartos++ 2017
Stone++ 2017
McKernan, Ford++

*THINGS may cause: BBH mergers, SNe, TDEs, turbulence, heating… and death. Astrophysicists are not liable for any adverse effects. Ask your astrophysicist about THINGS today.

ge credit: O'Dowd

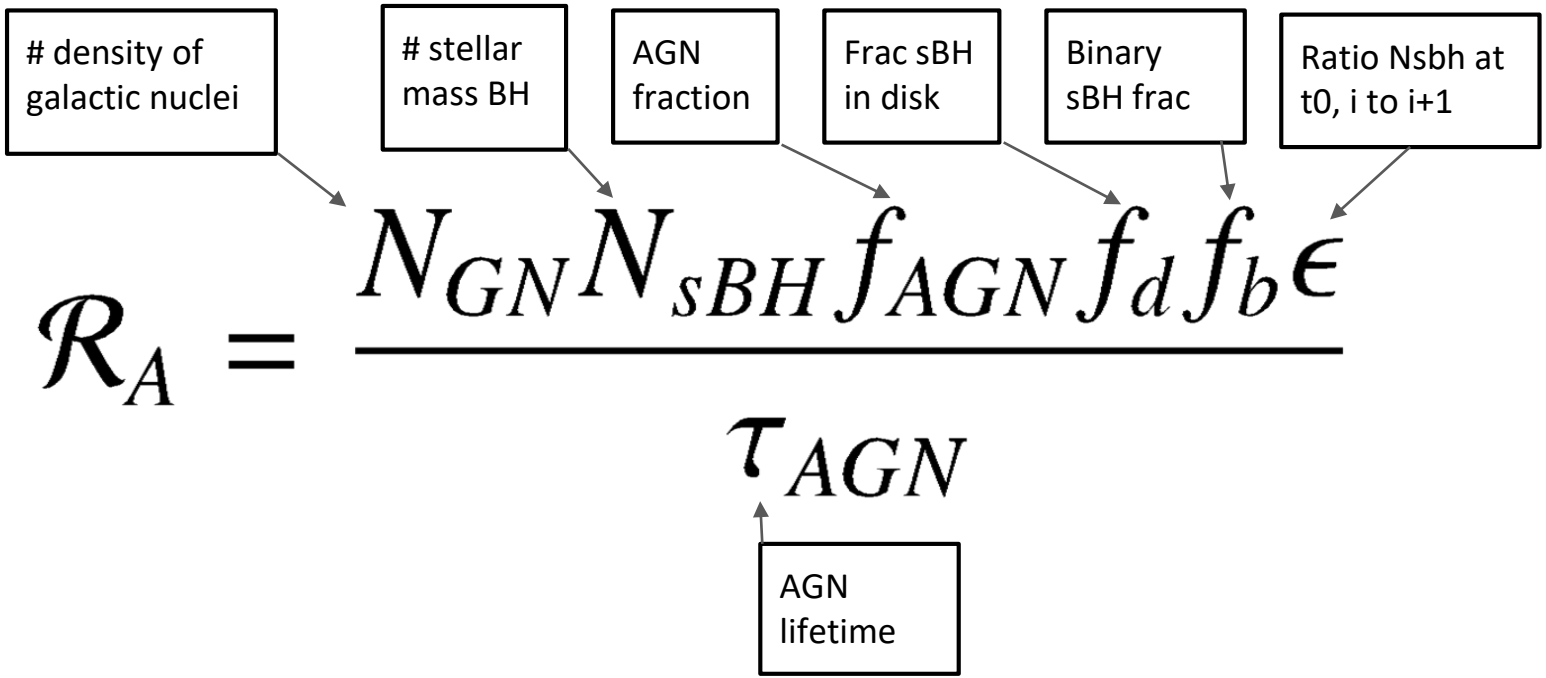
A Parameterized Rate Equation

$$\mathcal{R}_A = \frac{N_{GN} N_{sBH} f_{AGN} f_d f_b \epsilon}{\tau_{AGN}}$$

McKernan, Ford ++ 2018

arXiv:1702.07818

A Parameterized Rate Equation



McKernan, Ford ++ 2018

arXiv:1702.07818

Rate Values

Parameter	Lower	Upper
$N^a_{GN}(\mathrm{Mpc}^{-3})$	4×10^{-3}	10^{-2}
$N^b_{BH}(\mathrm{pc}^{-3})$	10^3	10^6
f^c_{AGN}	0.01	0.3
f_b	0.01	0.2
f^d_d	0.01	0.7
$\tau_{AGN}(\mathrm{Myr})$	1	100
ϵ	0.5	2
$\mathcal{R}(\mathrm{Gpc}^{-3}\ \mathrm{yr}^{-1})$	10^{-4}	10^4

McKernan, Ford++2018

It depends on the disk

f_d

-related to H/r,

f_b

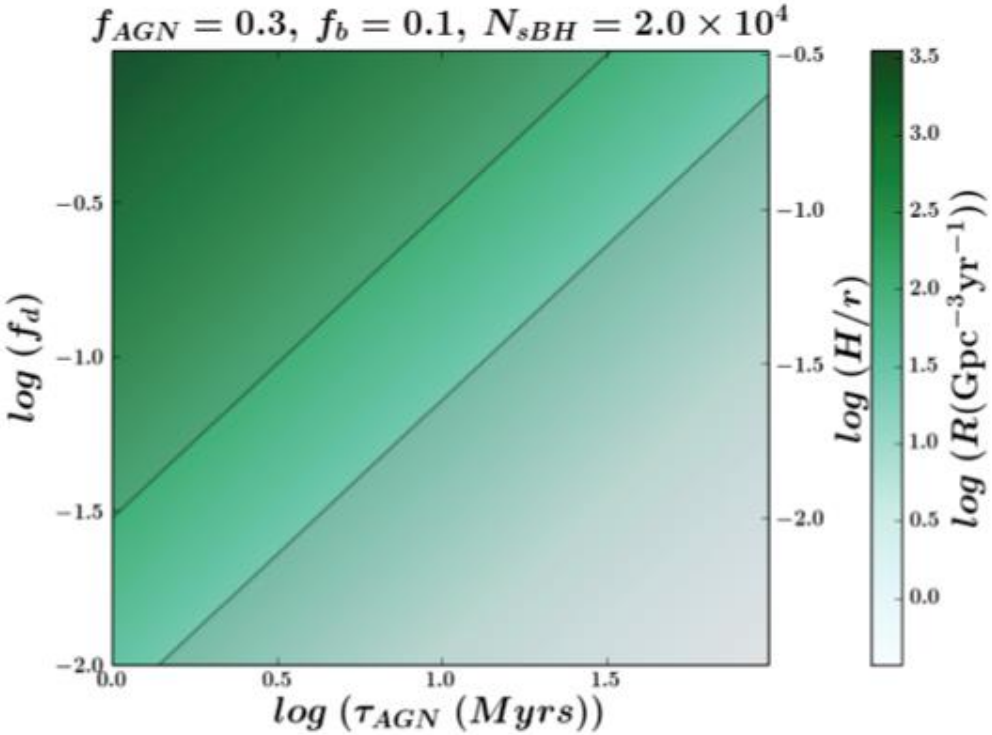
-related to t_{mig}, N_{sBH}, $d\Sigma/dr$

τ_{AGN}

-Why?

Also N_{sBH}, so NSC properties, IMF, etc.

LINERs: not optically thick RIAFs



Ford & McKernan 2019

What else can we learn?

Statistical inference: current localization + galaxy catalogs: 660 BBH events

Bartos++ 2017; Ford++ 2019

EM counterparts: multimessenger sources

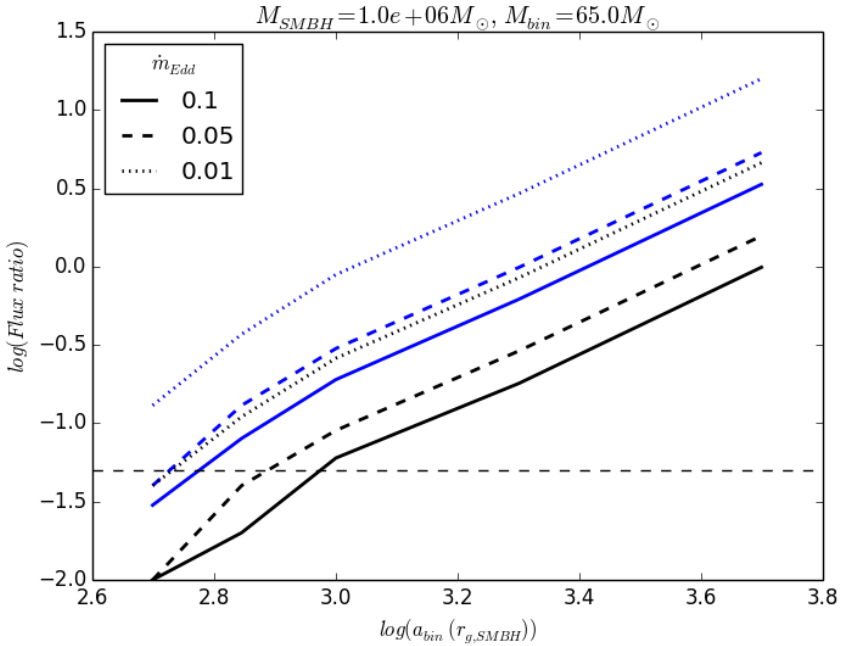
McKernan, Ford++ 2013, 2014, 2015

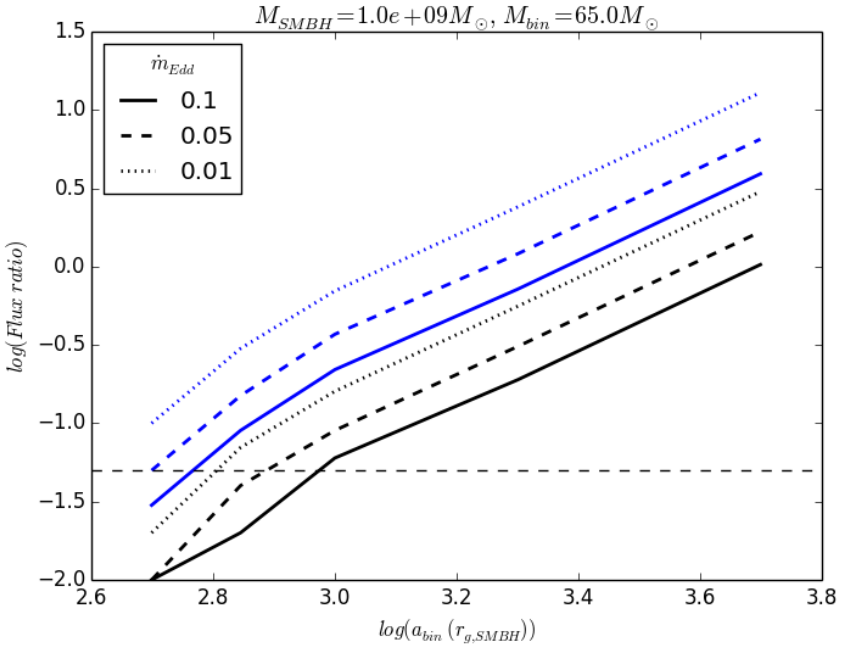
McKernan, Ford++ 2019: 1907.03746

Make lots of LISA sources

IMBH-SMBH binaries; evolution of multiband BBH

EM counterparts





McKernan, Ford++2019
Candidates! Graham++107.10

Even non-detections get us lots of info

1. Simulate universe
2. Simulate LIGO observations
3. Simulate EM followup

AGN become massive inverse problem

What we need

Improved galaxy catalogs (out to LIGO horizon redshifts)

Masses--to optimize EM followup

UV coverage

-Wide field/fast mosaicking

Theory work

-For the AGN inverse problem

-For LISA: multi-band evolution & IMRI waveforms

LISA data center: help non-GW astrophysicists