

[NAOJ]

*GWVerse Conference, Trieste 2020*

# Gravitational waves from accreting black hole binaries

Laura Sberna

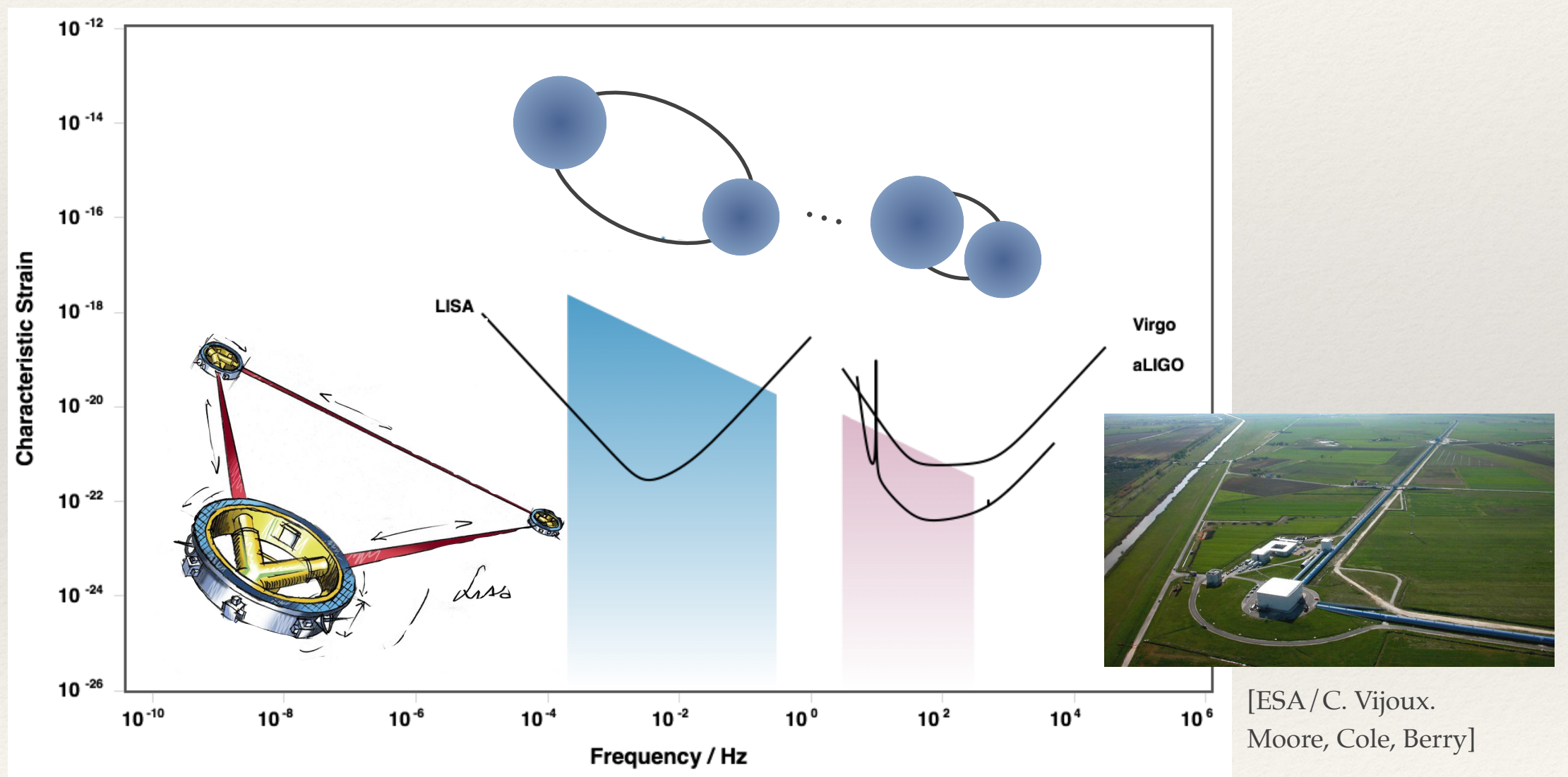


arXiv:2001.03620 ,with A. Caputo, A. Toubiana, S. Babak, E. Barausse, S. Marsat, P. Pani



# The LISA mission

LIGO and VIRGO are detecting stellar origin BHs, and studying their properties at **high GW frequencies**.

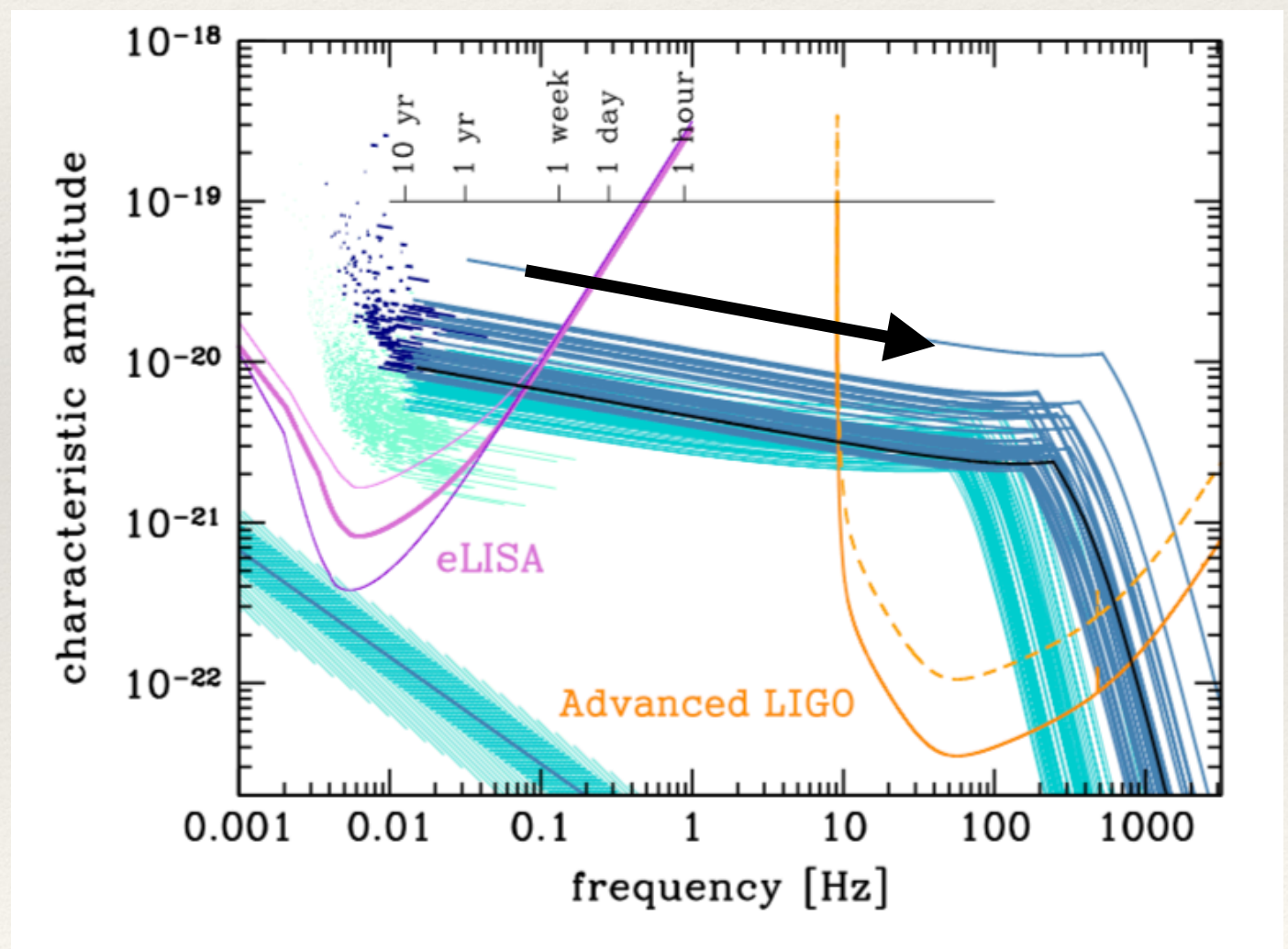


LISA will be sensitive to *properties* and *sources* that are relevant at **low frequencies**.



# Multiband observations

We will detect the same system in LISA and on the ground!  
**Small effects will accumulate.**



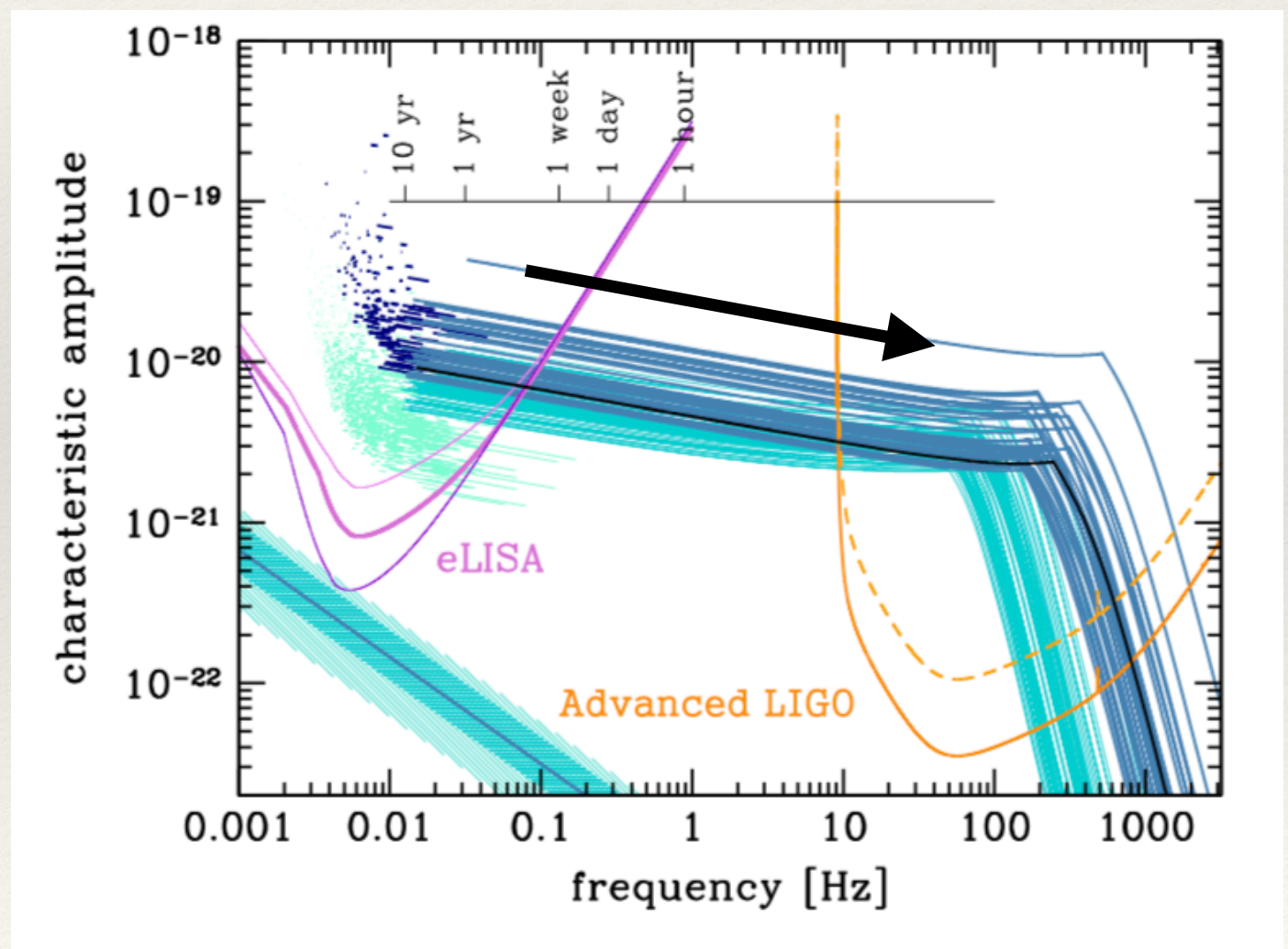


# Multiband observations

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Effects include

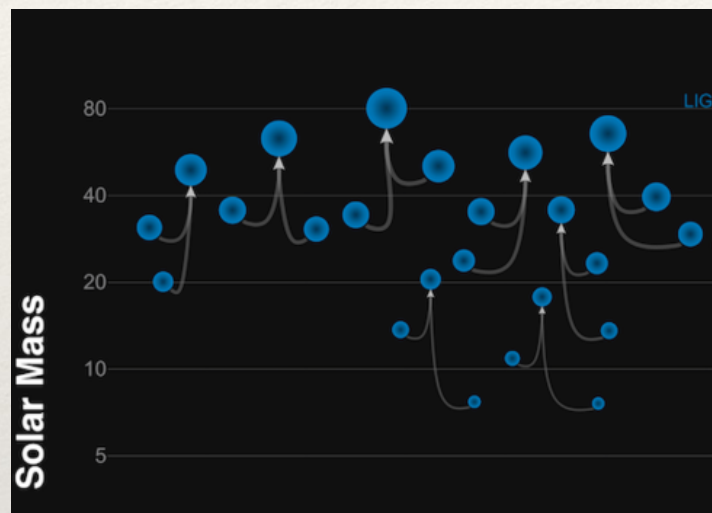
- modified-gravity corrections
- **environmental effects:**
  - ❖ Mass accretion
  - ❖ Peculiar acceleration
  - ❖ Electromagnetic fields
  - ❖ Dynamical friction
  - ❖ Planetary migration
  - ❖ Dark matter features (spikes)...





# Sources

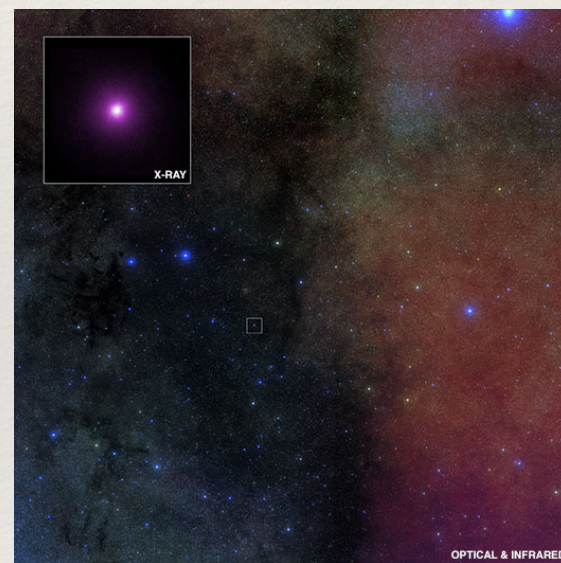
Stellar mass BH binaries,  $\lesssim 50 M_{\odot}$



AGN



ULX

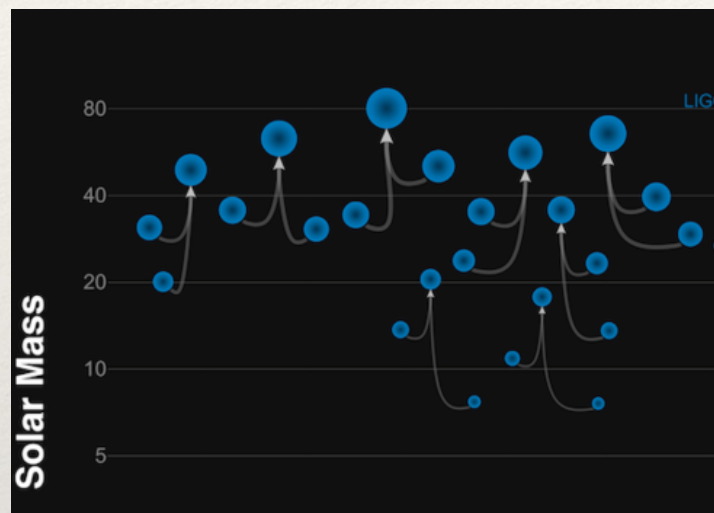


[NASA/CXC/Harvard/J.Neilsen;  
Palomar DSS2]



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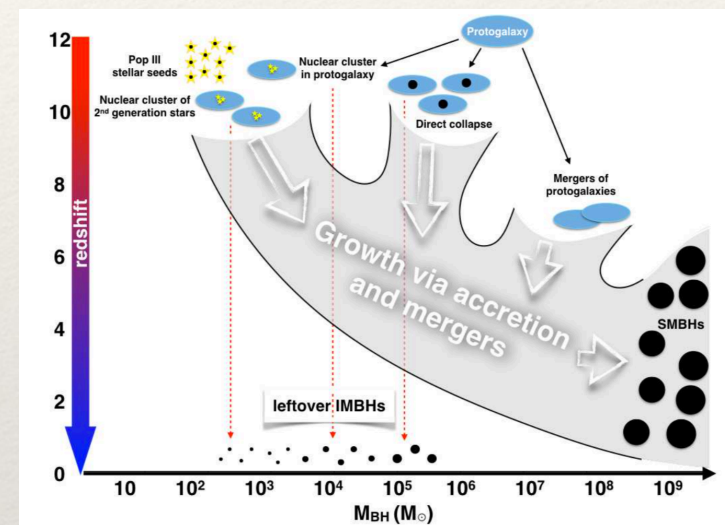
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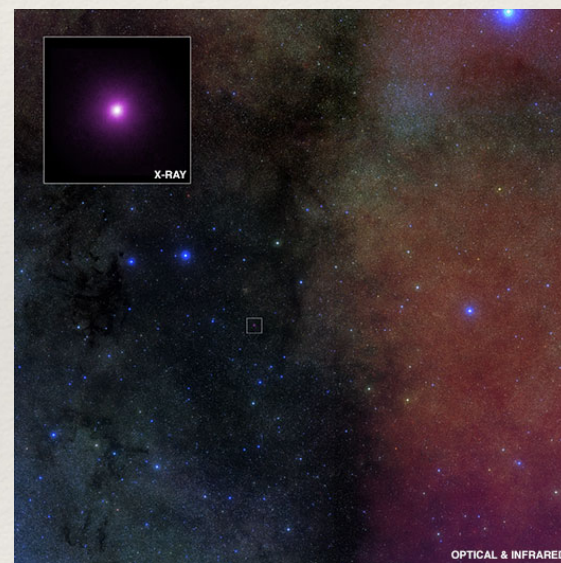
AGN



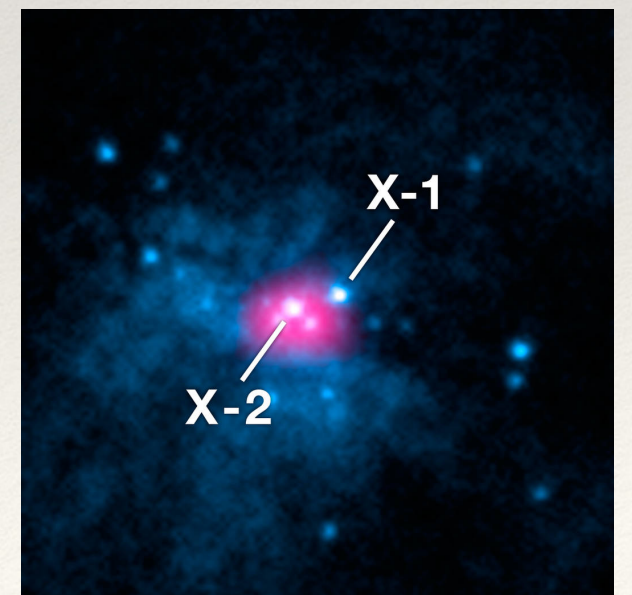
Intermediate mass BH binaries,  $10^2 - 10^5 M_{\odot}$



ULX



[NASA/CXC/Harvard/J.Neilsen;  
Palomar DSS2]



[NASA/JPL-Caltech/SAO]

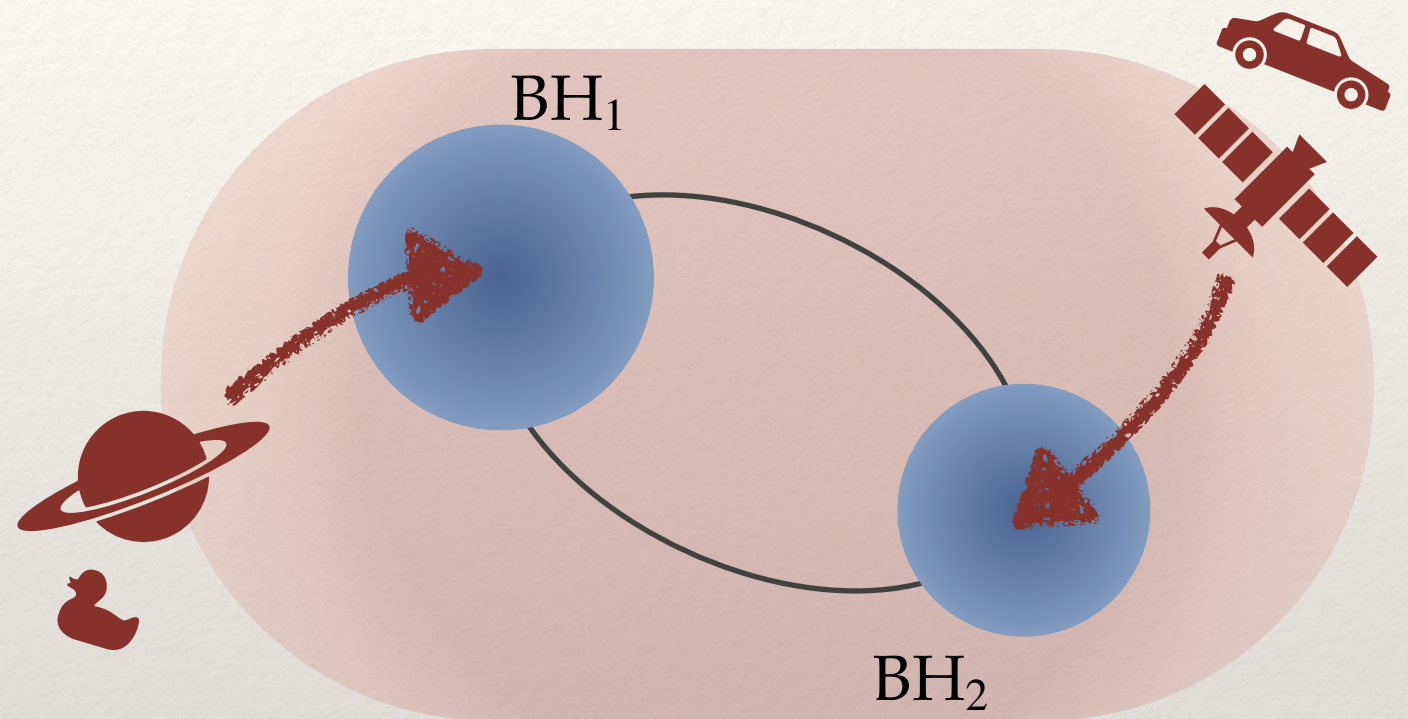


# Mass accretion

Each mass grows in time according to the **Eddington ratio**:

$$f_{\text{Edd}} = \frac{\dot{m}_i}{\dot{m}_{\text{Edd}}},$$

$$\dot{m}_{\text{Edd}} \simeq 2.2 \times 10^{-8} \left( \frac{m_i}{M_{\odot}} \right) M_{\odot} \text{ yr}^{-1}$$



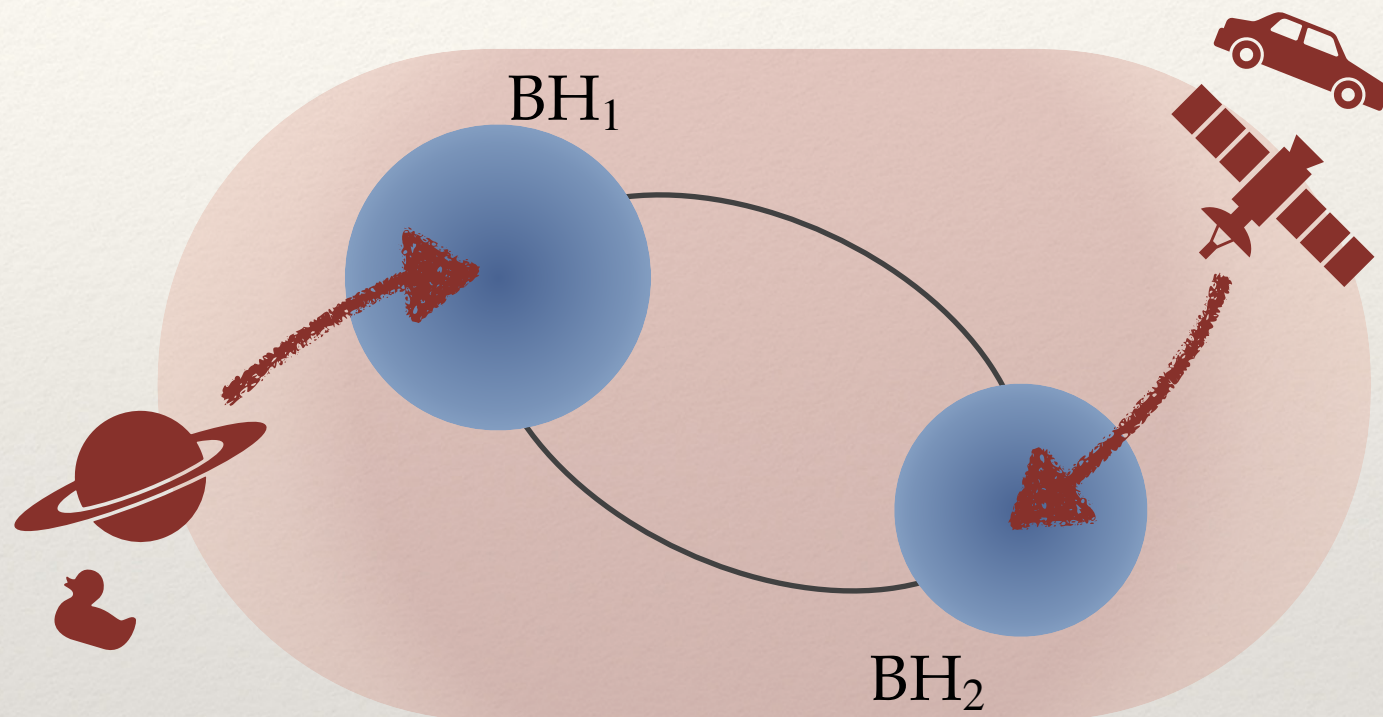


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Accretion affects the waveform at **-4 PN** order (and higher):

$$\phi \sim f_{\text{Edd}} f^{-13/3}$$

relative to the leading-order radiation-reaction term (  $\sim f^{-5/3}$  )



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# Stellar mass: Event rates

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The **number of events with relative error on  $f_{\text{Edd}} = 100\%, 50\%, 10\%$**   
based on mock astrophysical catalogues and Fisher matrix analysis.

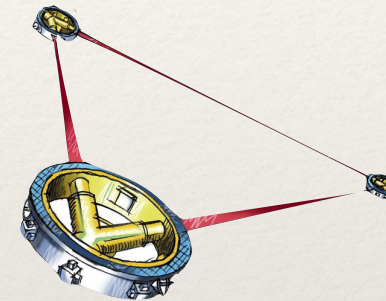
	LISA+Earth					LISA-only				
Duration	All	$f_{\text{Edd}}$	100%	50%	10%	All	$f_{\text{Edd}}$	100%	50%	10%
4 yr	$88 \pm 8$	1	$0.1 \pm 0.2$	0	0	$77 \pm 8$	1	0	0	0
		10	$4.1 \pm 2.3$	$1.7 \pm 1.2$	$0.1 \pm 0.2$		10	$1.6 \pm 1.4$	$0.6 \pm 0.6$	0
10 yr	$207 \pm 11$	1	$5.2 \pm 1.9$	$1.1 \pm 1.2$	$0.1 \pm 0.2$	$182 \pm 10$	1	$1.5 \pm 1.2$	$0.4 \pm 0.7$	0
		10	$36 \pm 4$	$32 \pm 3$	$5.2 \pm 1.9$		10	$11 \pm 3$	$9.5 \pm 2.7$	$1.5 \pm 1.2$



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## Multiband



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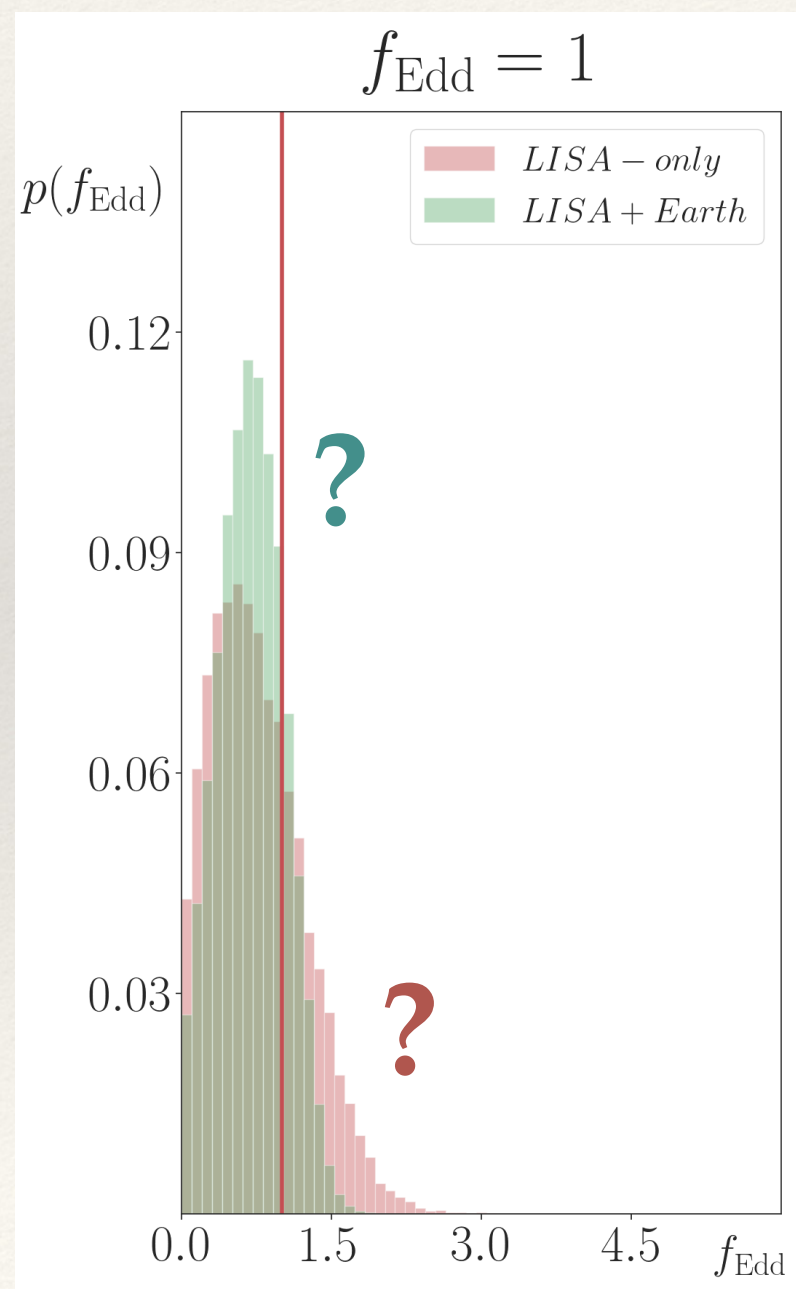
## Eddington/super Eddington





# Stellar mass: Detection

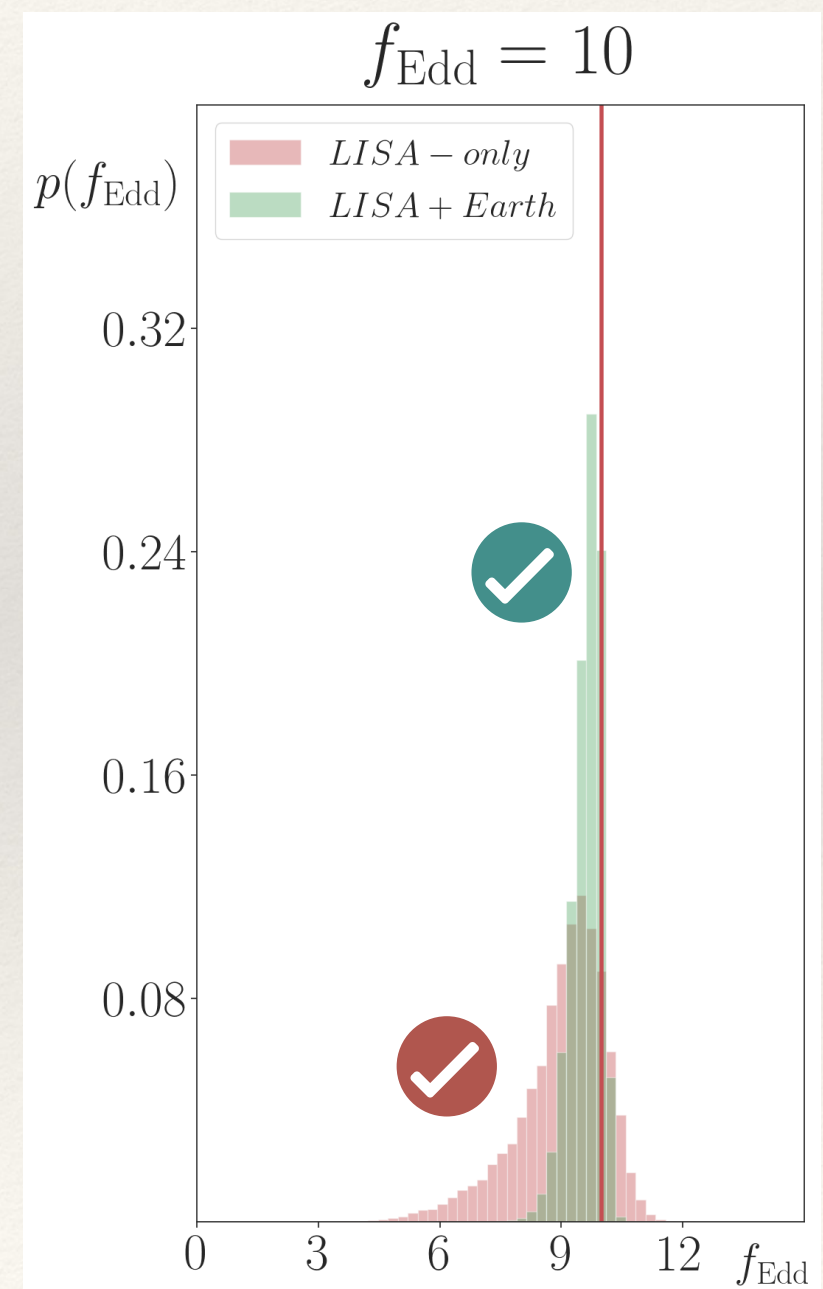
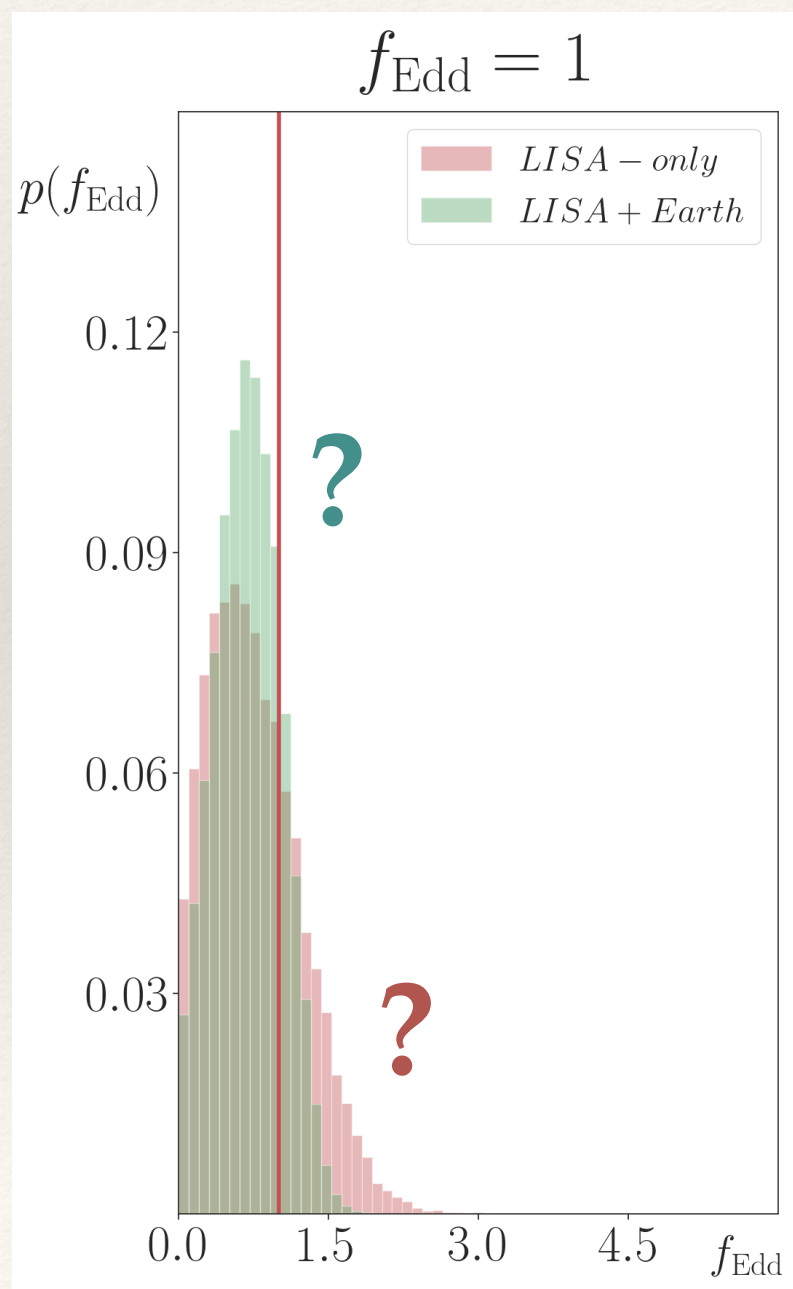
The effect of **multiband** (constraining prior on merger time  $t_c$ )





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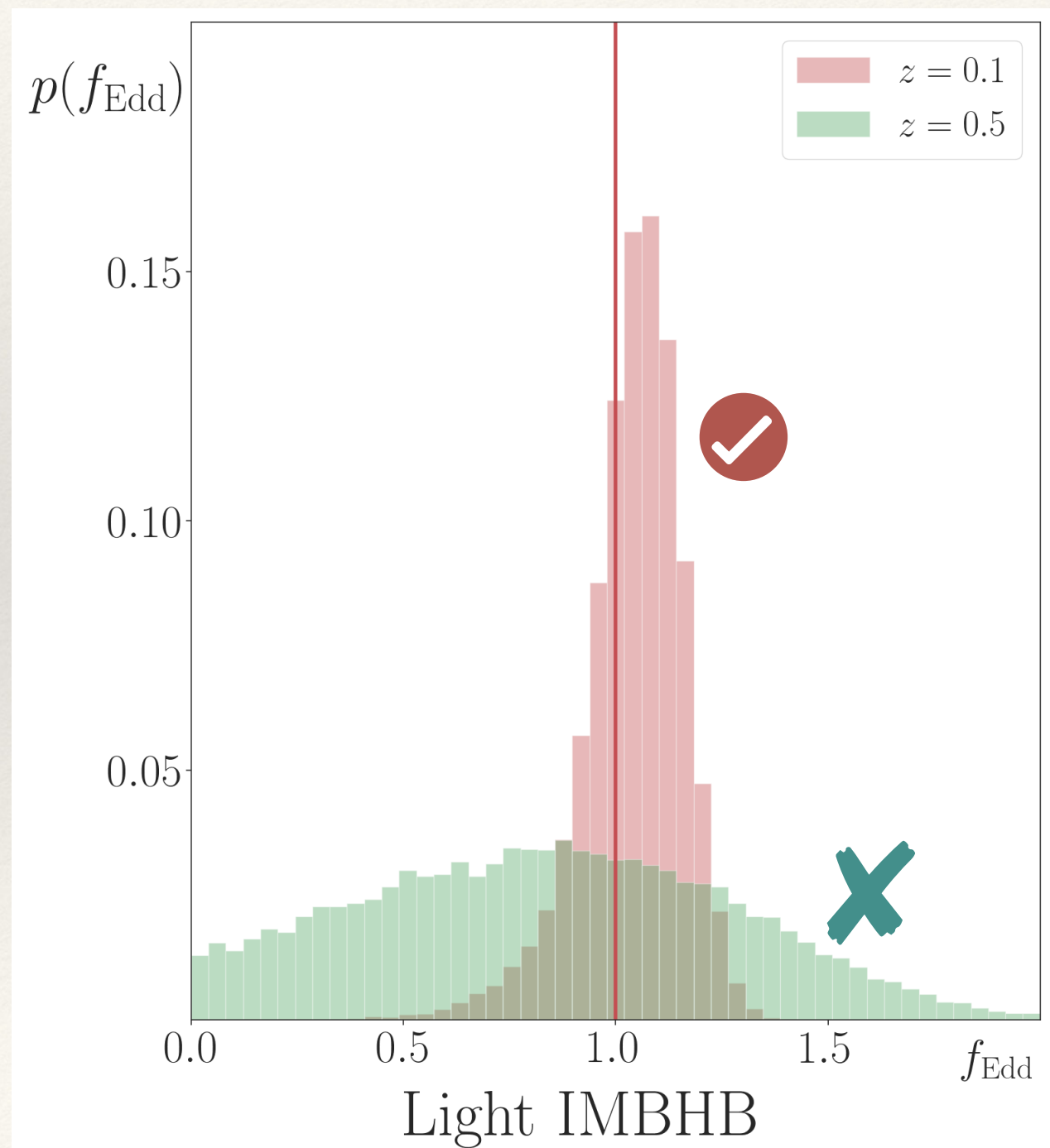
The effect of **multiband** (constraining prior on merger time  $t_c$ )





# Intermediate mass: Detection across redshift

$$f_{\text{Edd}} = 1$$



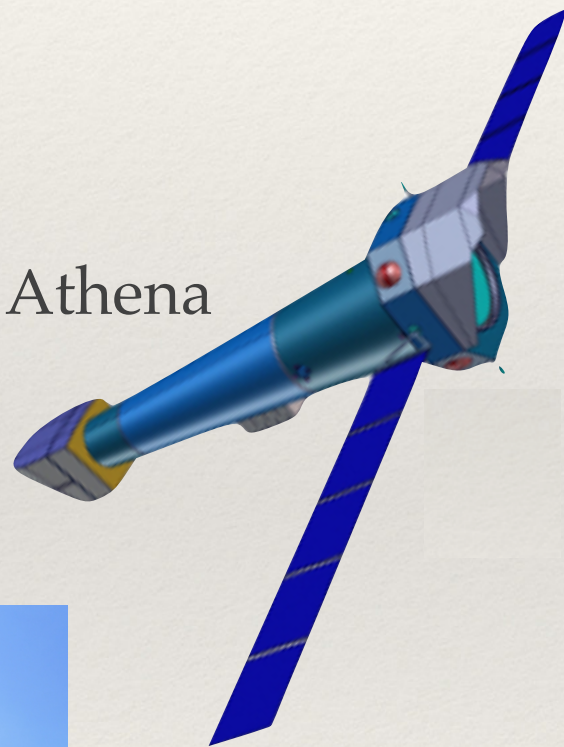


# Electromagnetic counterparts

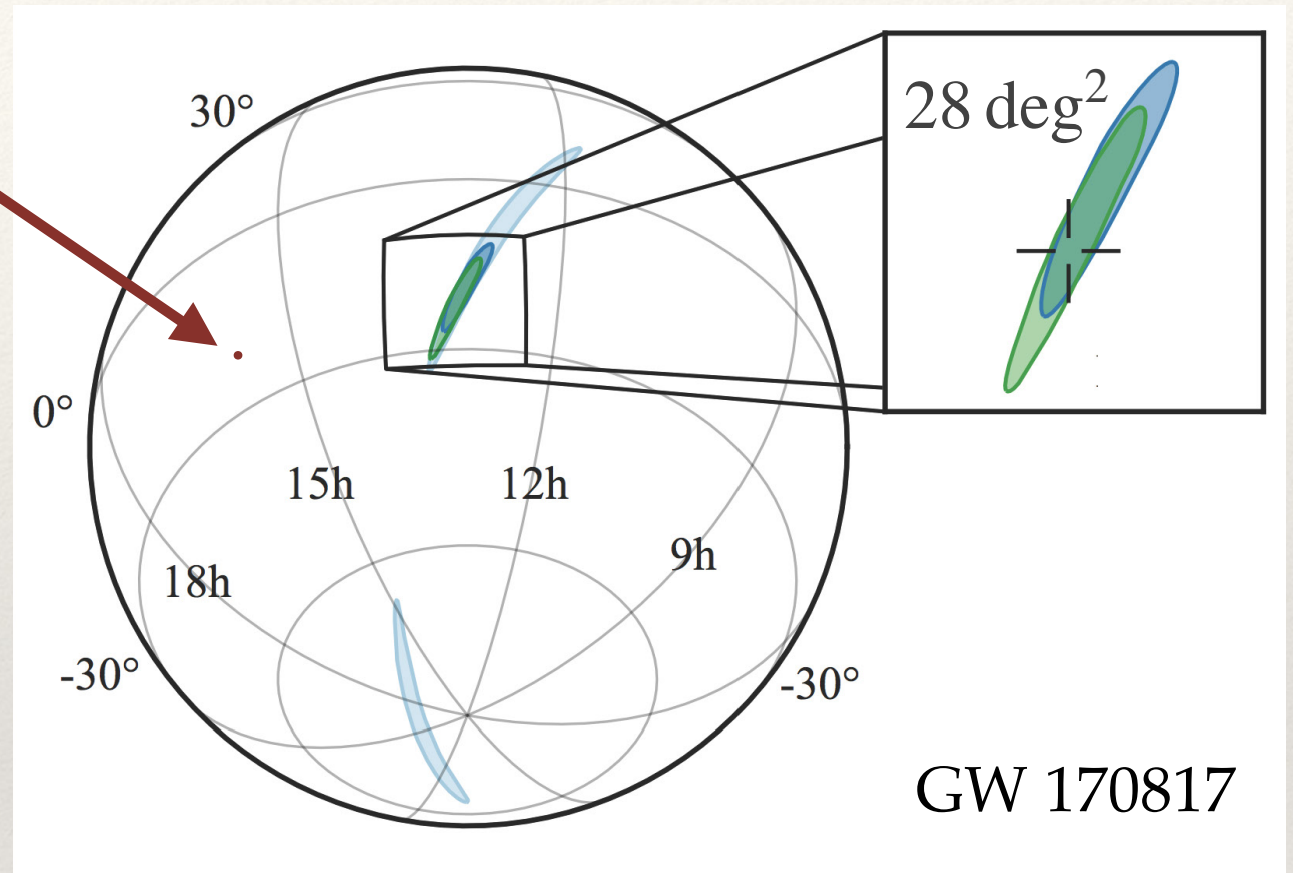
[slide: A. Toubiana]

$< 0.4 \text{ deg}^2$

Athena



SKA



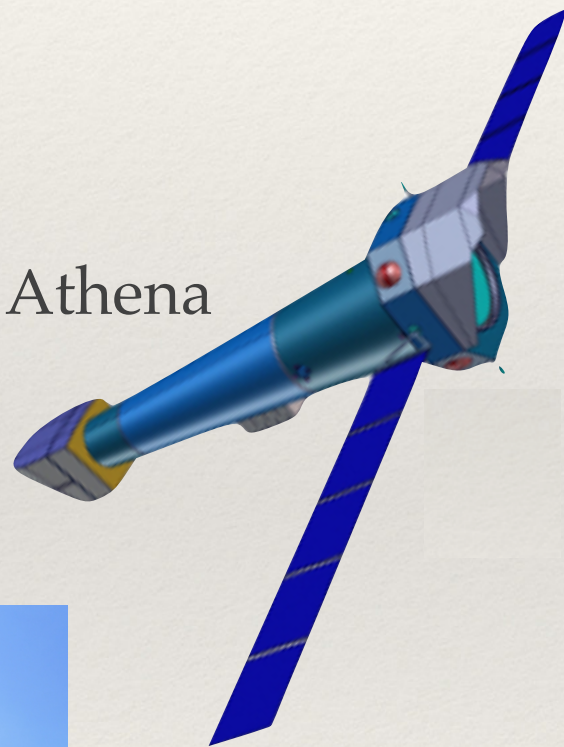


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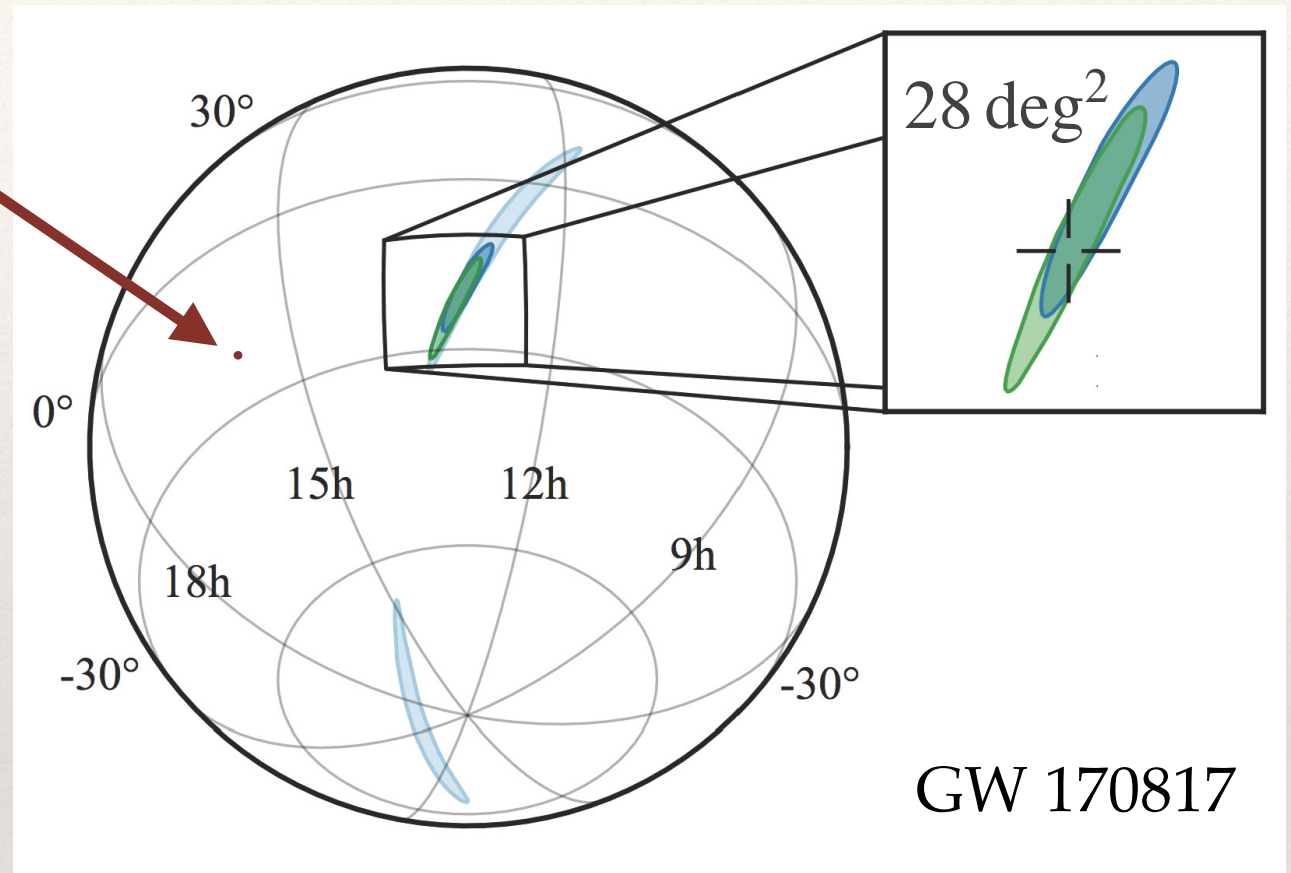
[slide: A. Toubiana]

$< 0.4 \text{ deg}^2$

Athena



SKA



**Intermediate mass:**

- ❖ After merger flare (radio) ✓
- ❖ Accretion emission (x-ray) ✓

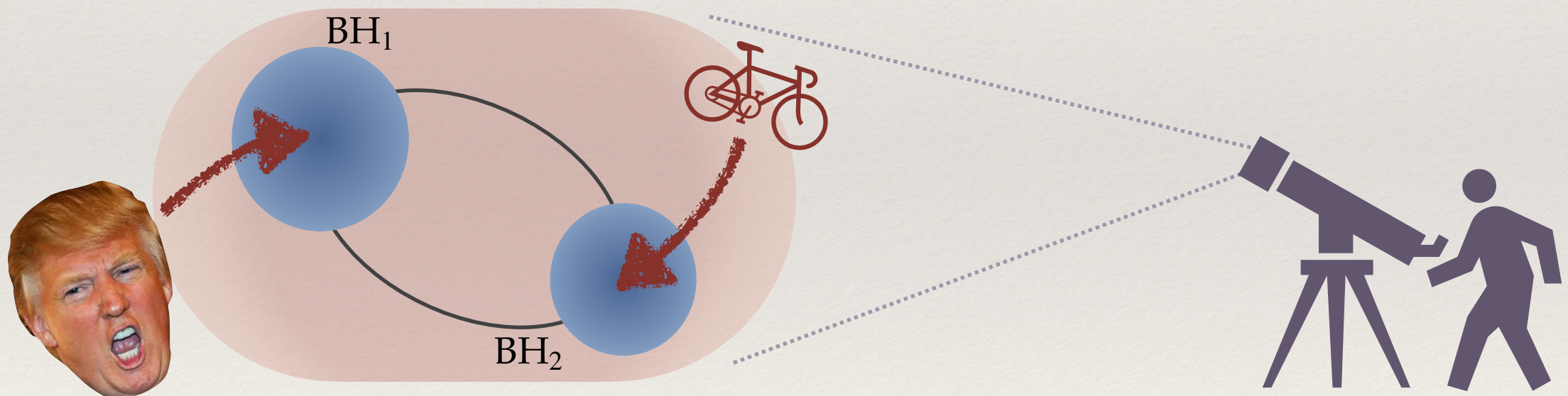
**Stellar mass: ?**



# Make Accretion Great Again

**Accretion could be detected** if  $\sim$  above Eddington rate,  $f_{\text{Edd}} \simeq 1 - 10$ :

- ❖ Confirmed by **Fisher** and **MCMC** analysis
- ❖ In stellar mass and intermediate mass black holes
- ❖ If accretion not included, **bias** in some parameters
- ❖ Detectable **EM counterparts** from IMBHBs

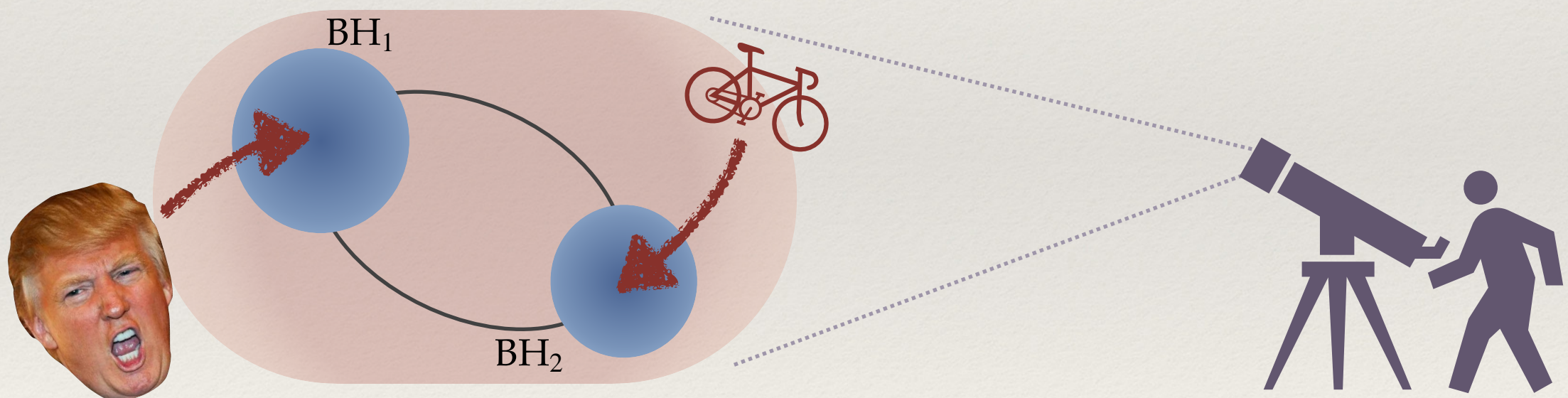




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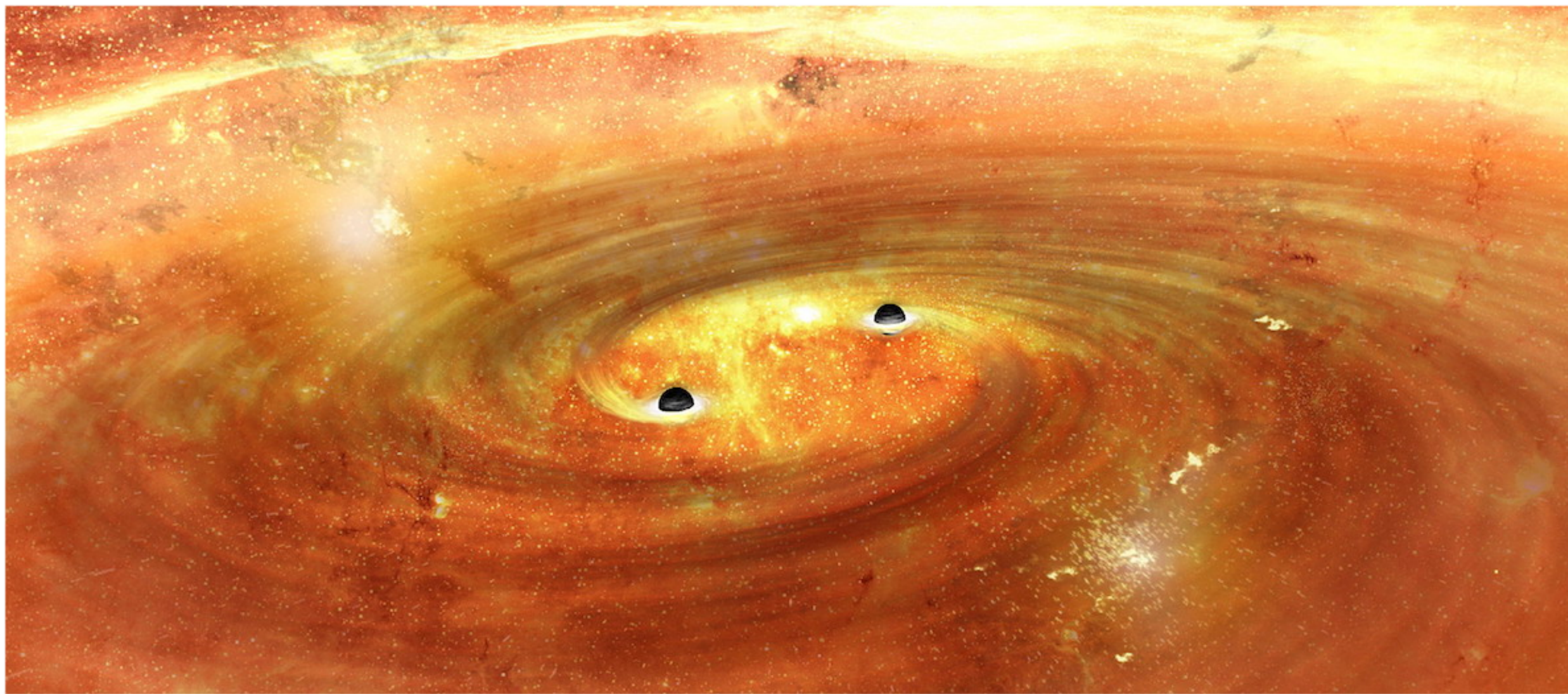
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*Important to understand BH formation and accretion mechanisms,  
assess modifications of gravity, cosmology?*





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**Thank you!**

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