Eliminating the LIGO bounds on PBH dark matter

Zachary S.C. Picker

ICTS INTERNATIONAL CENTRE for THEORETICAL SCIENCES
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PBHs as Dark Matter

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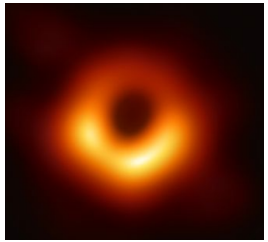
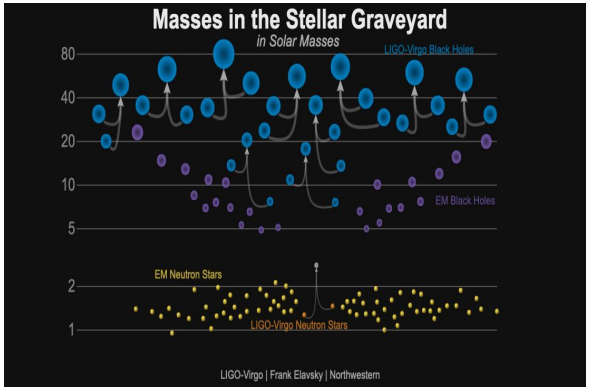
PBHs as Dark Matter

The good:





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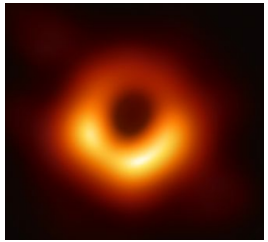

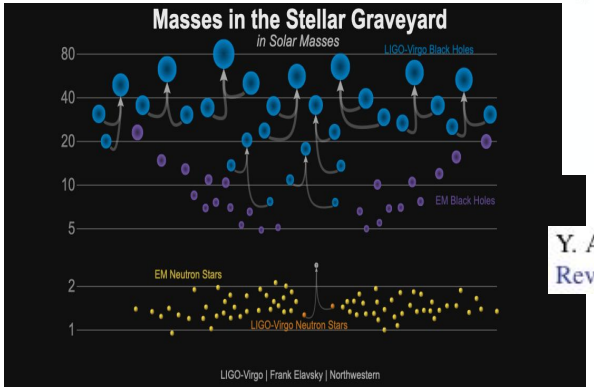

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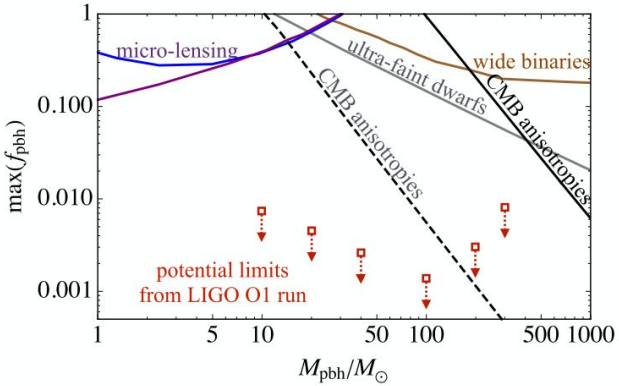

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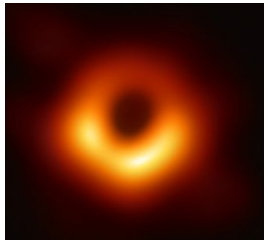

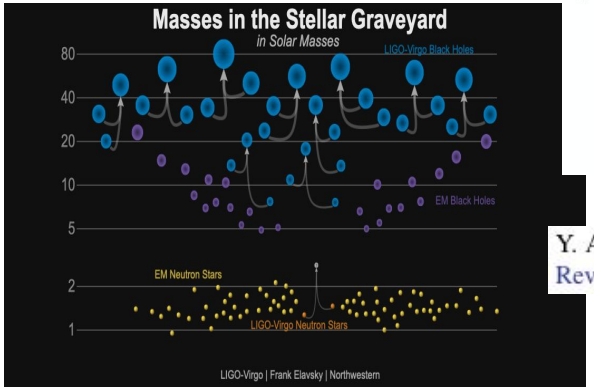

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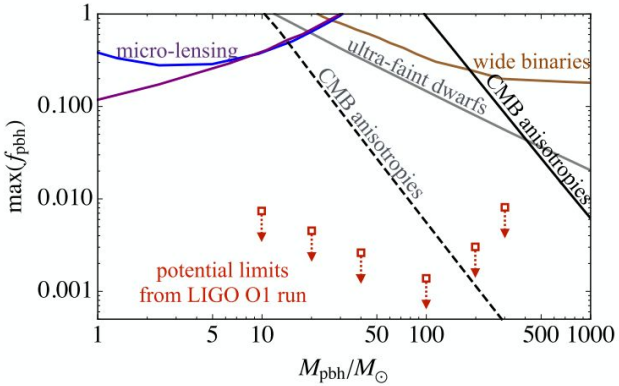

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The smugly (uncertain):

Accretion limits :

theoretical uncertainties

Dynamical limits :

modelling & astro. uncertainties

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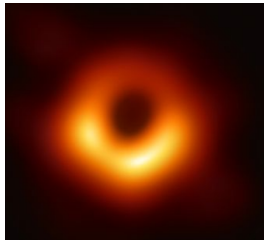

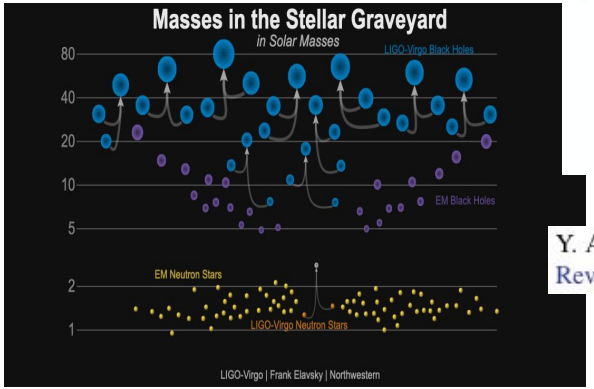

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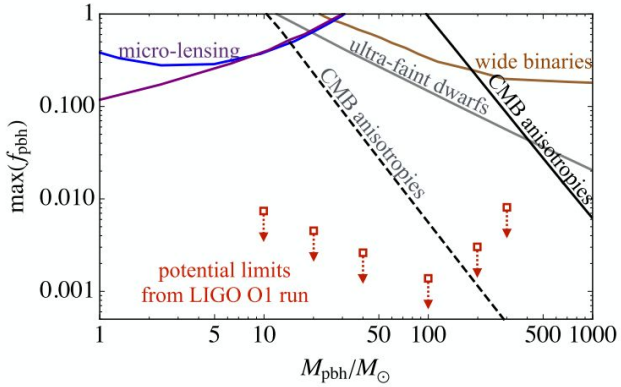

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<u>Any</u> early universe limit :

Black hole metrics in FLRW background

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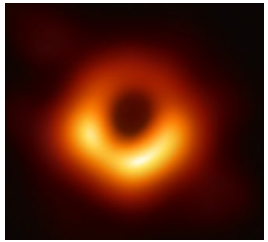

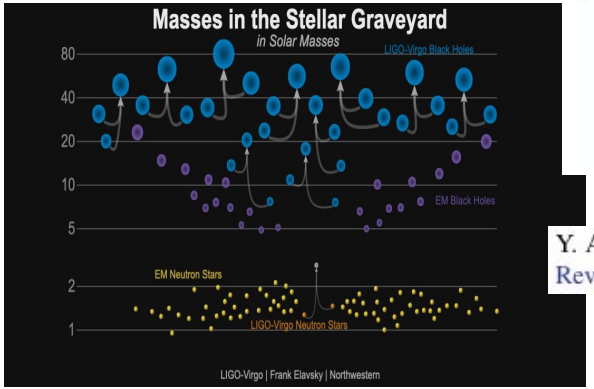

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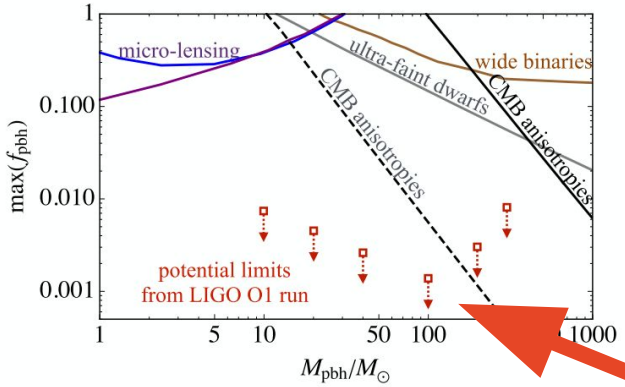

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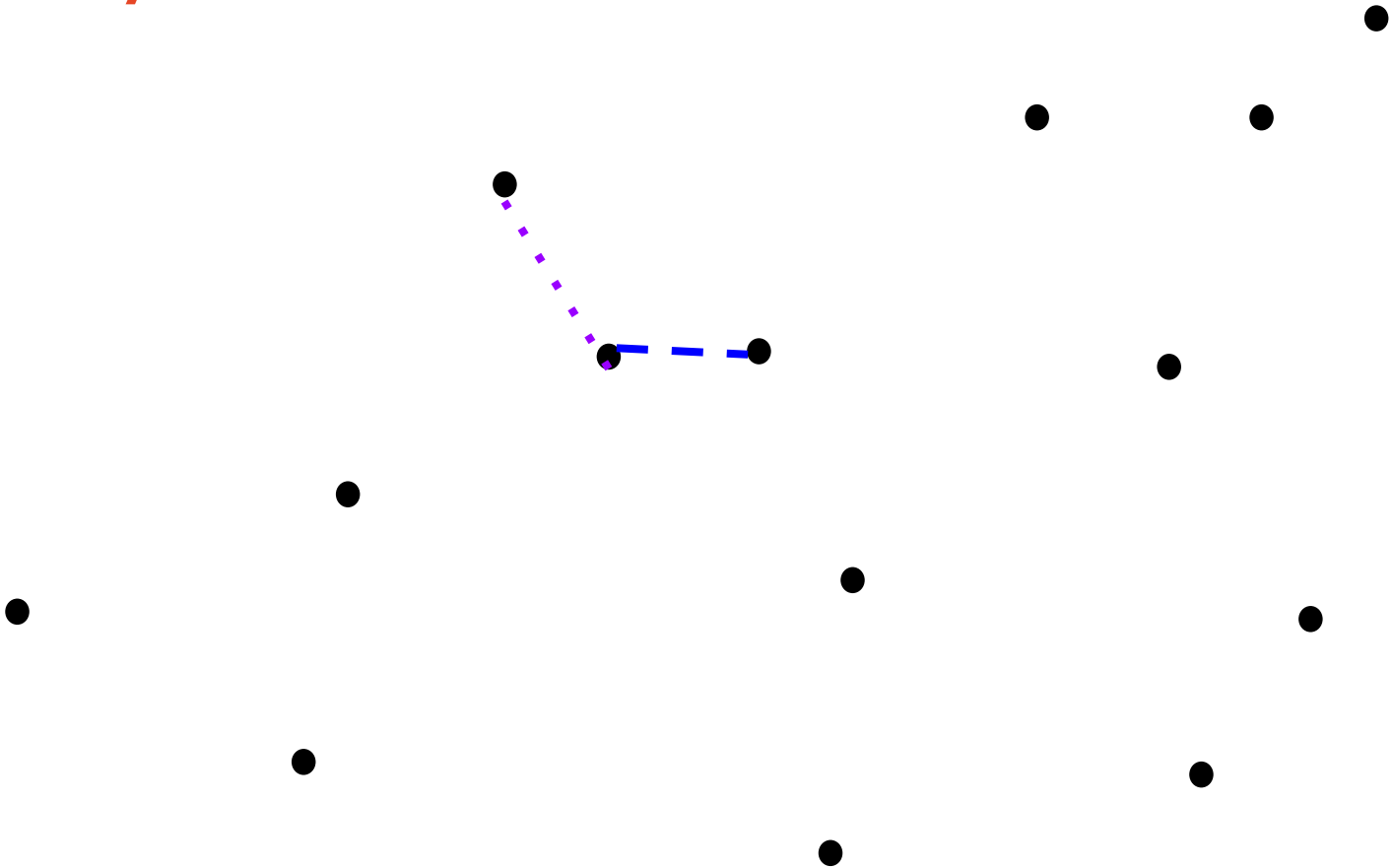
Binary Abundance Limits



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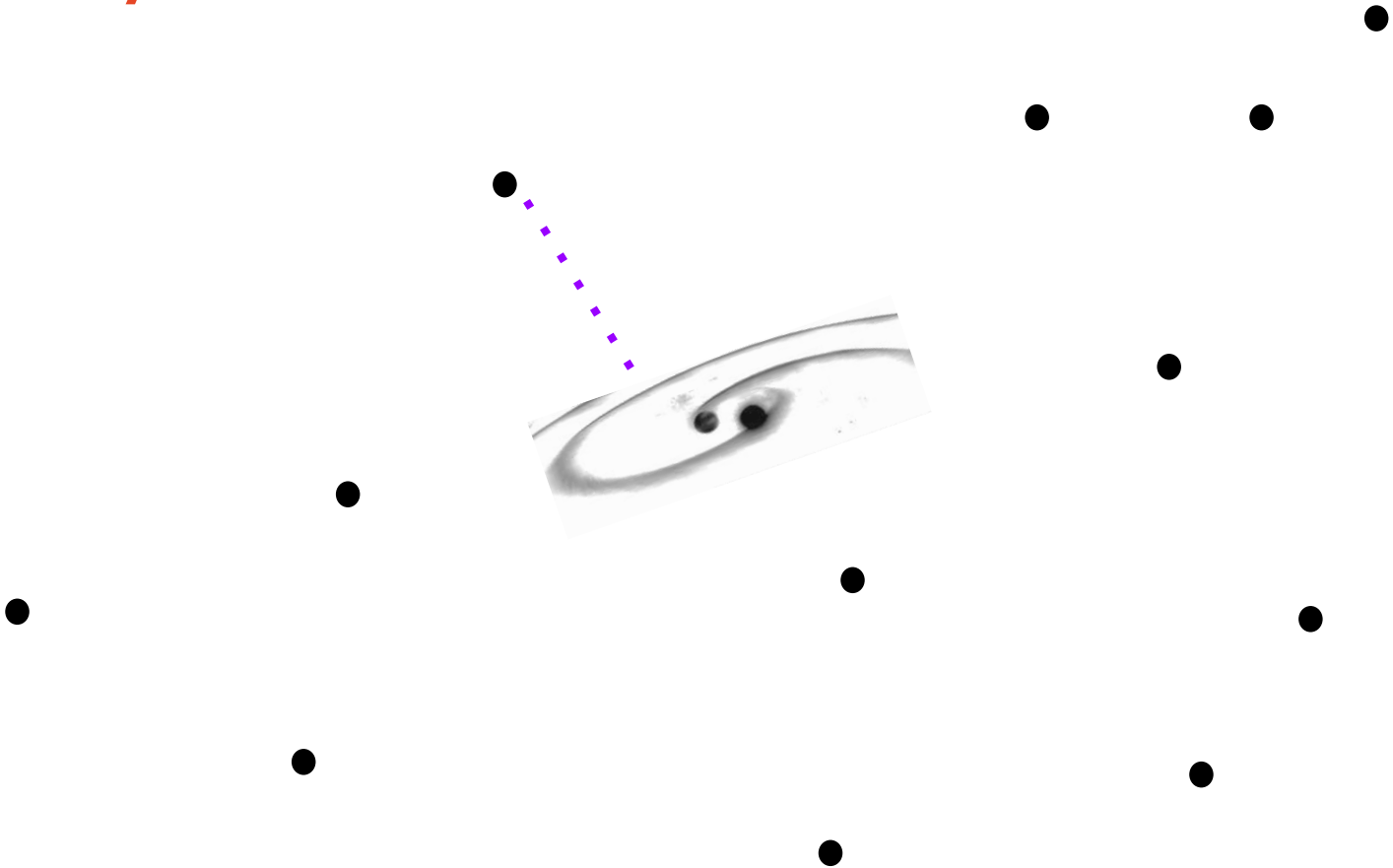

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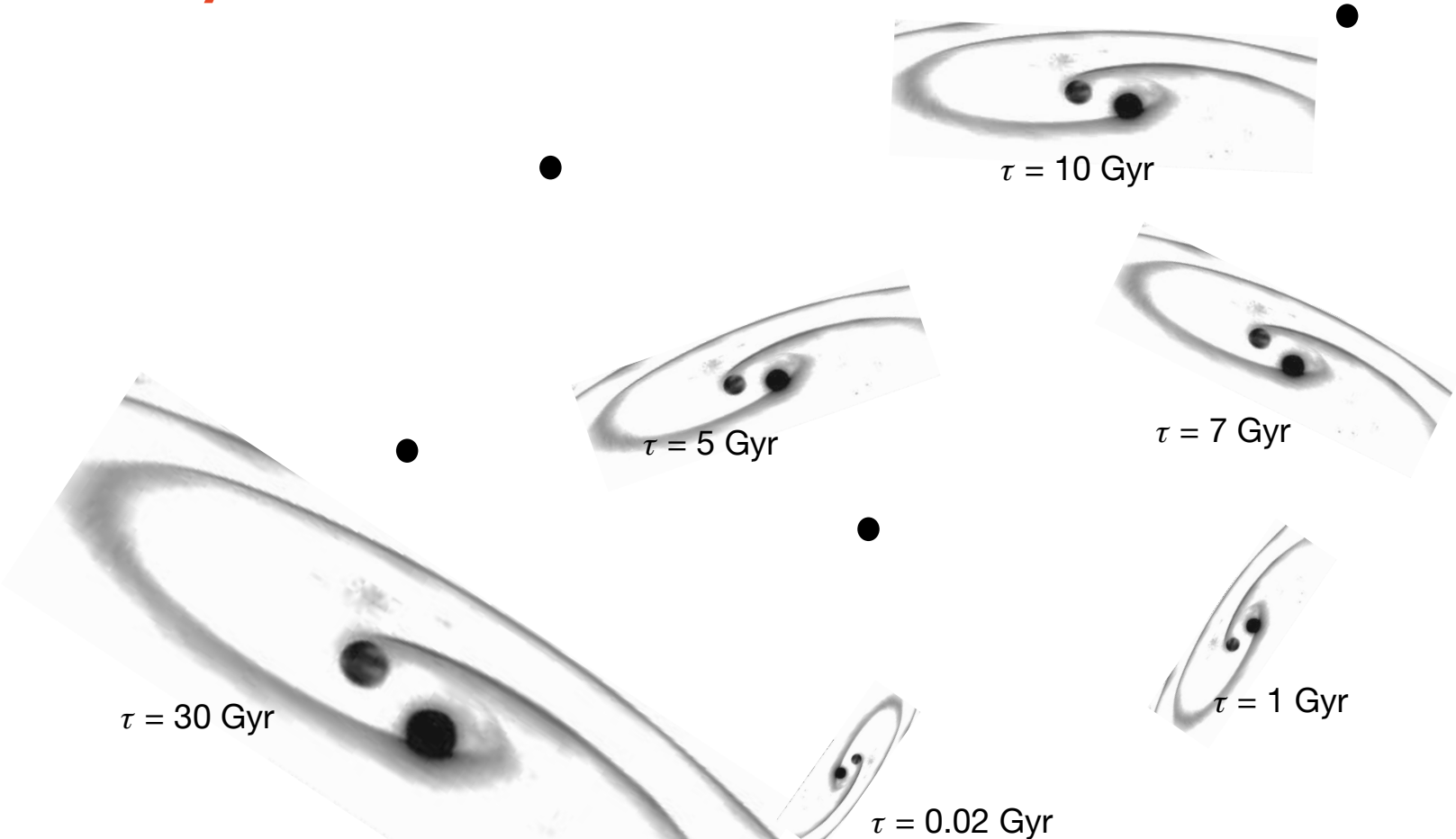

The problem

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Schwarzschild metric is not useful

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Inherently GR effect

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What mass to use?

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Schwarzschild metric is not useful

Inherently GR effect

What mass to use?

$$1 - \frac{2M_{MSH}}{R} \equiv \nabla^c R \nabla_c R$$

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Cosmological Black Holes

Einstein-Strauss

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Cosmological Black Holes

~~Einstein-Strauss~~: can never decouple

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McVittie

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Cosmological Black Holes

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~~McVittie~~: naked singularity -> pathologies

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Generalized McVittie

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Generalized McVittie

↓

Thakurta Metric: $\mathrm{d}s^2 = a^2 \mathrm{d}s^2_{schw.}$

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Cosmological Black Holes

~~Einstein-Strauss~~: can never decouple

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Generalized McVittie

↓

Thakurta Metric: $\mathrm{d}s^2 = a^2 \mathrm{d}s^2_{schw.}$

↓

Local mass: $m_{\mathrm{MS}} = ma(t) + \dfrac{H^2 R^3}{2Gf(R)}$

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Decoupling Conditions

Previous:

$$\ddot{R} = \frac{\ddot{a}}{a} R - \frac{Gm}{R^2}$$

$$\frac{m}{V} \gtrsim \rho$$

Thakurta PBH:

$$\ddot{R} = -\frac{Gma}{R^2} + \frac{\ddot{a}}{a} R$$

$$\frac{ma(t)}{V} \gtrsim \rho$$

and

$$E = -GM\mu a^2/(2R)$$

$$\dot{R}/R = -\dot{E}/E + 2H$$

$$\boxed{\dot{E}/E > 2H}$$

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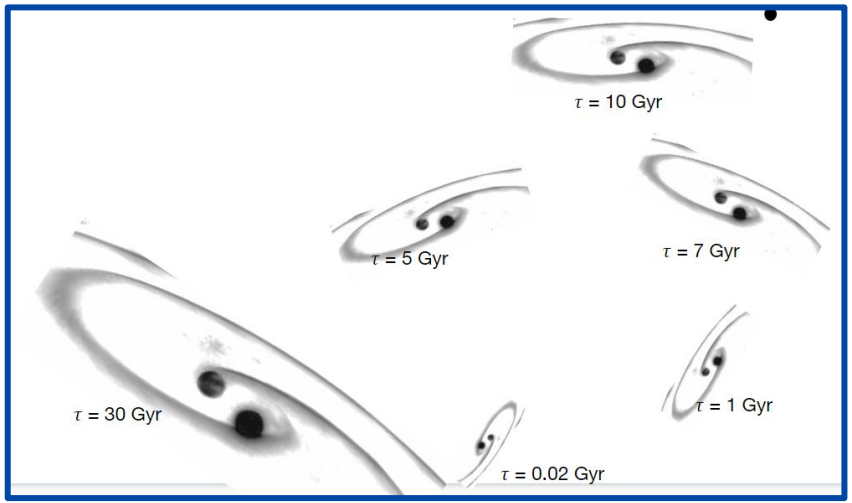
Thakurta Binary Abundances

Previously

At matter-radiation equality:



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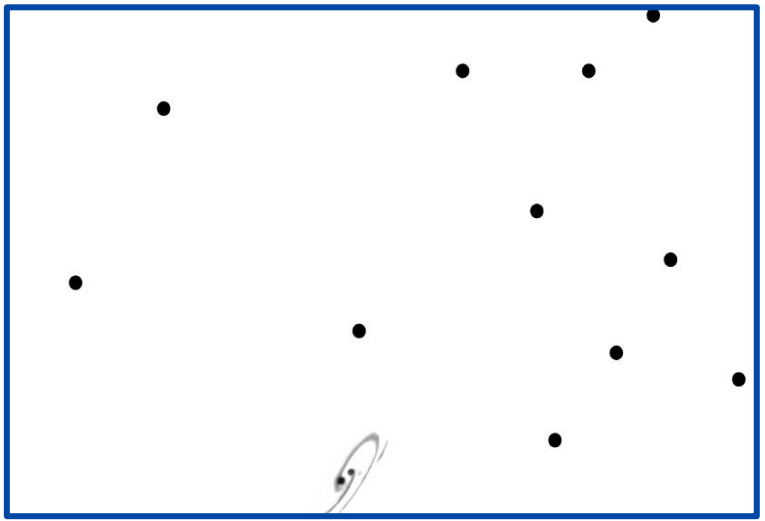

τ_{max} ~ 100 sec (!)

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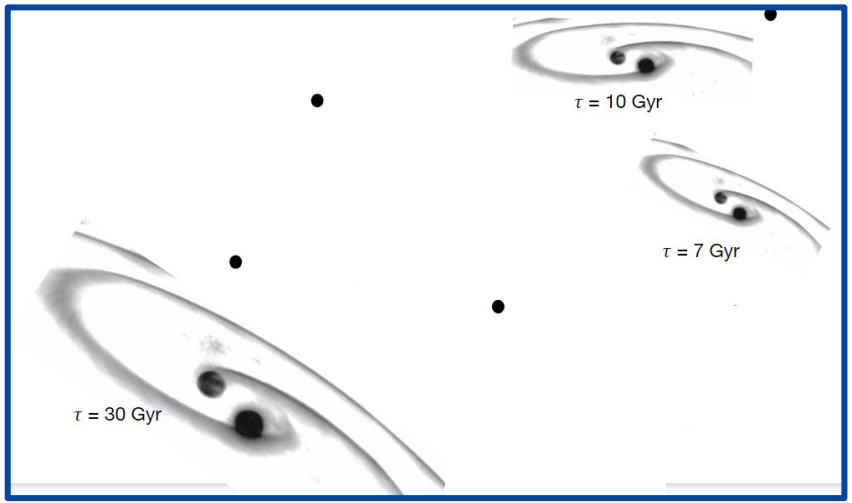
Thakurta Binary Abundances

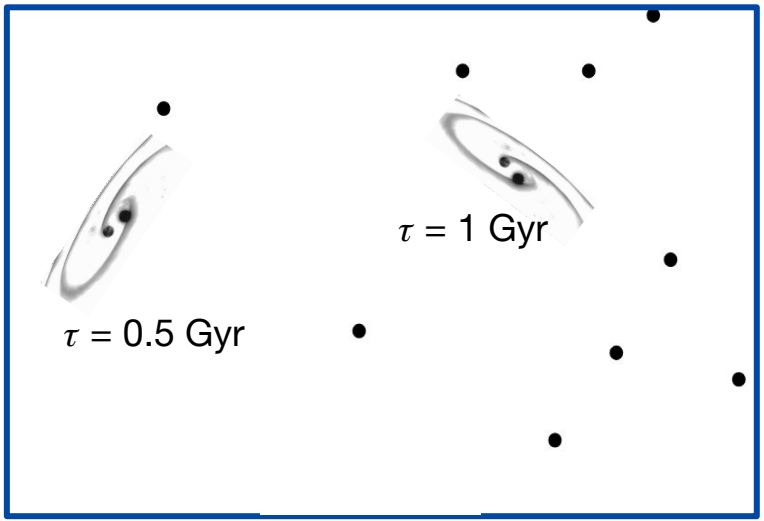
Previously

At z=1 (~7 Gyr ago)



Our work

At z=1 (~7 Gyr ago)



τ_{max} ~ 1 Gyr

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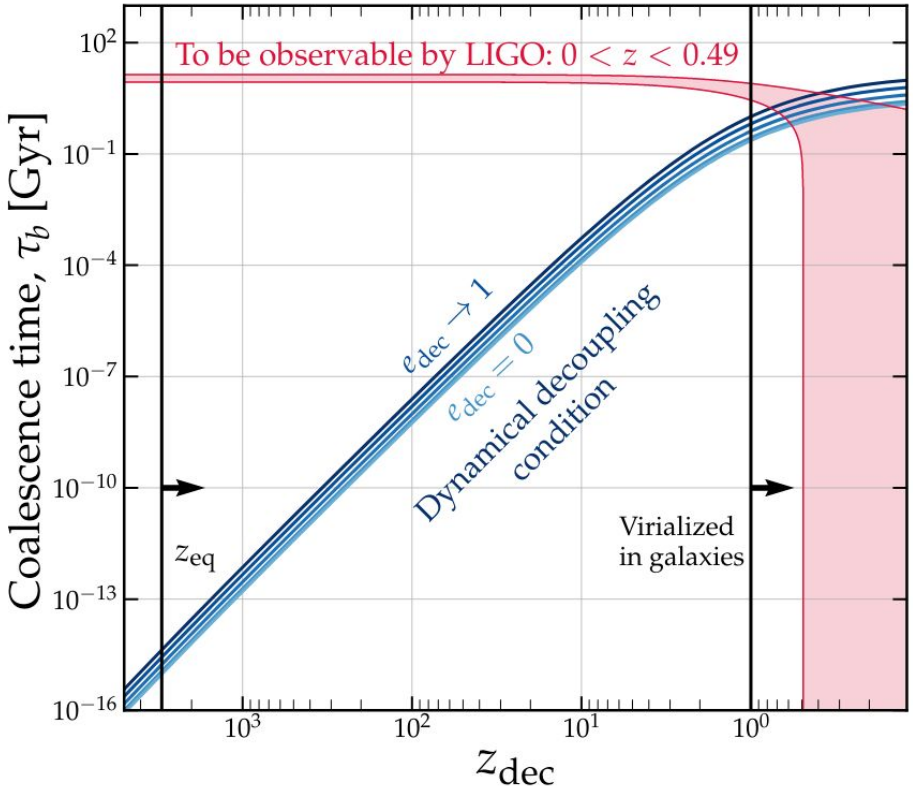

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Conclusions

Binary formation limits are totally avoided

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Huge effects from modelling PBHs cosmologically!

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A lot of work to do now...

Thanks for listening!

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and

$$E = -GM\mu a^2/(2R)$$

$$\dot{R}/R = -\dot{E}/E + 2H$$

$$\dot{E}/E > 2H$$

$$(1+z_{\rm dec})^3 H(z_{\rm dec}) < \frac{1}{\tau_b}\frac{96}{425}\left(1 + \frac{73}{24}e_{\rm dec}^2 + \frac{37}{96}e_{\rm dec}^4\right)$$