Inflation and Dark Matter

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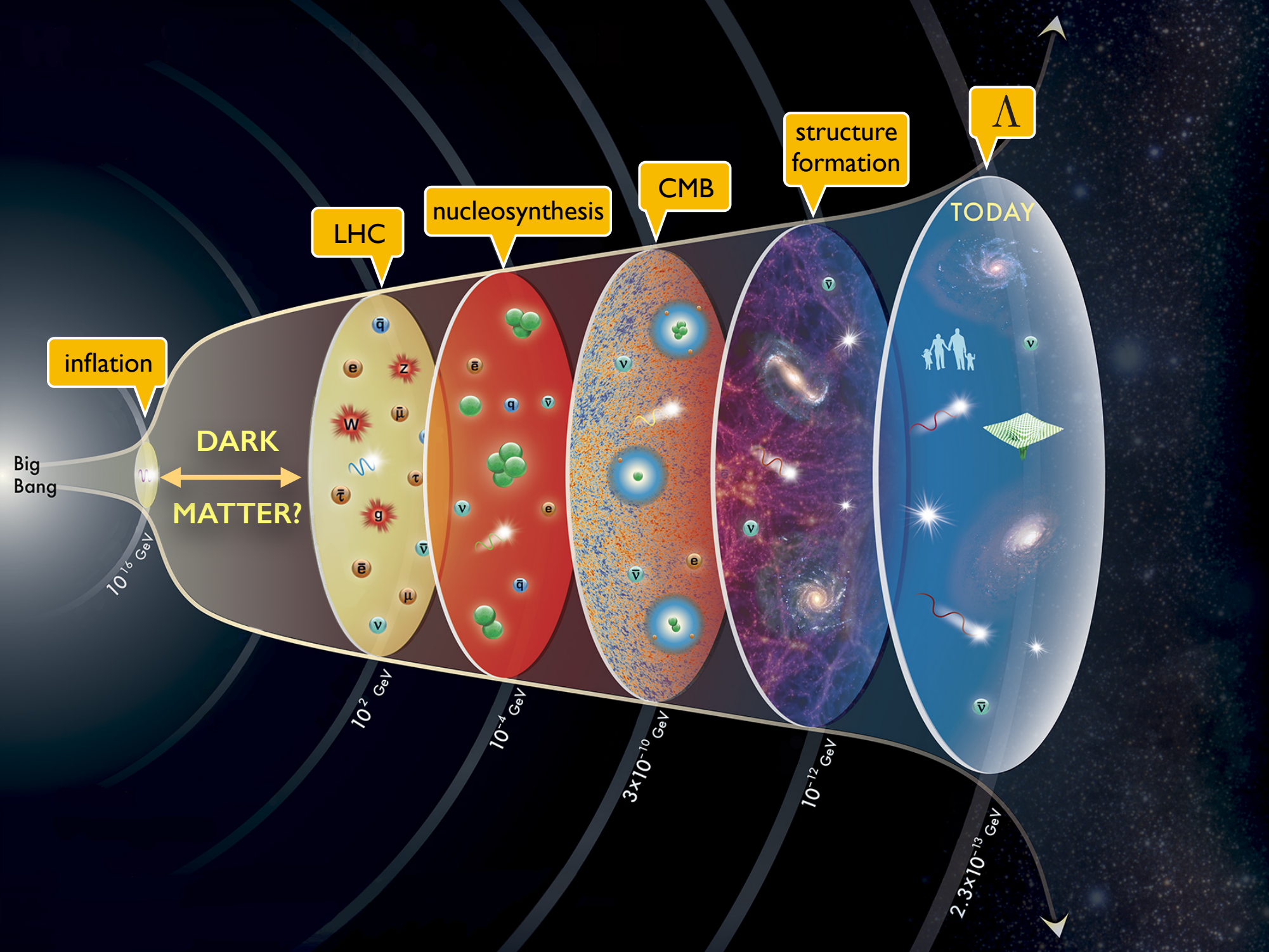
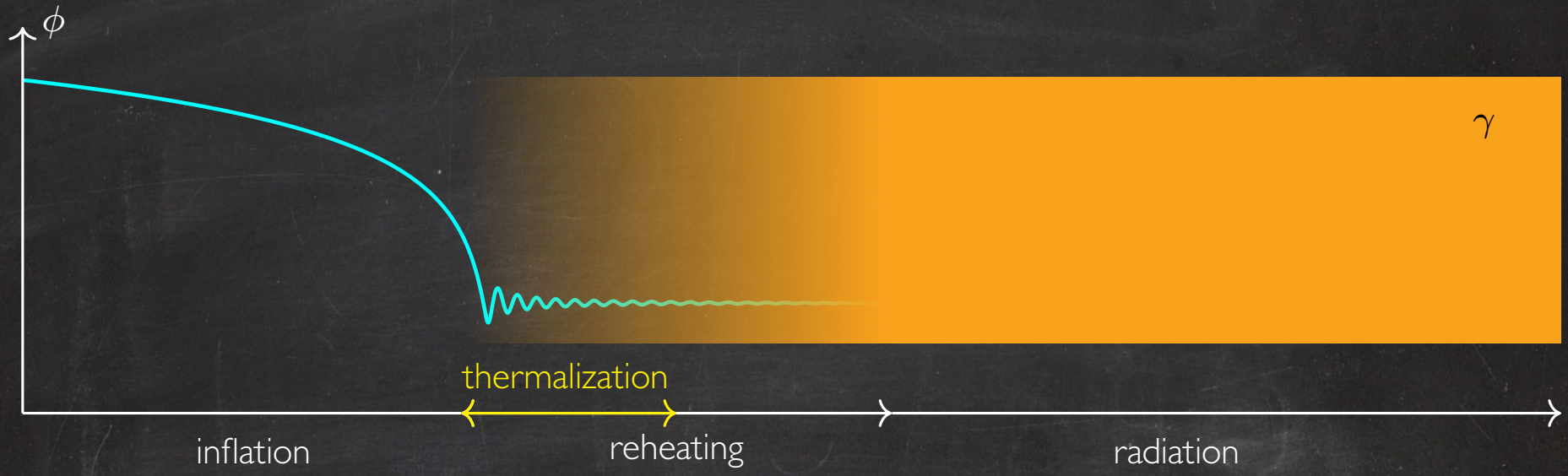
Universidad Autónoma de Madrid

CSIC Consejo Superior de Investigaciones Científicas


inflation
Big Bang
DARK
MATTER?
LHC
nucleosynthesis
CMB
structure formation
Λ
TODAY
10^{16} GeV
10^{2} GeV
10^{-4} GeV
3×10^{-10} GeV
10^{-12} GeV
2.3×10^{-13} GeV

The perturbative STH picture



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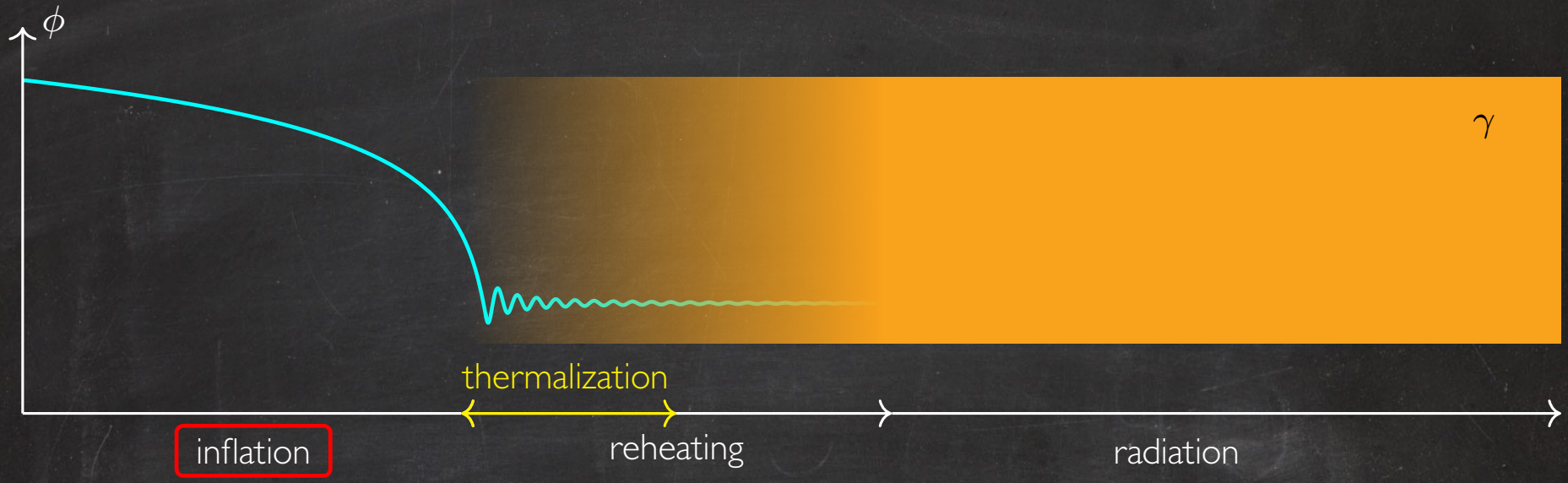
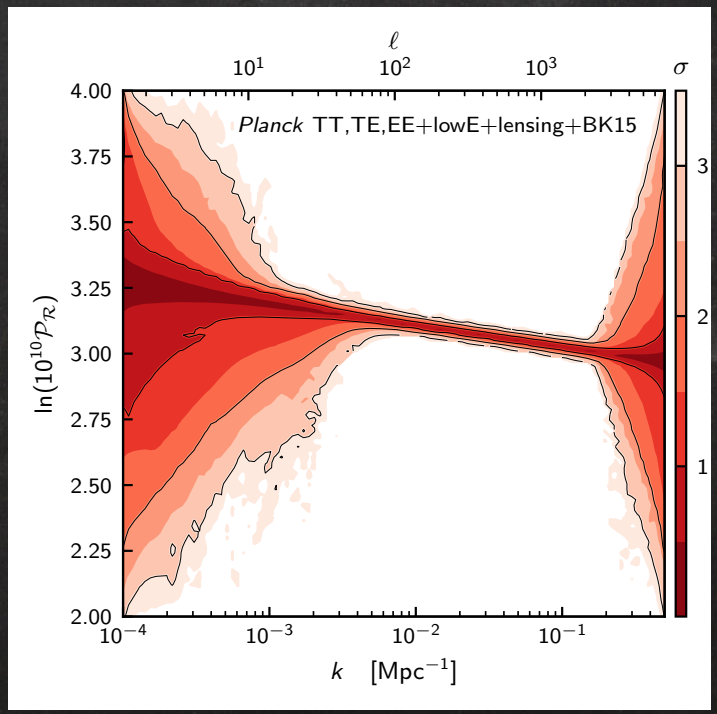


$$\ddot{\phi} + 3H\dot{\phi} + V'(\phi) = 0$$

$$H^2 \equiv \left(\frac{\dot{a}}{a}\right)^2 = \frac{1}{3}\left(\frac{\dot{\phi}^2}{2} + V(\phi)\right)$$

$$\mathcal{P}_{\mathcal{R}} = \frac{H^4}{4\pi^2\dot{\phi}^2}\left(\frac{k}{aH}\right)^{n_s - 1}$$

$$\mathcal{P}_{\mathcal{T}} = \frac{2}{\pi^2}H^2\left(\frac{k}{aH}\right)^{n_T}$$



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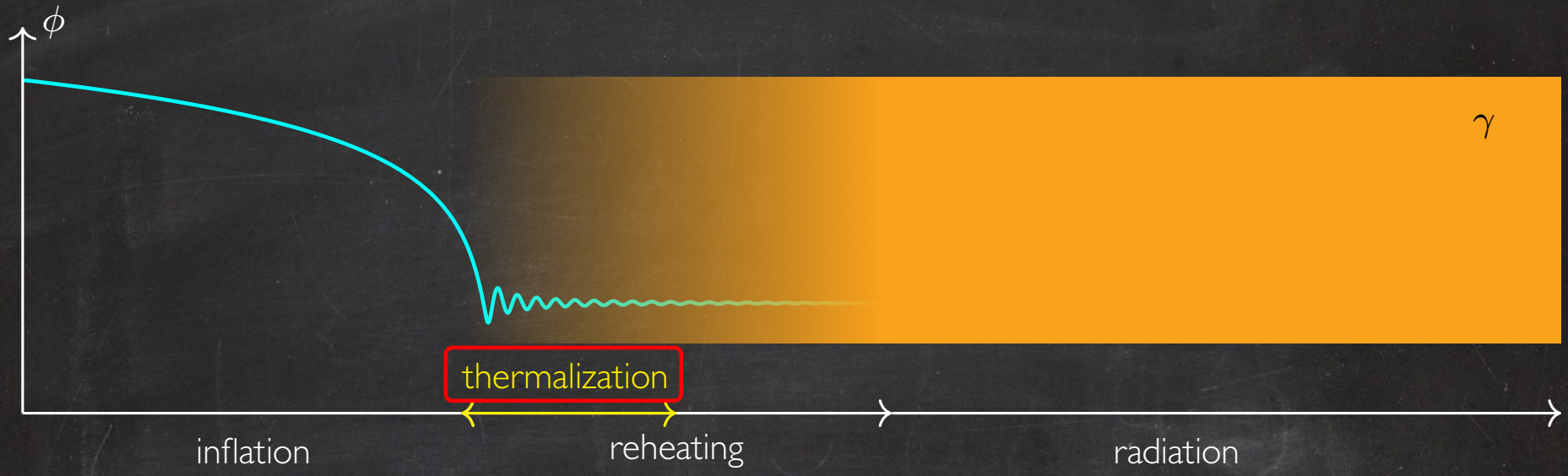
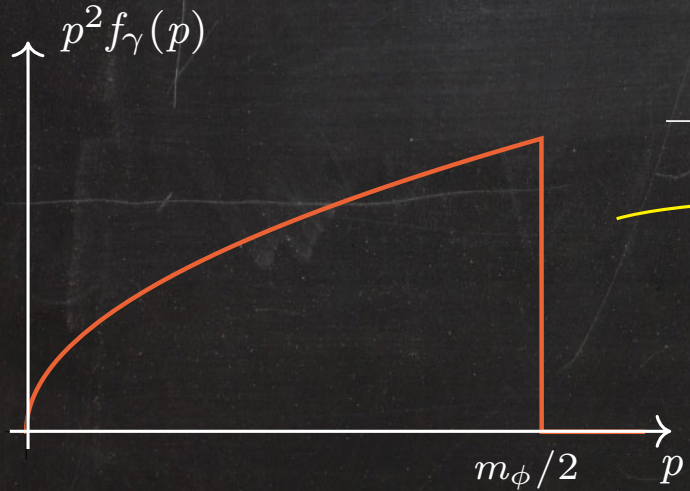
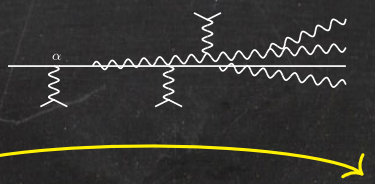
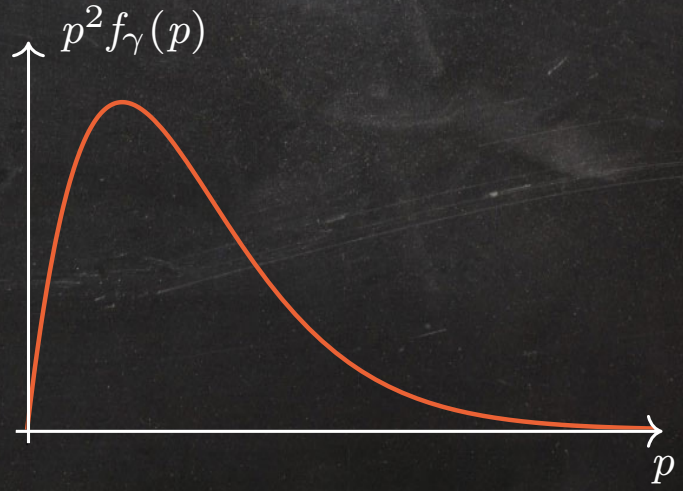


$$\ddot{\phi} + (3H + \Gamma_\phi)\dot{\phi} + V'(\phi) = 0$$







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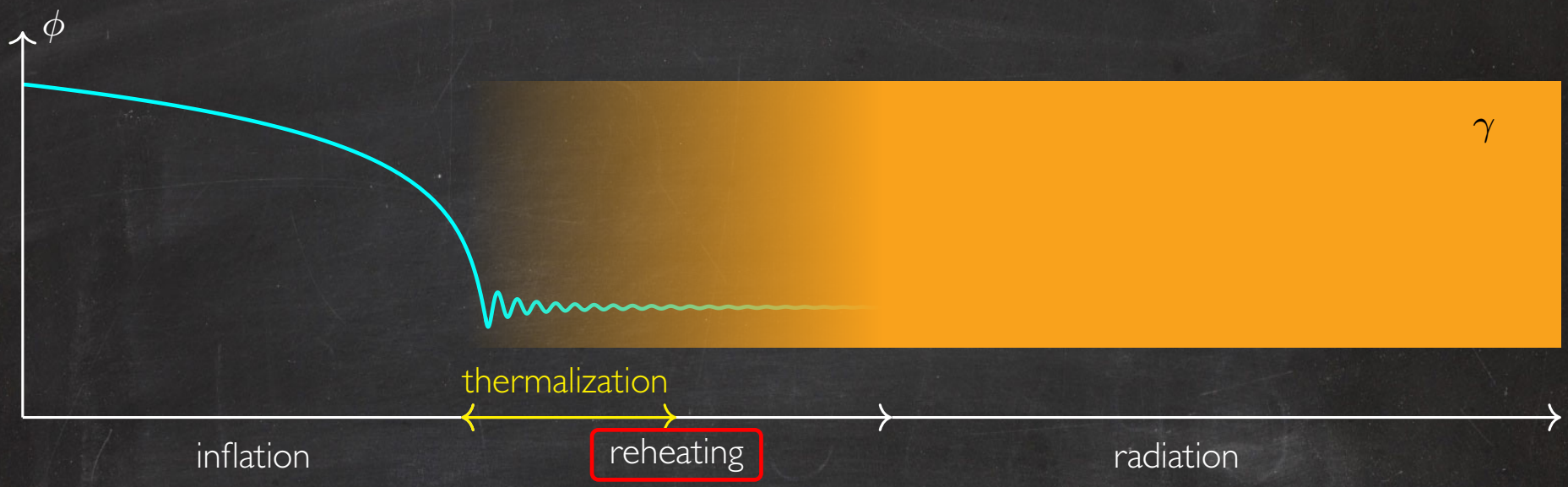

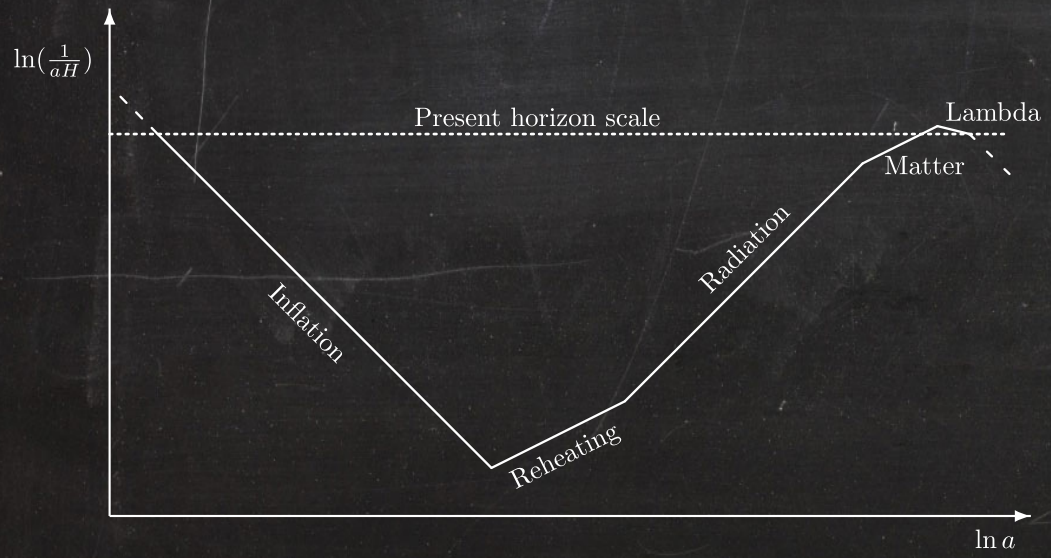

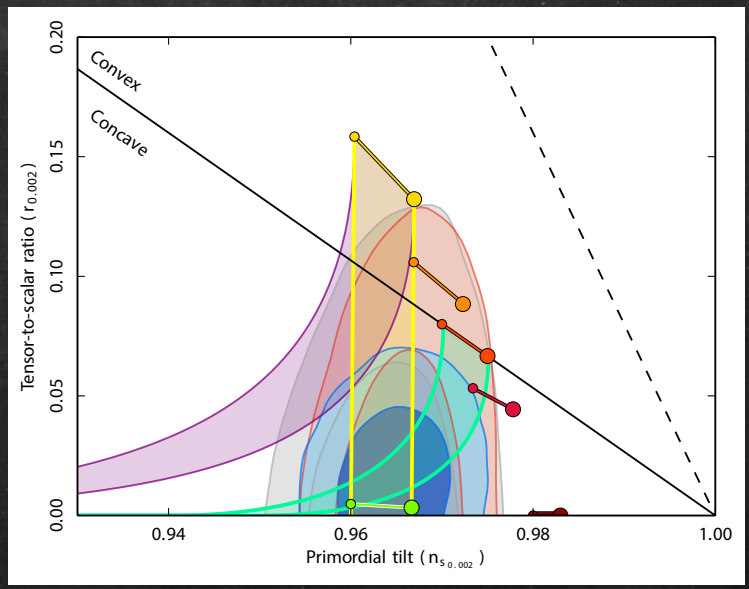

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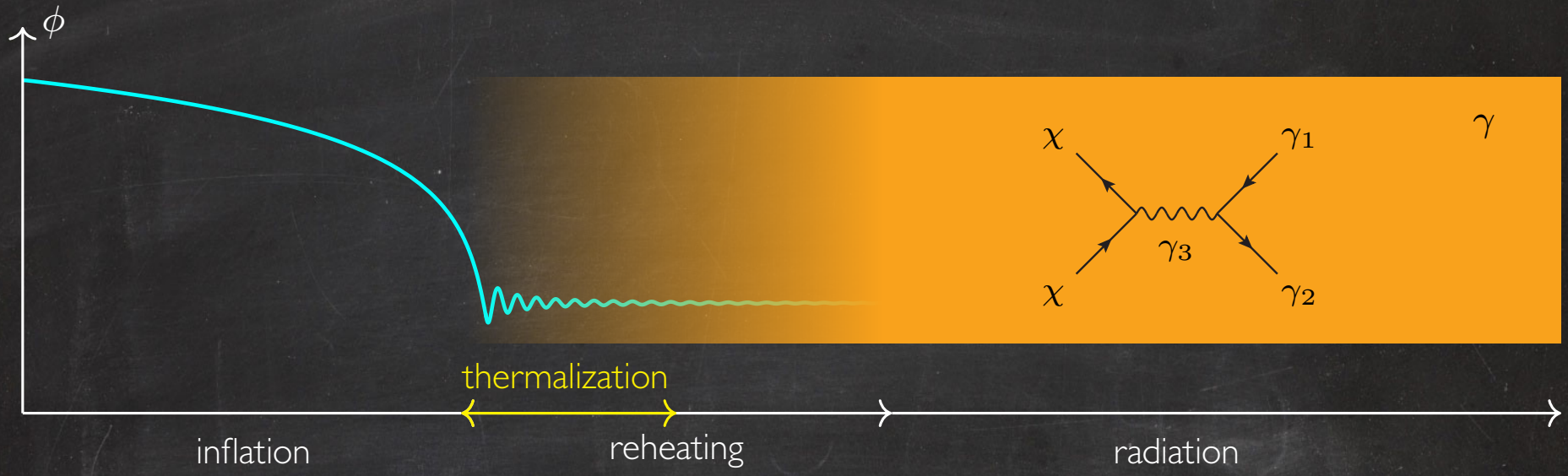
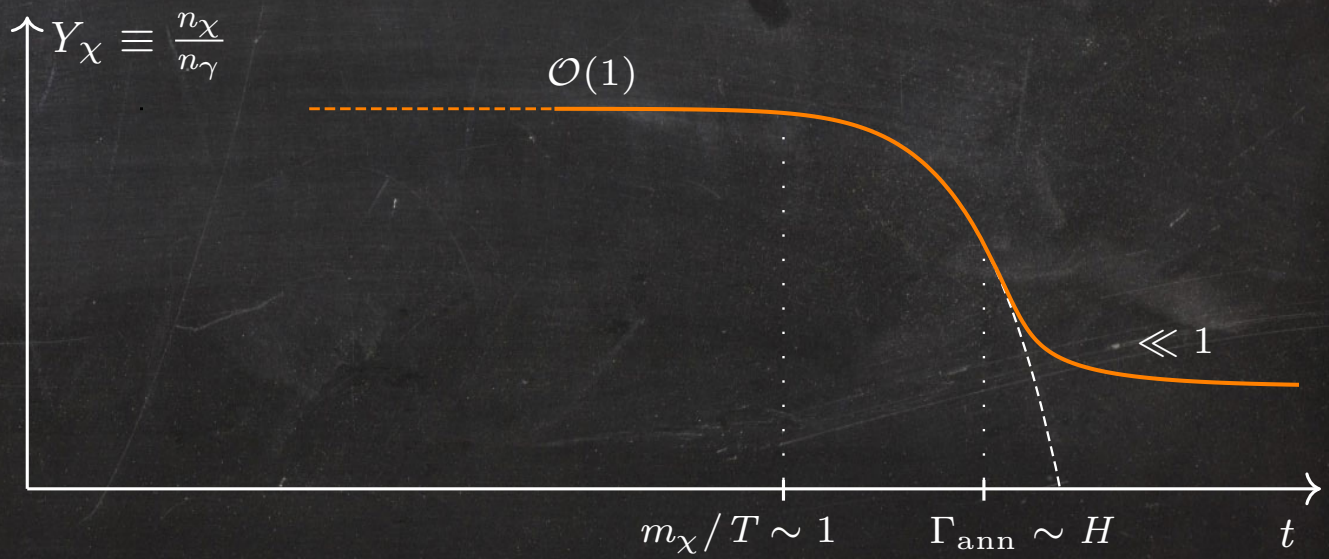


Freeze-out:

- Thermal equilibrium
- Thermal production
- $Y_\chi \longleftrightarrow \langle \sigma v \rangle_{\rm ann}$
- IR dominated



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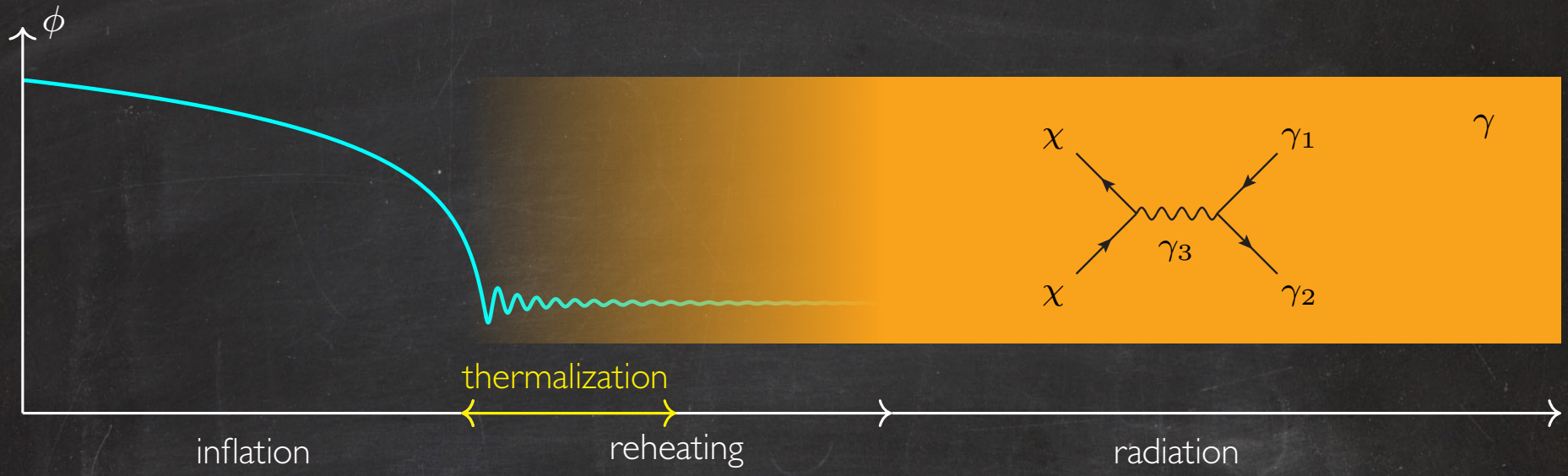

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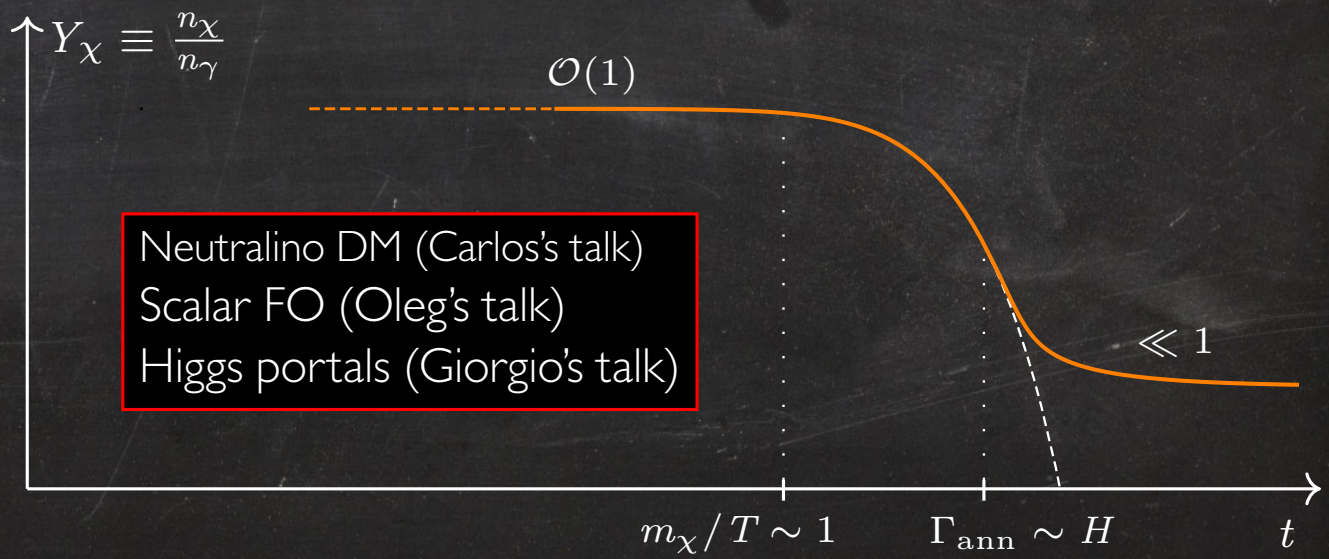
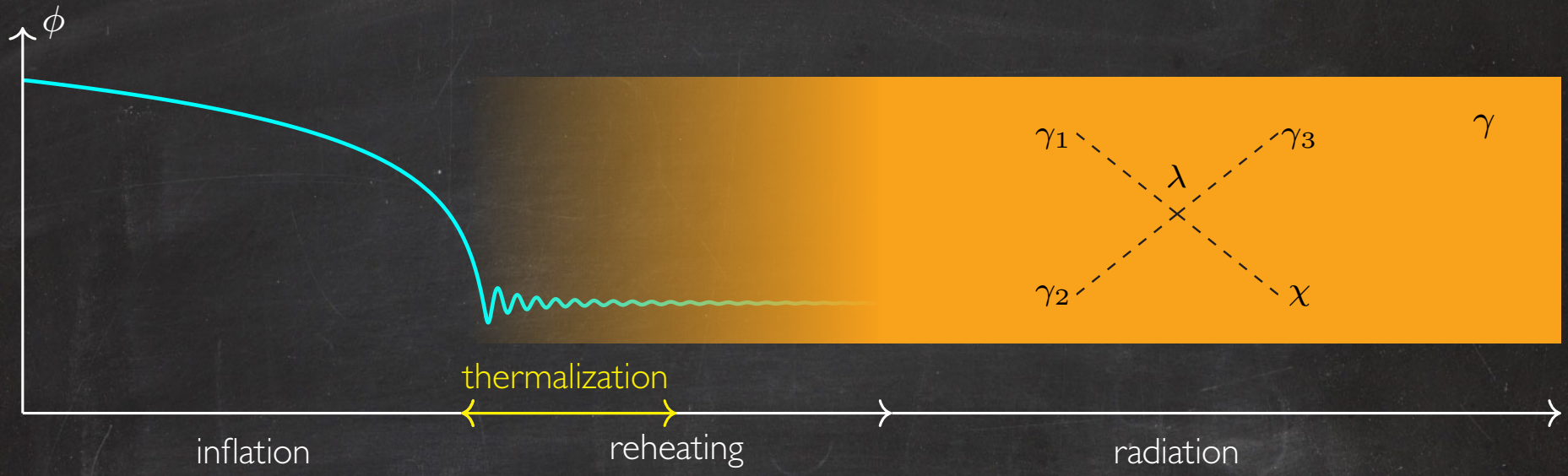


Neutralino DM (Carlos's talk)
Scalar FO (Oleg's talk)
Higgs portals (Giorgio's talk)

The perturbative STH picture



Freeze-in:

- Not in equilibrium
- Thermal production
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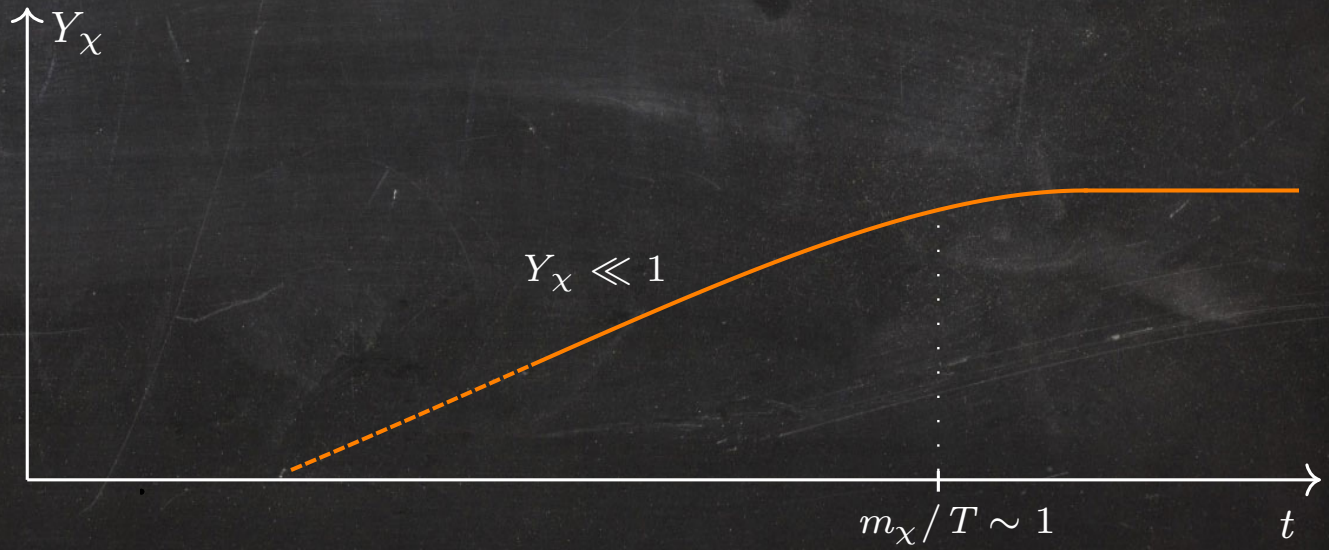

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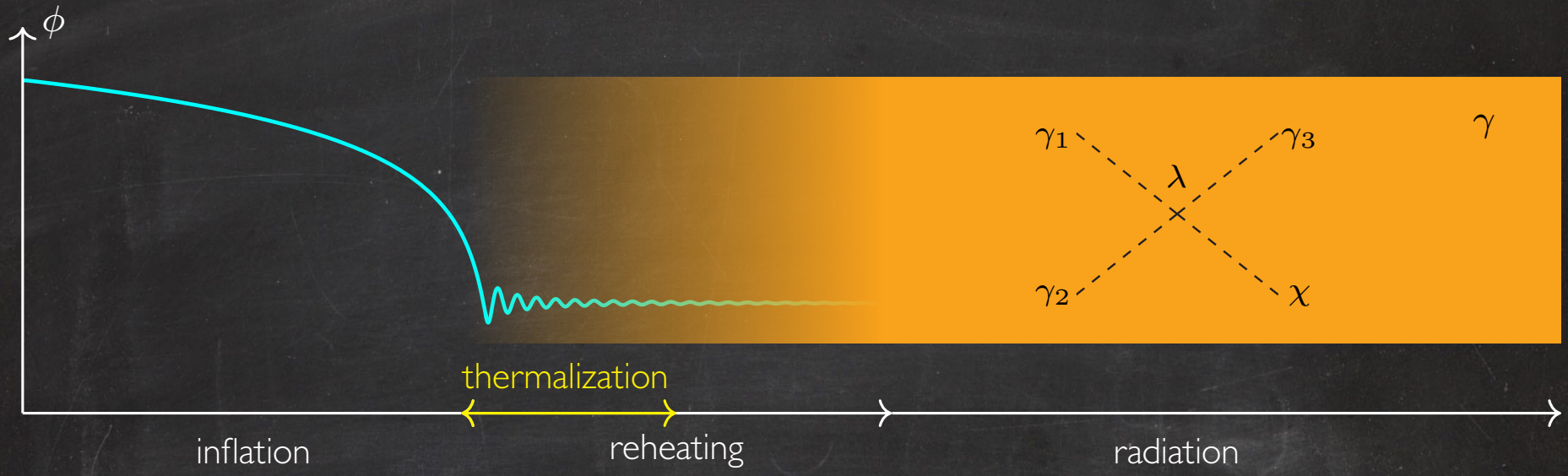

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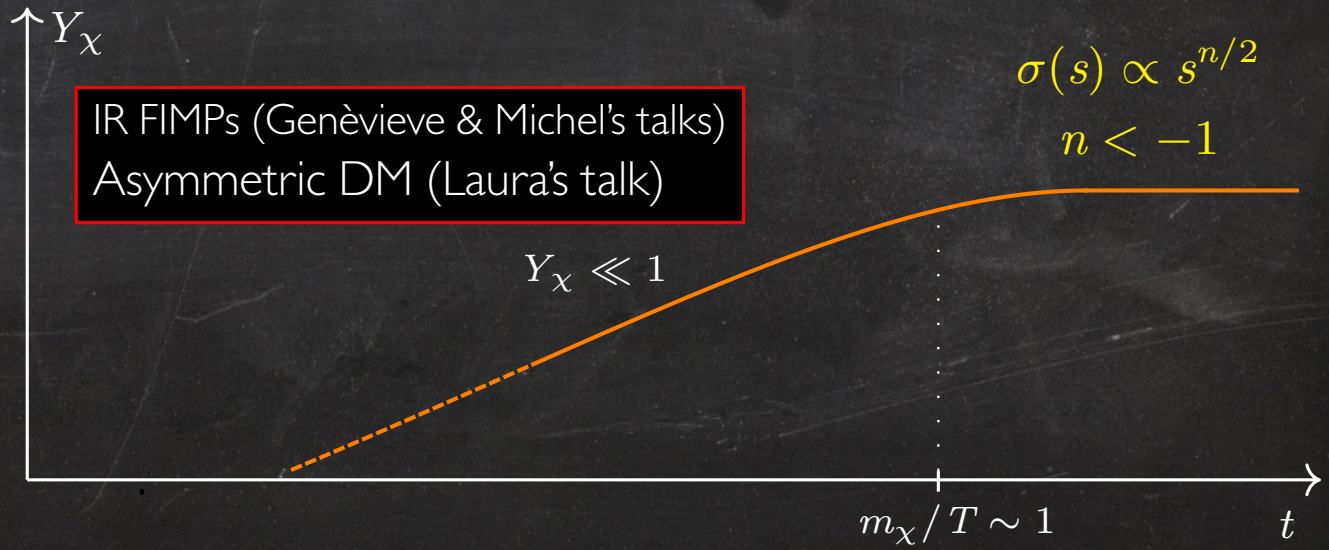

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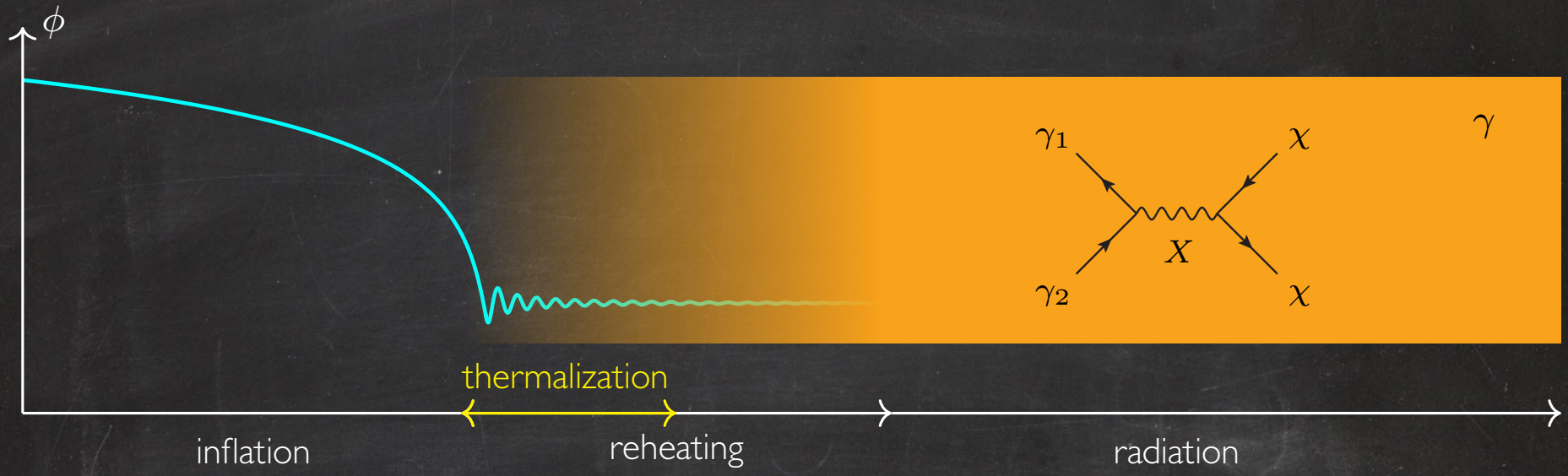
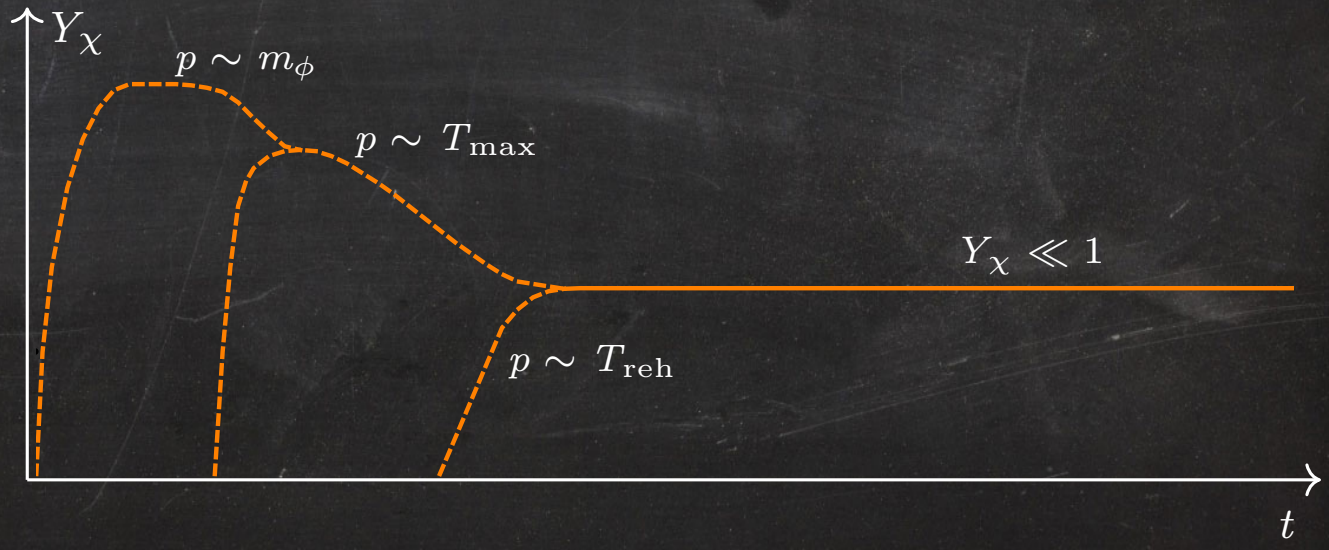


Freeze-in:

- Not in equilibrium
- Non-thermal and thermal production
- $Y_\chi \longleftrightarrow \langle \sigma v \rangle_{\rm prod}$
- UV dominated



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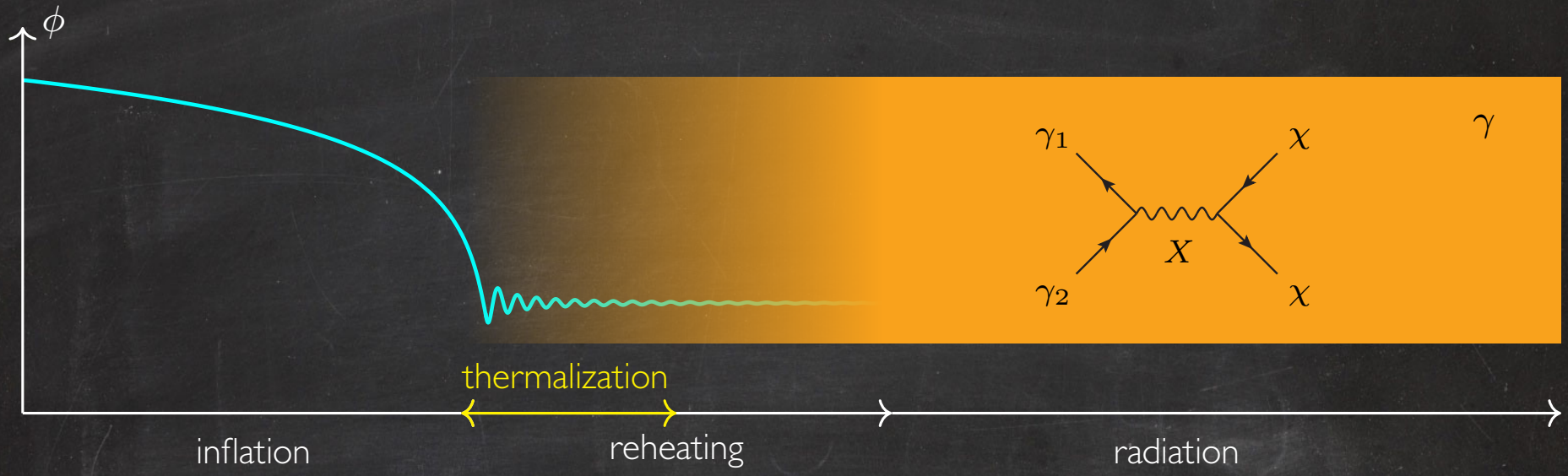

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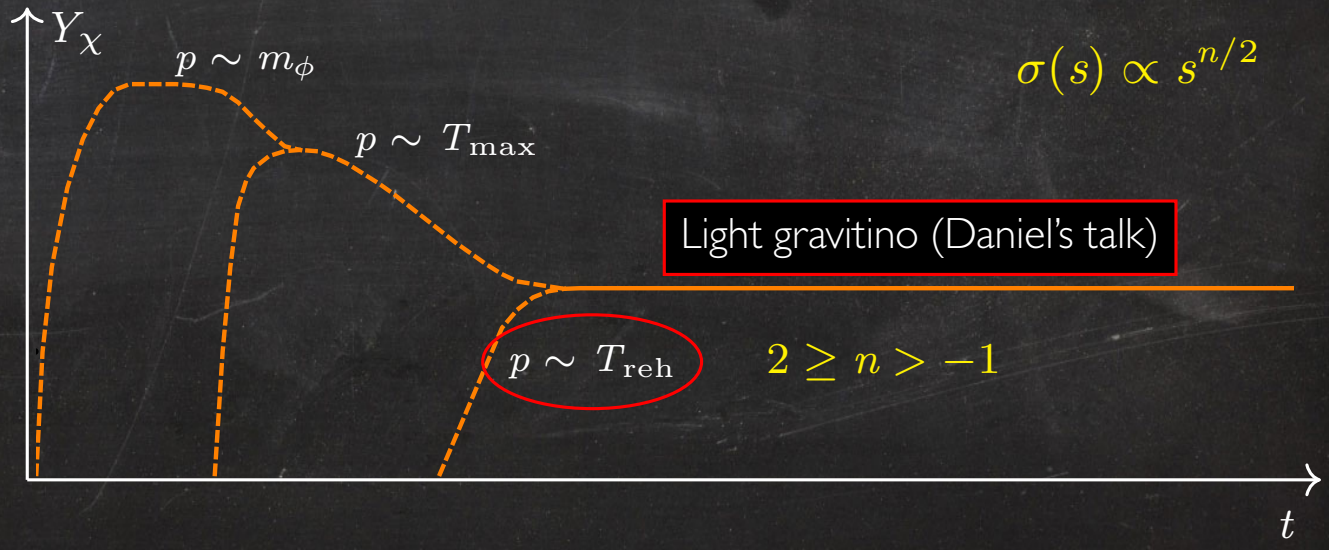
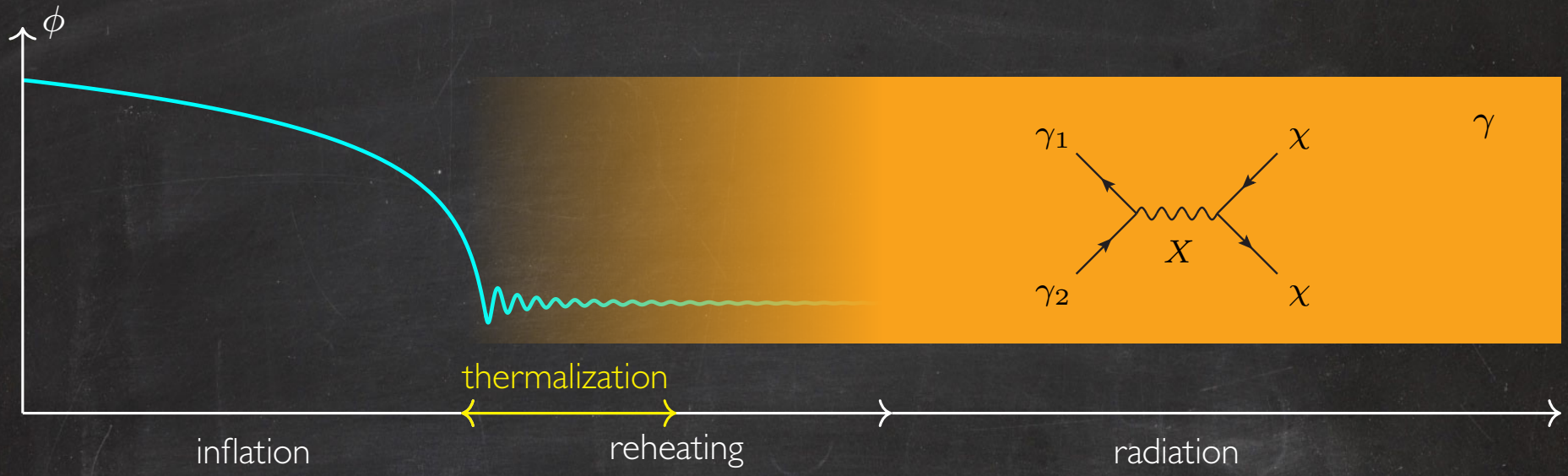


$\sigma(s) \propto s^{n/2}$

Light gravitino (Daniel's talk)

$2 \geq n > -1$

The perturbative STH picture



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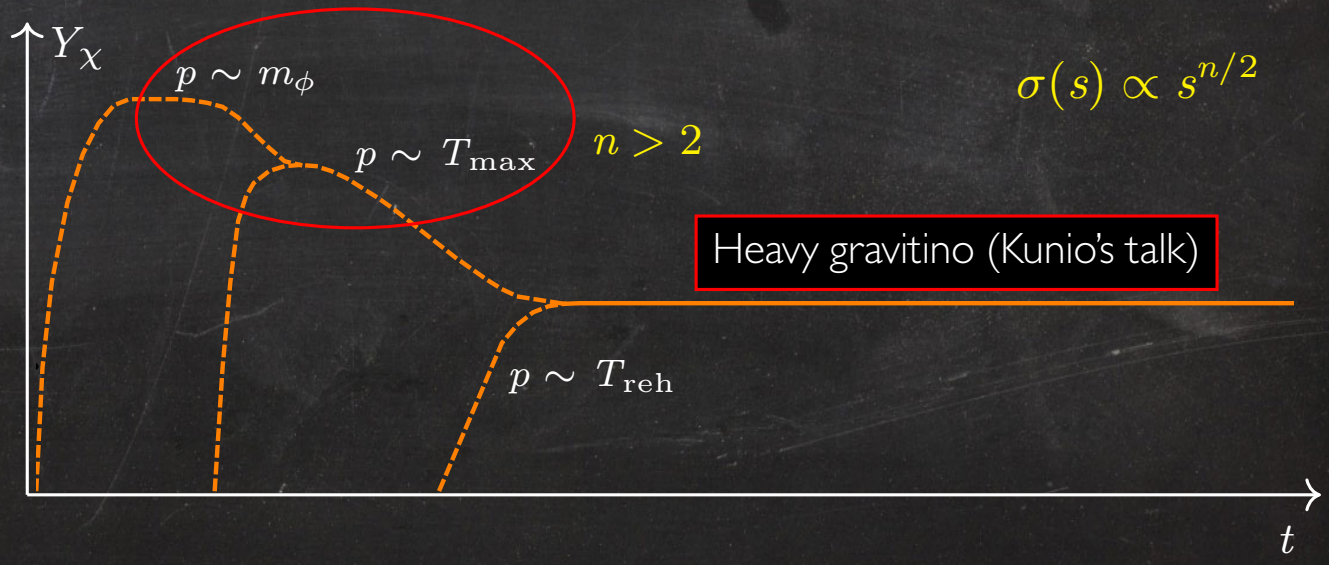

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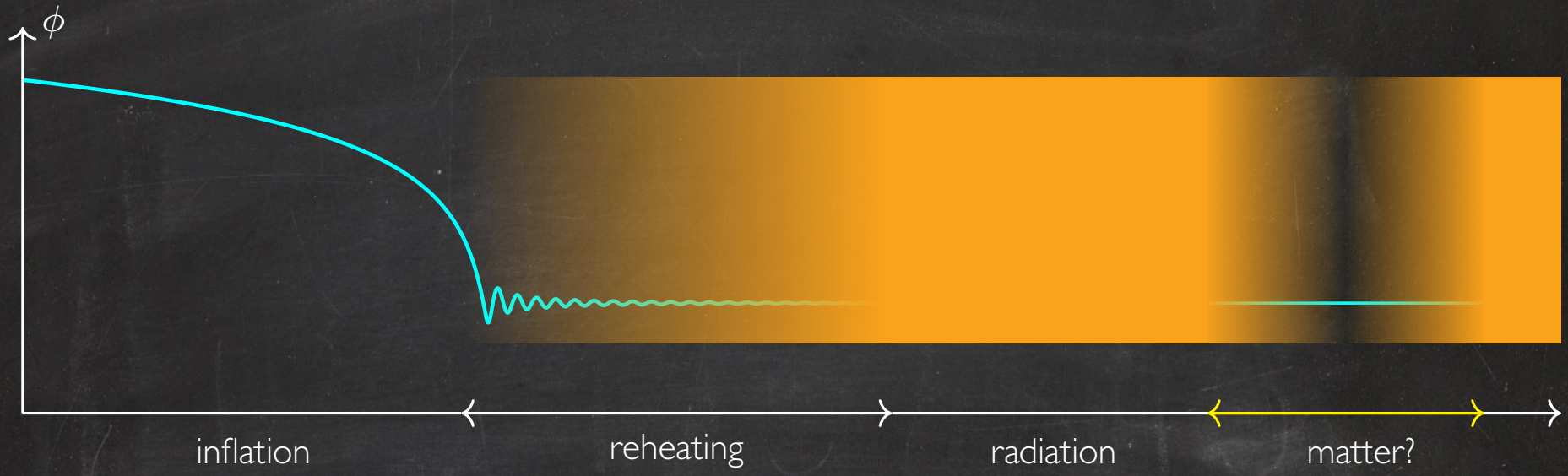

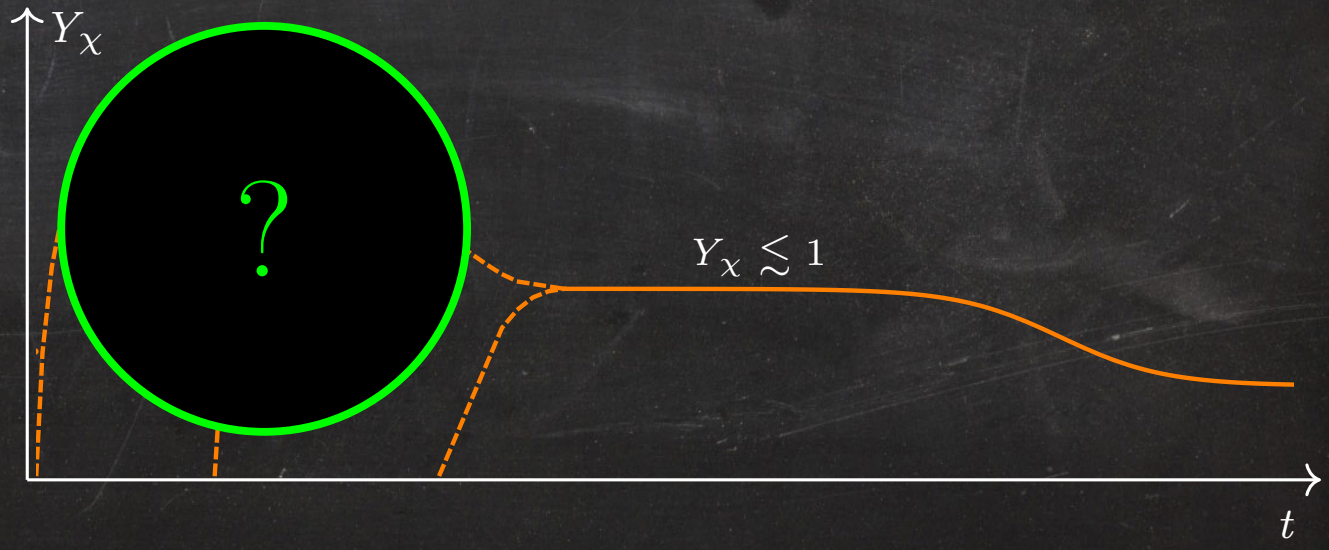

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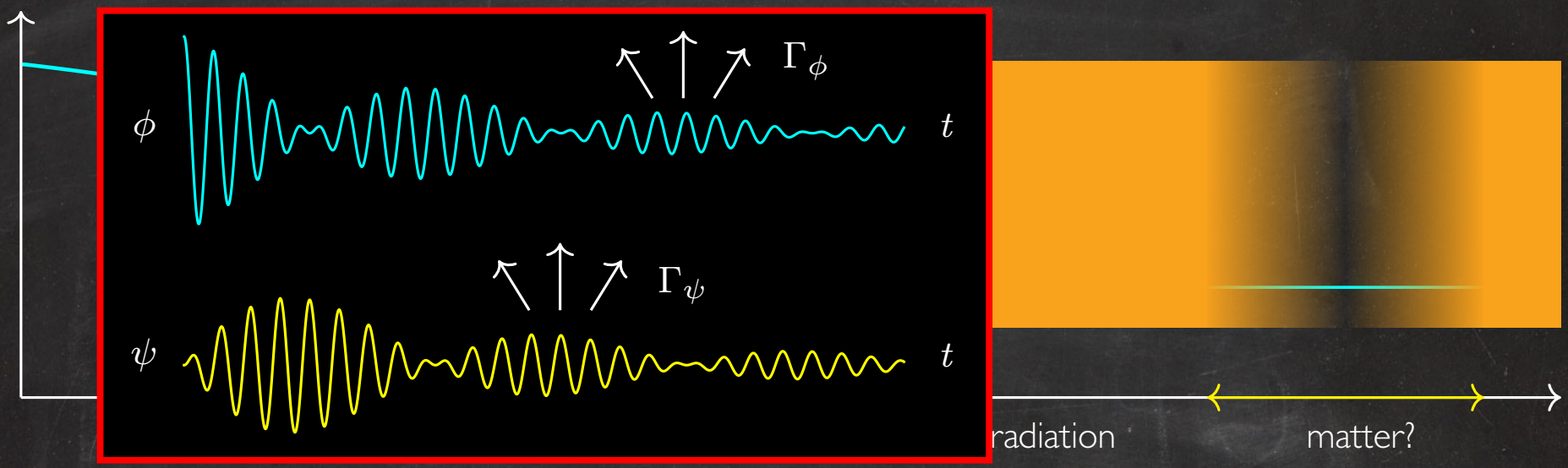

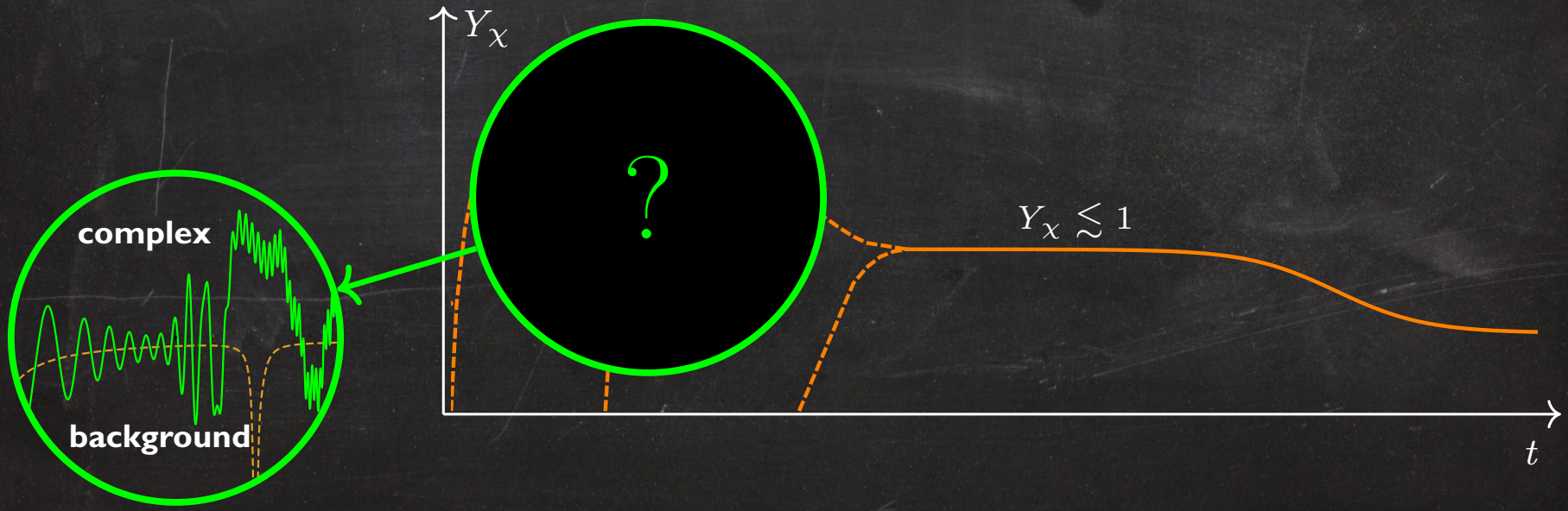

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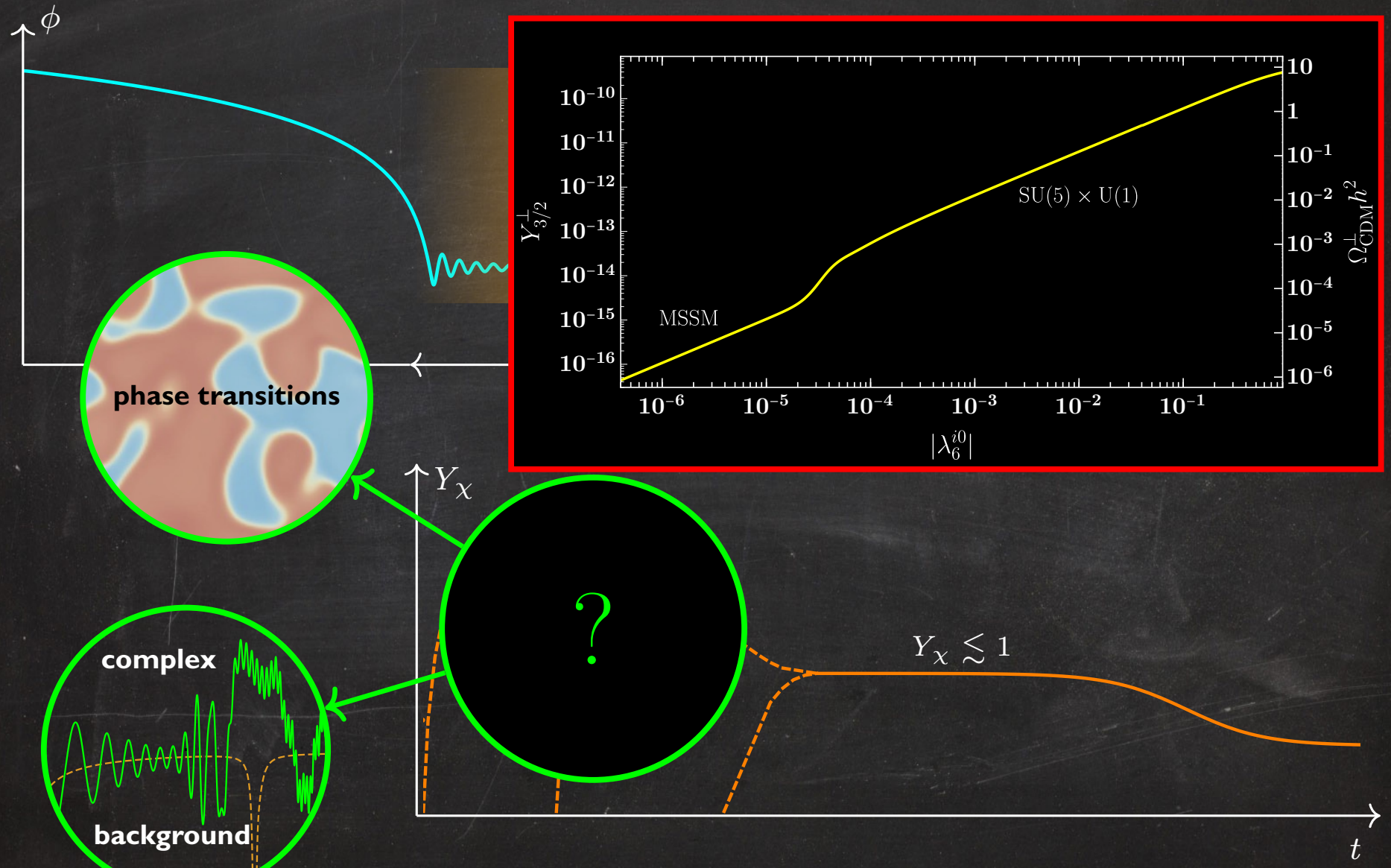

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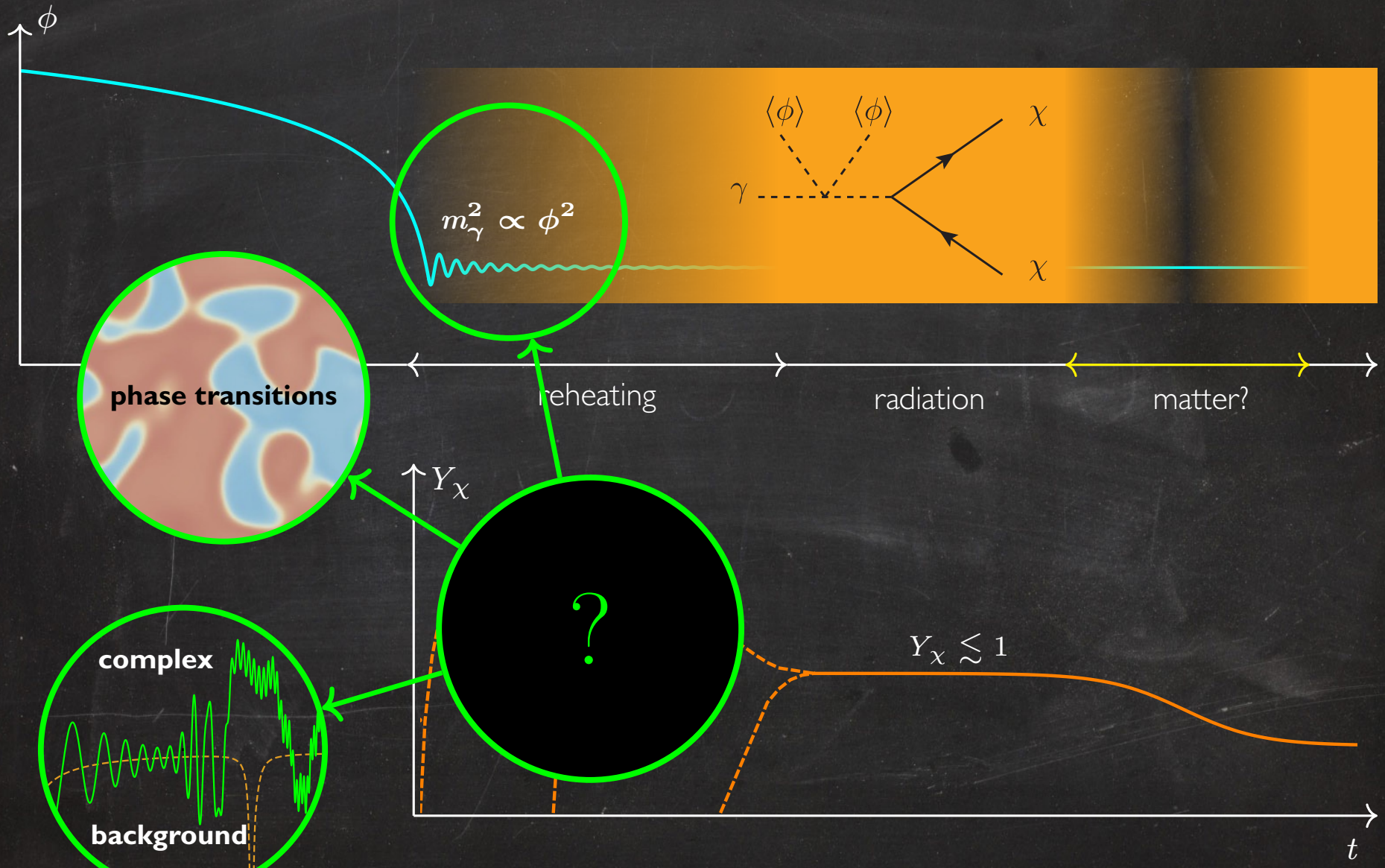

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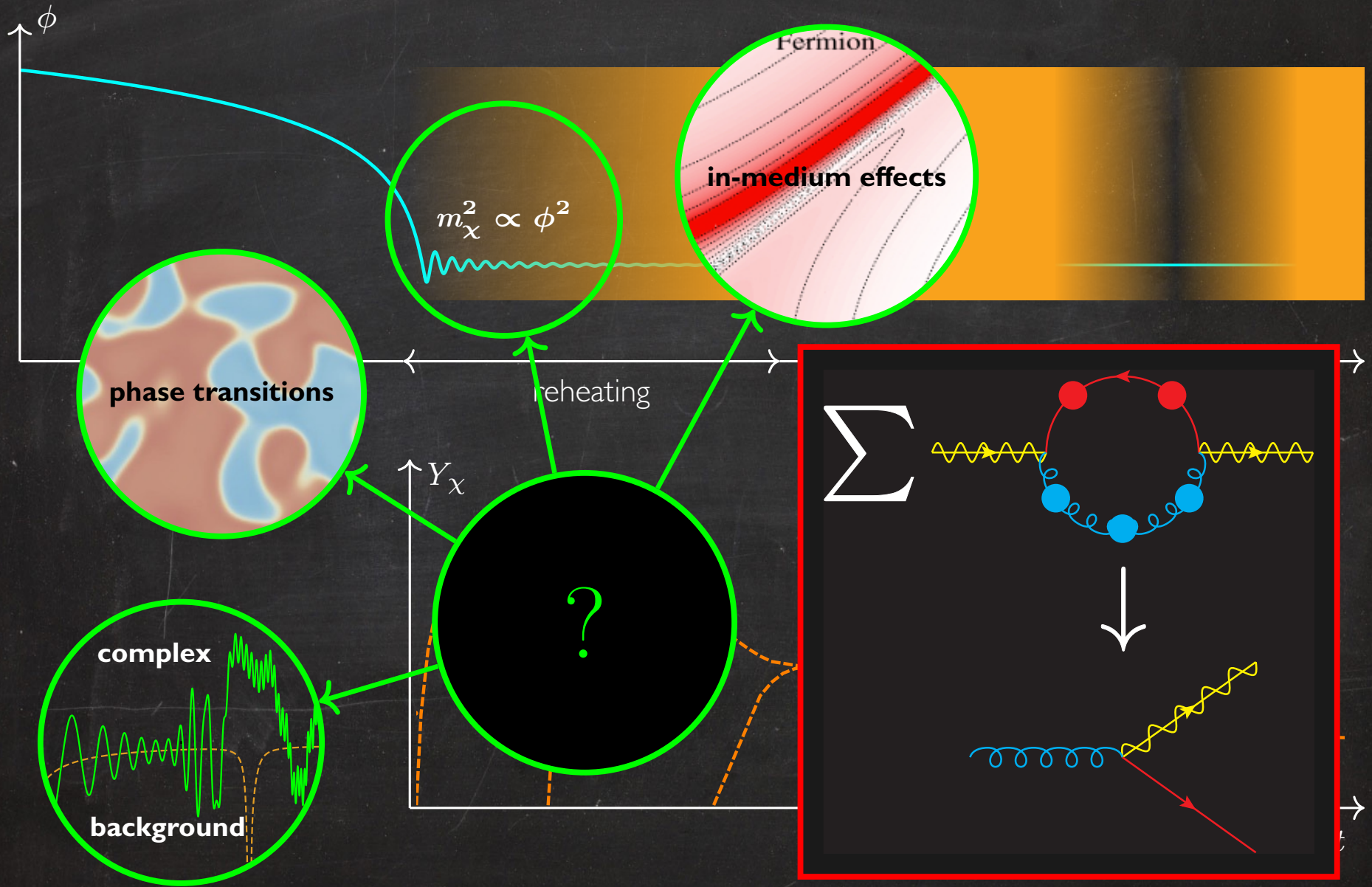

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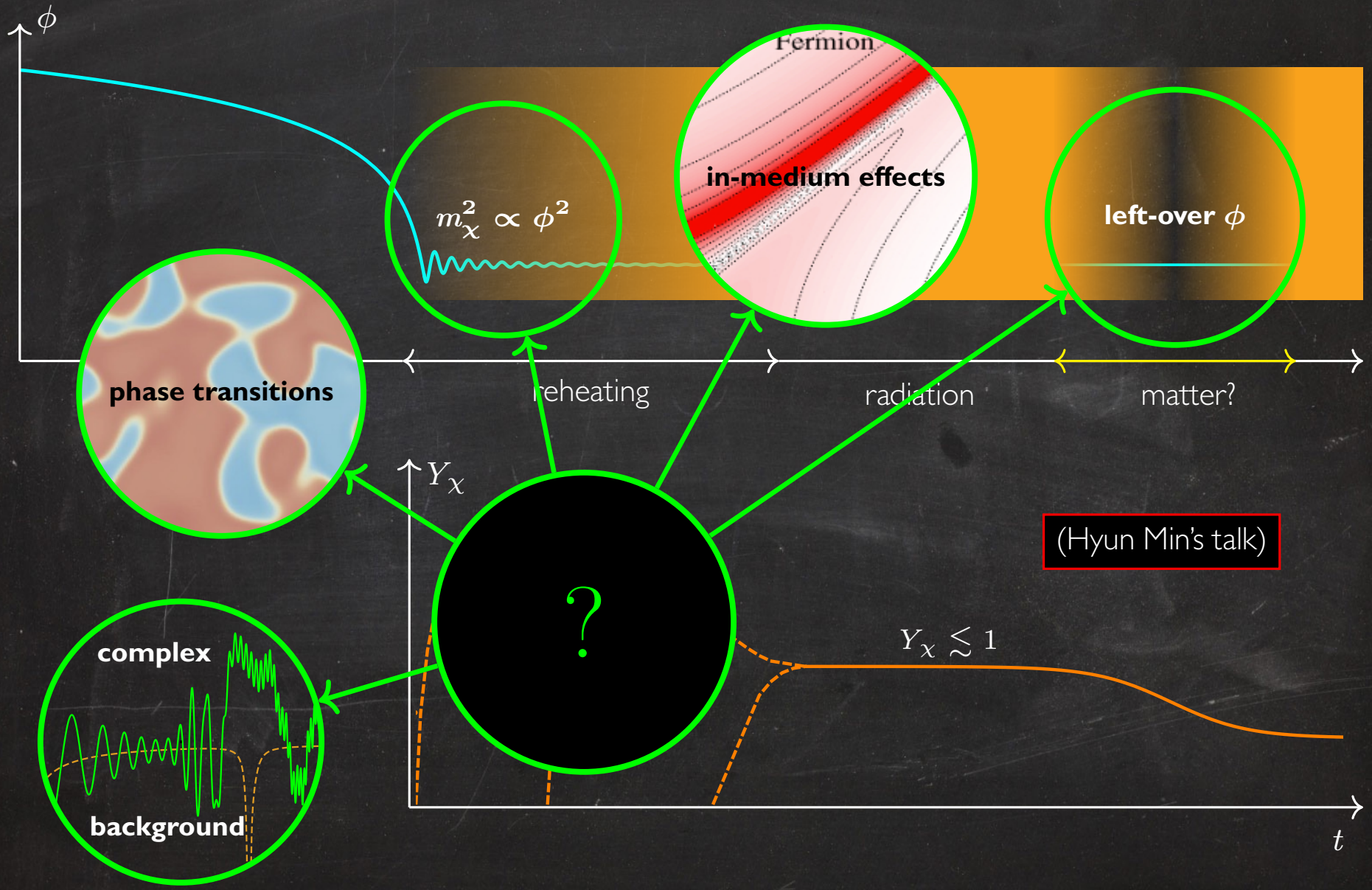

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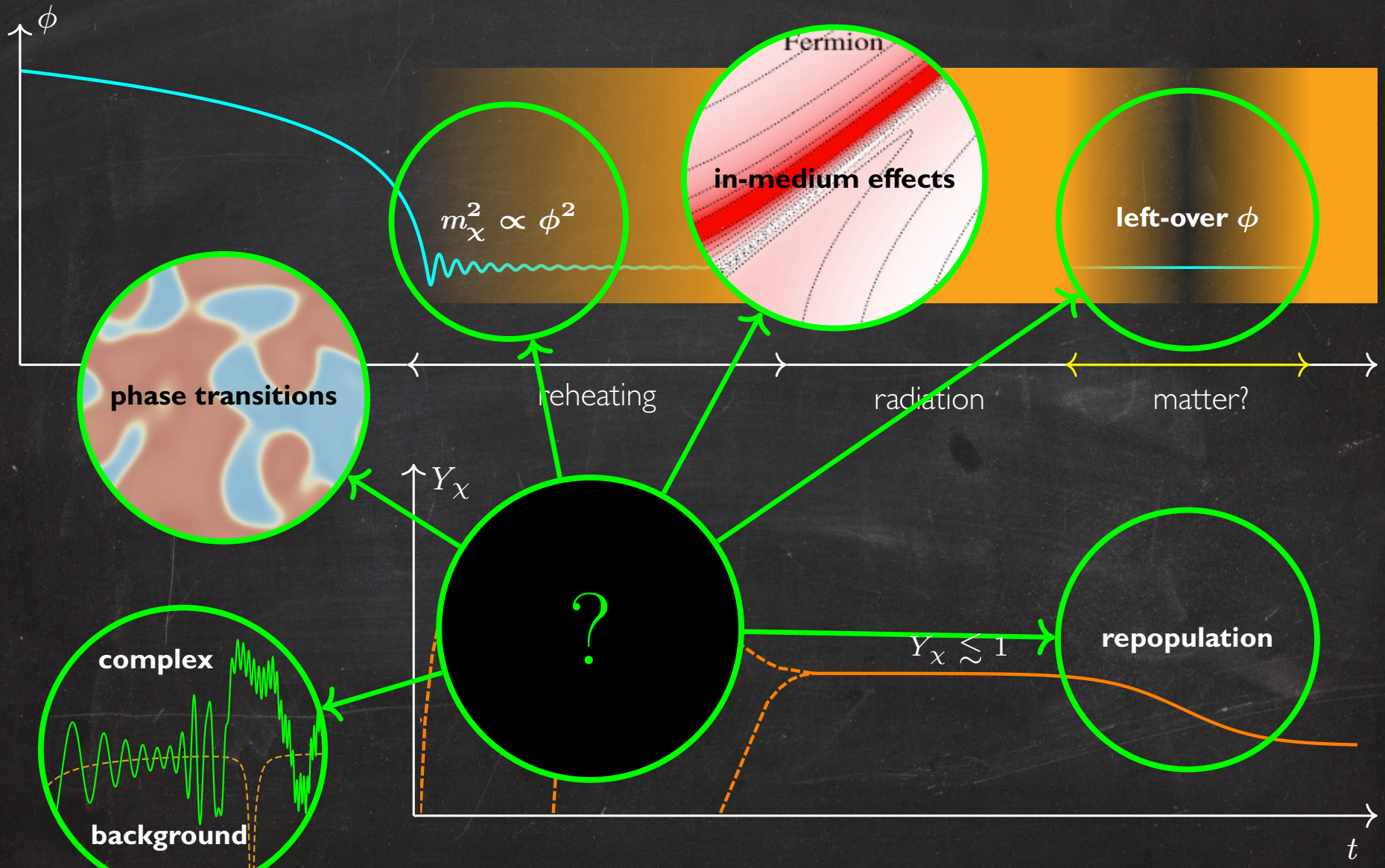

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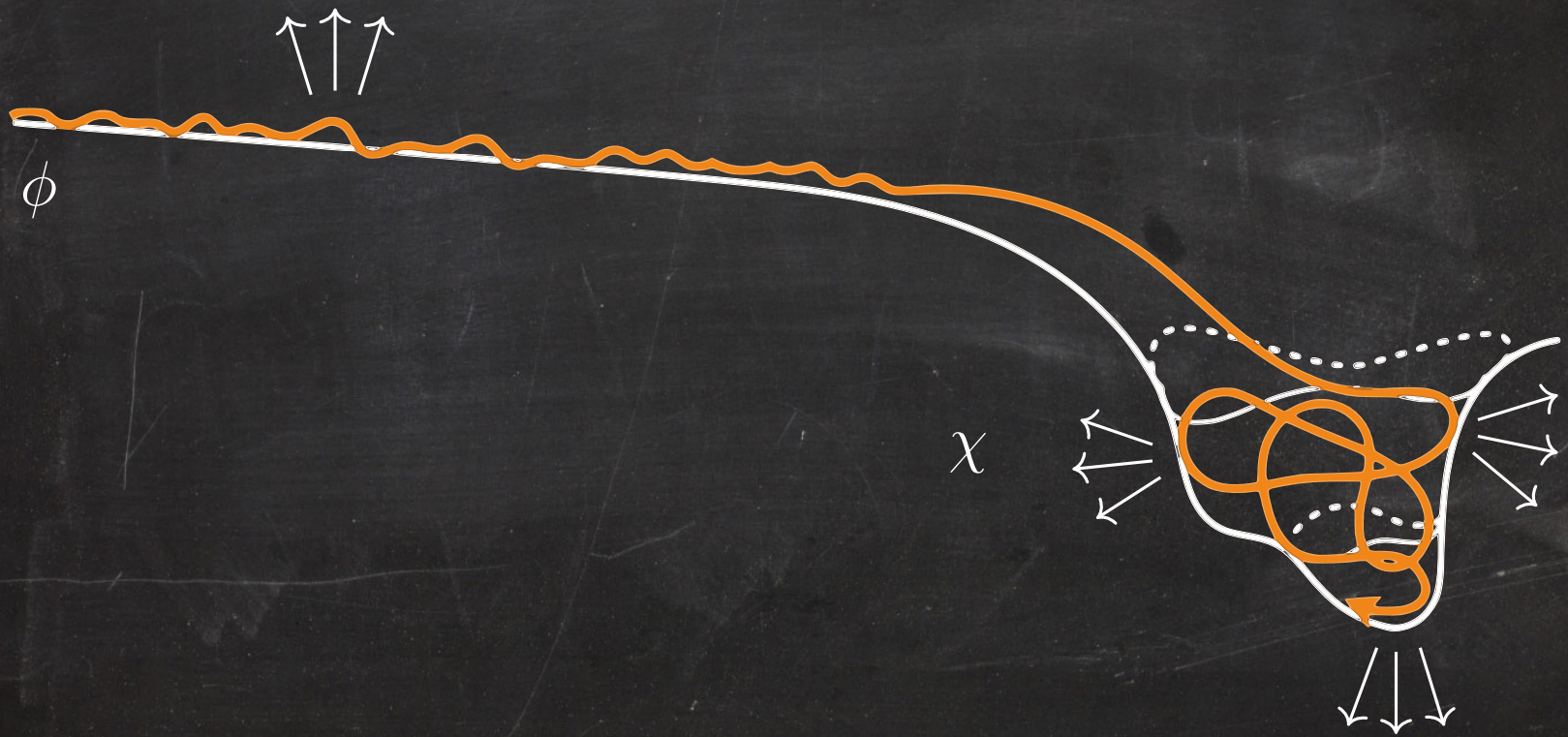

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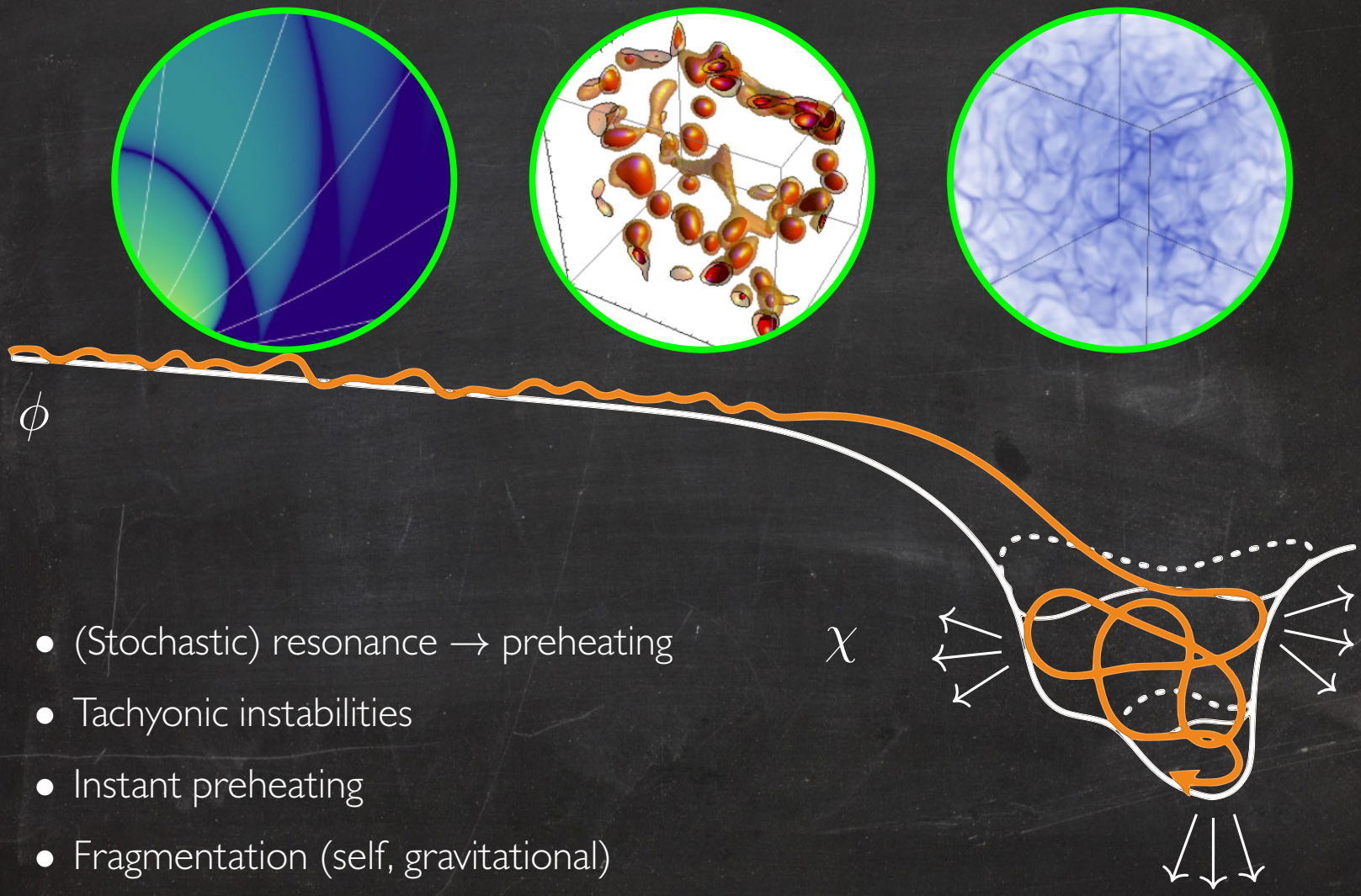
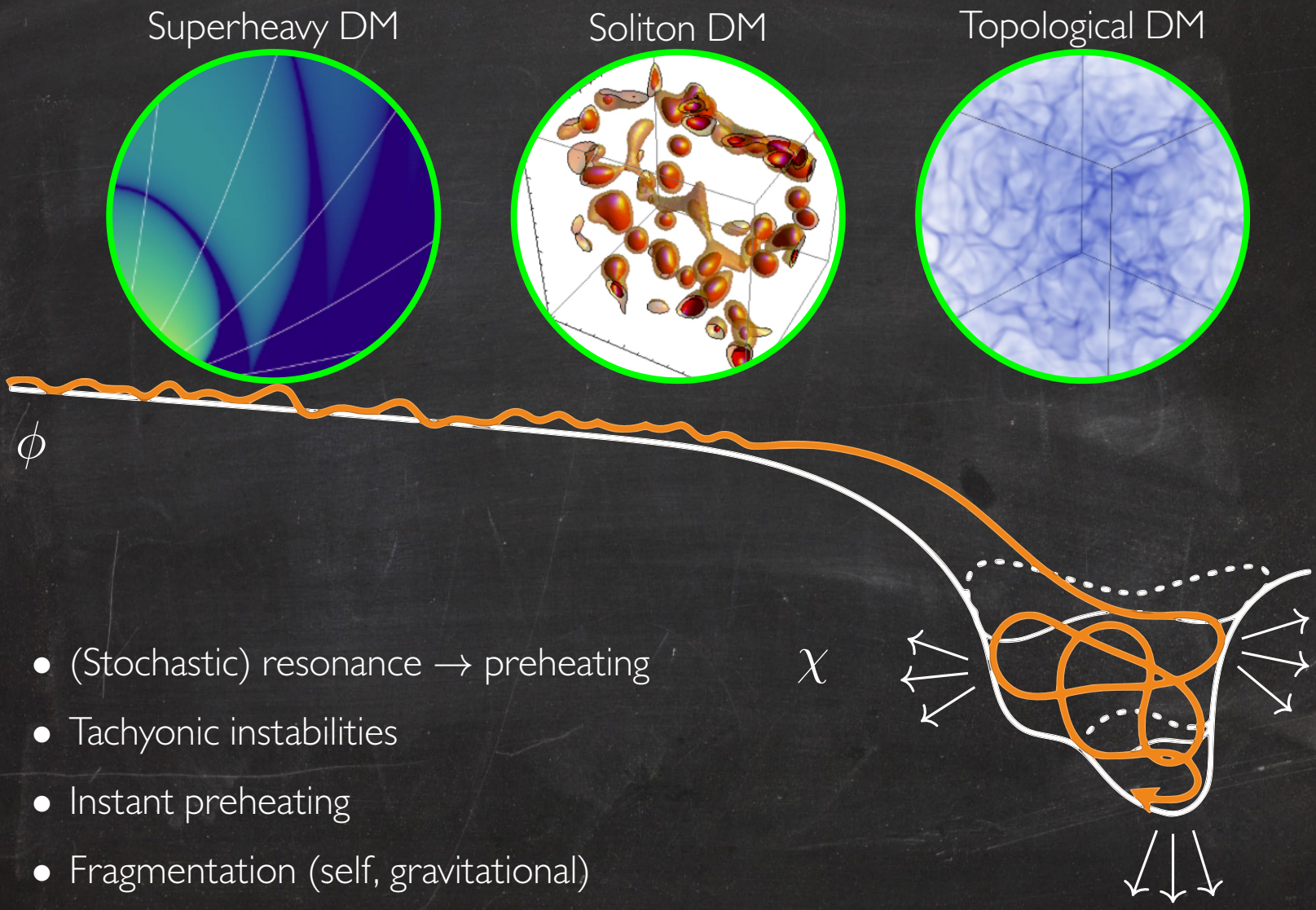


- (Stochastic) resonance $\rightarrow$ preheating
- Tachyonic instabilities
- Instant preheating
- Fragmentation (self, gravitational)
- Formation of non-linear structures

The non-perturbative picture



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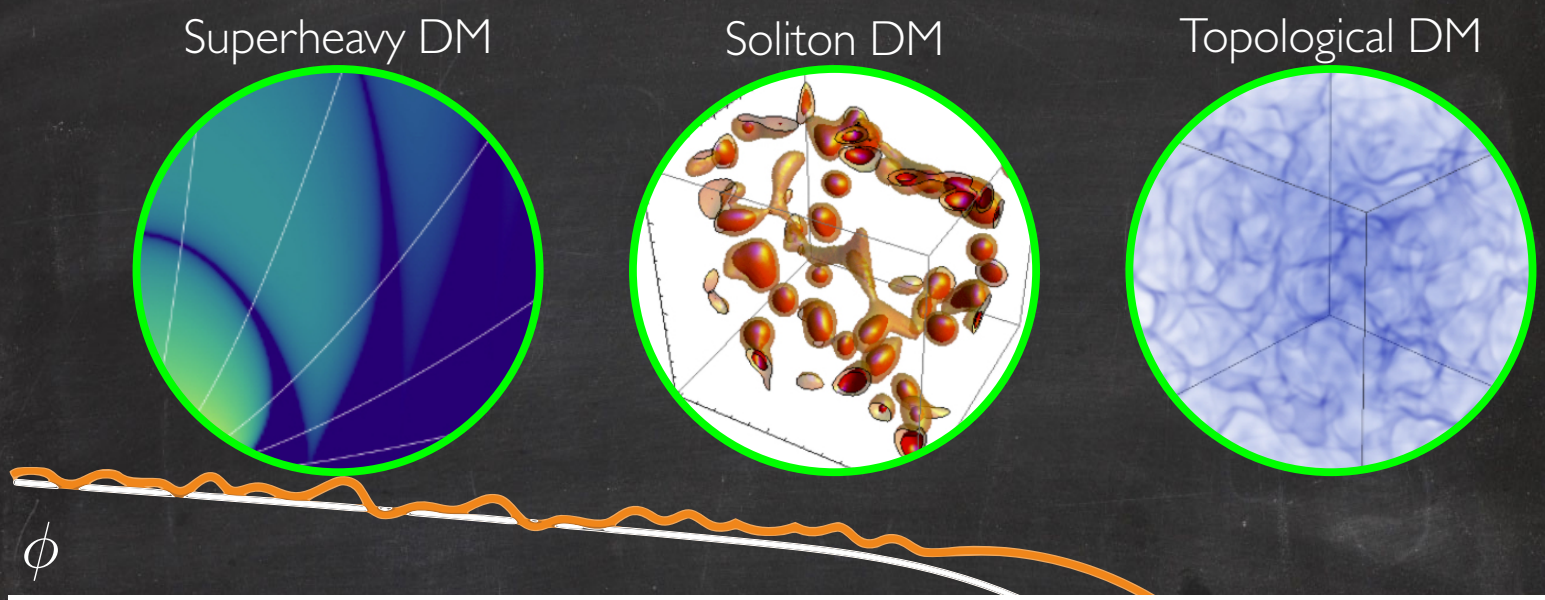
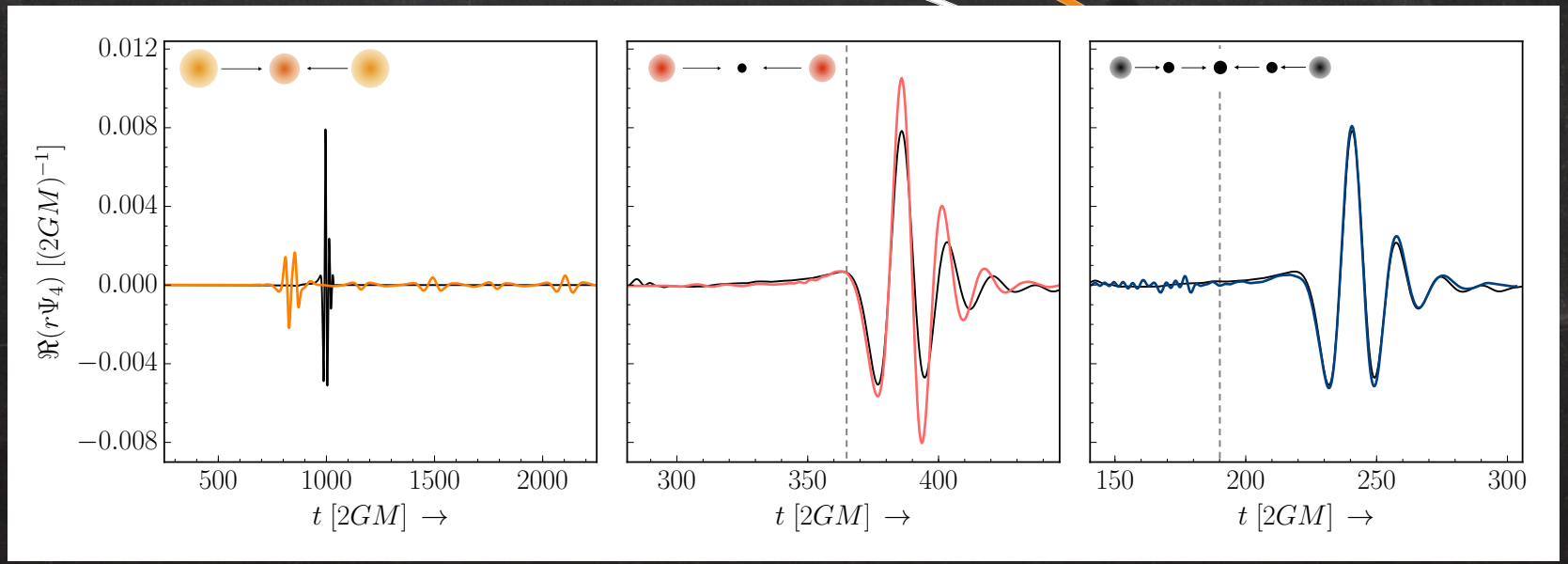
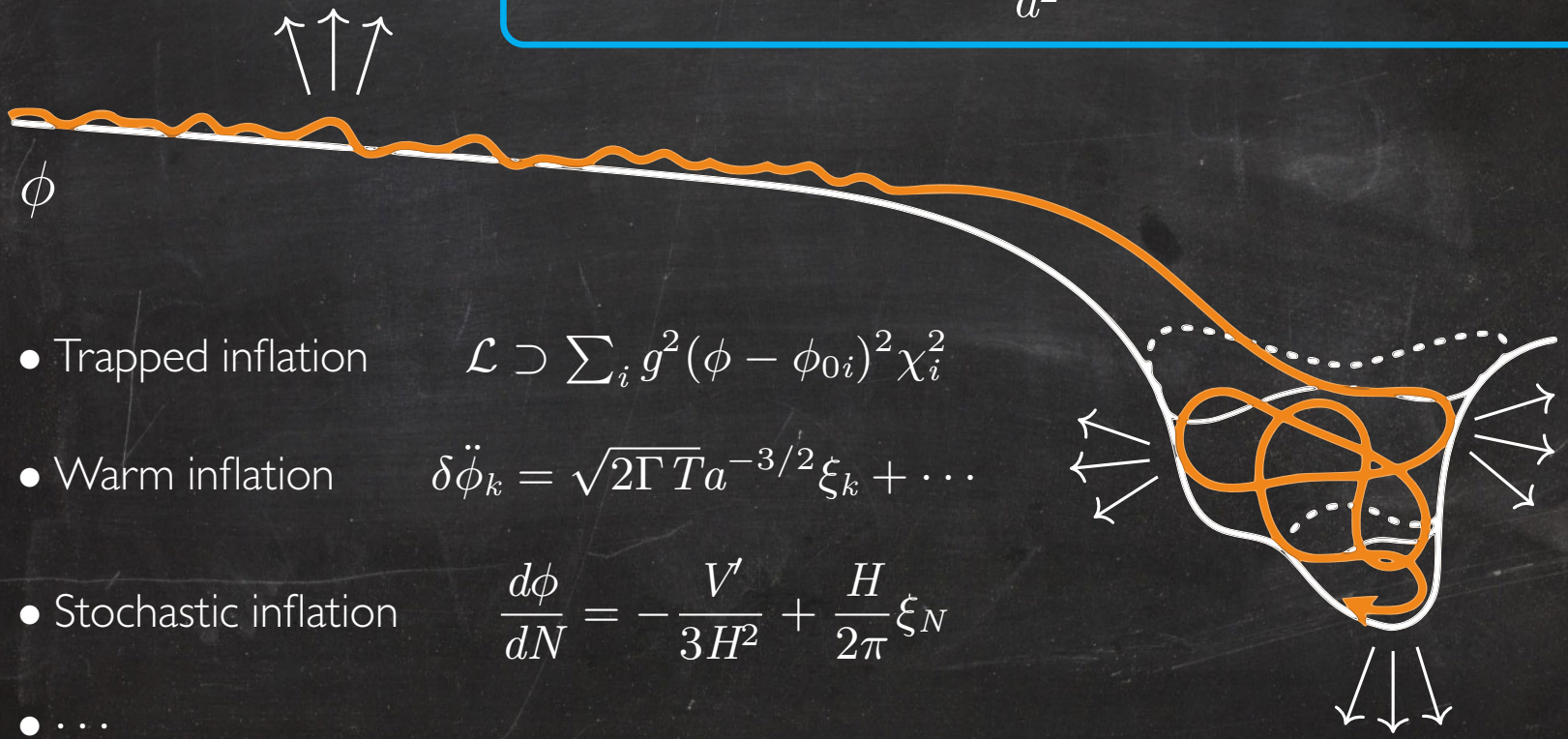




The non-perturbative picture

background dynamics $\longleftrightarrow$ particle production $\langle \chi_{\boldsymbol{k}_1} \chi_{\boldsymbol{k}_2} \cdots \rangle$ $\longleftrightarrow$ curvature fluctuations $\langle \zeta_{\boldsymbol{k}_1} \zeta_{\boldsymbol{k}_2} \cdots \rangle$

$$\ddot{\pi}_{\boldsymbol{k}} + [3H + \mathcal{O}_d]\, \pi_{\boldsymbol{k}} + \frac{k^2}{a^2} \pi_{\boldsymbol{k}} \;=\; \mathcal{O}_s \left(\langle \chi\chi \cdots \rangle_{\boldsymbol{k}} \right)$$



- Trapped inflation $\quad \mathcal{L} \supset \sum_i g^2 (\phi - \phi_{0i})^2 \chi_i^2$
- Warm inflation $\quad \delta\ddot{\phi}_k = \sqrt{2\Gamma T} a^{-3/2} \xi_k + \cdots$
- Stochastic inflation $\quad \dfrac{d\phi}{dN} = -\dfrac{V'}{3H^2} + \dfrac{H}{2\pi} \xi_N$
- $\cdots$

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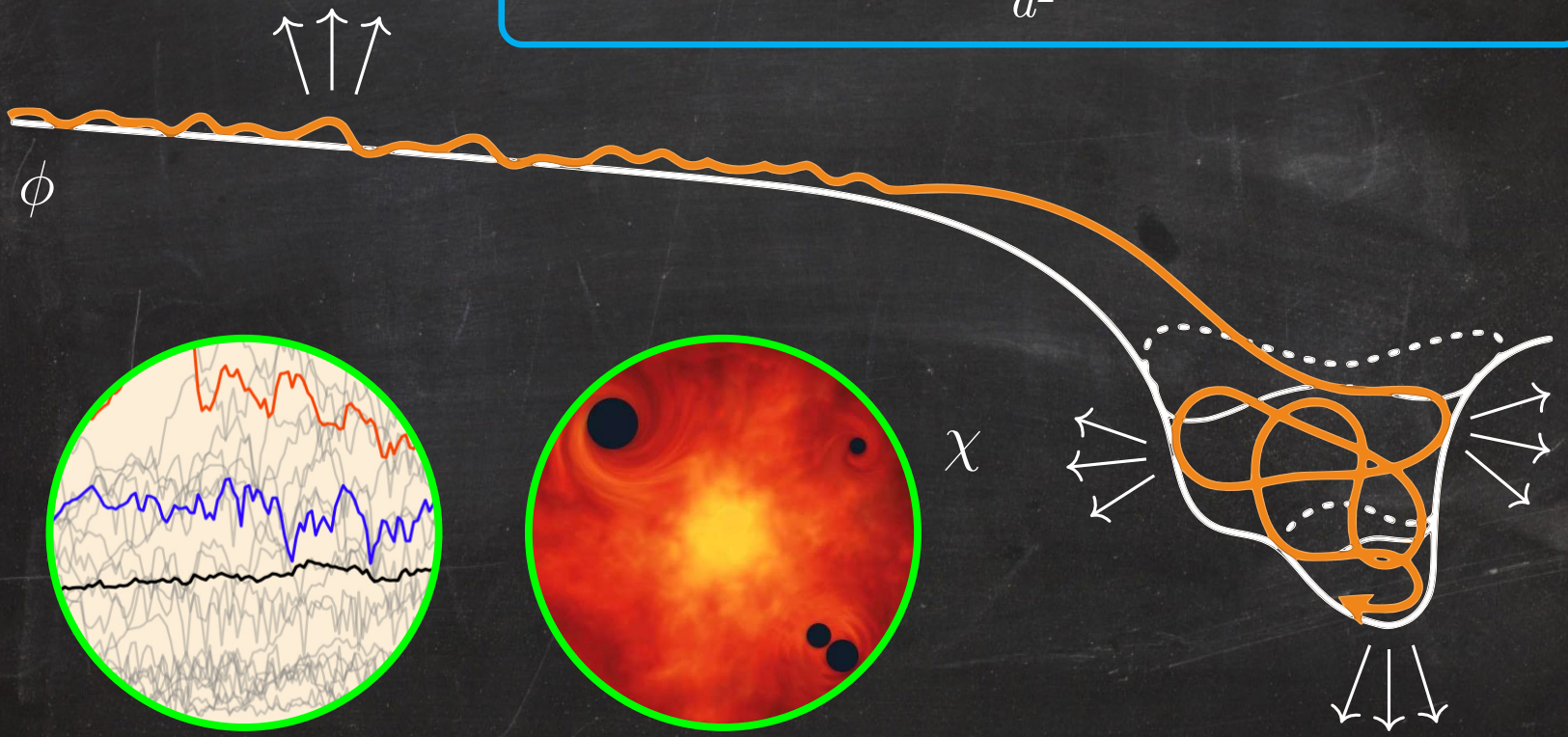

Discussion

- Dark Matter bestiary
  - What did I miss?

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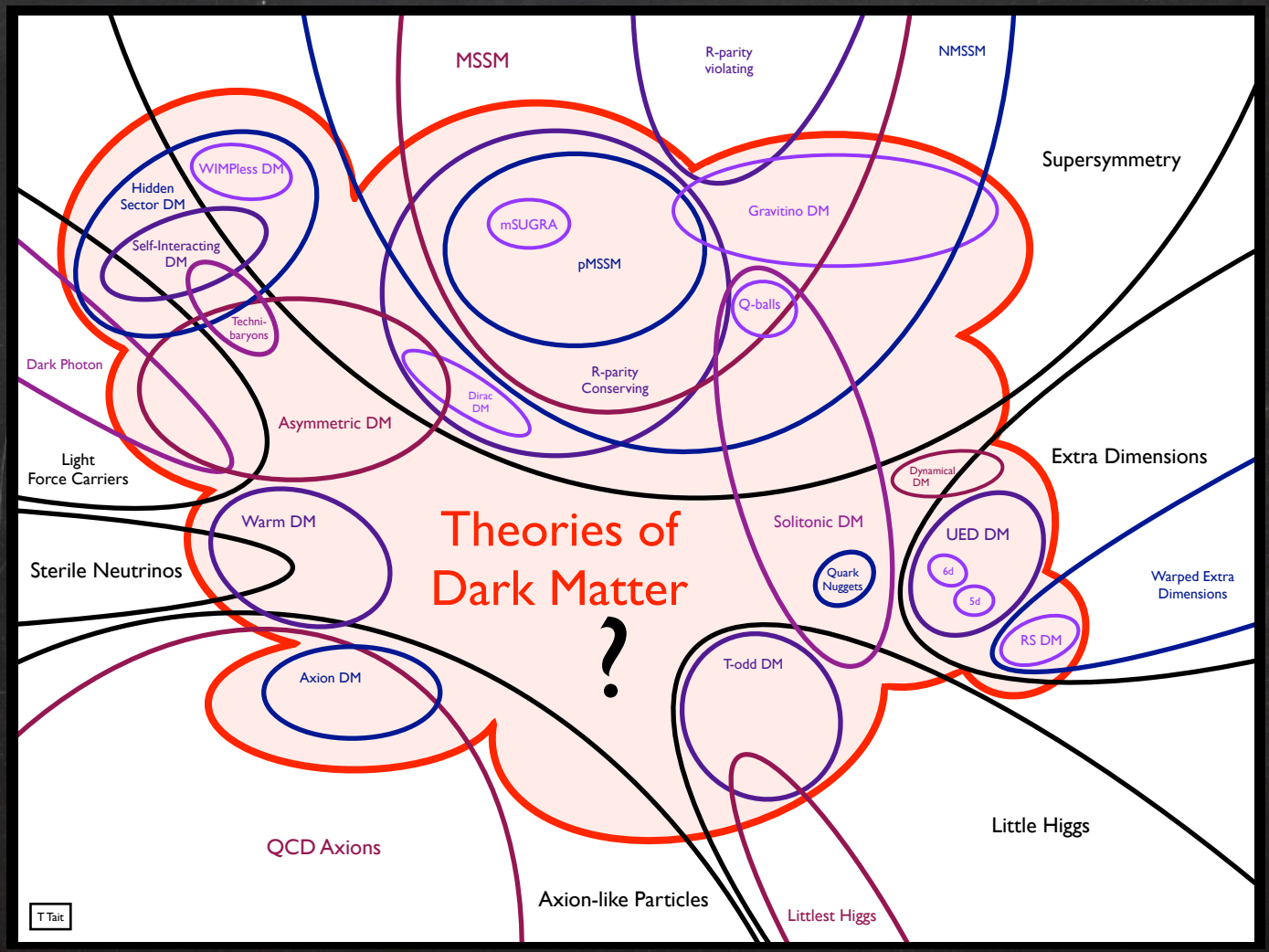
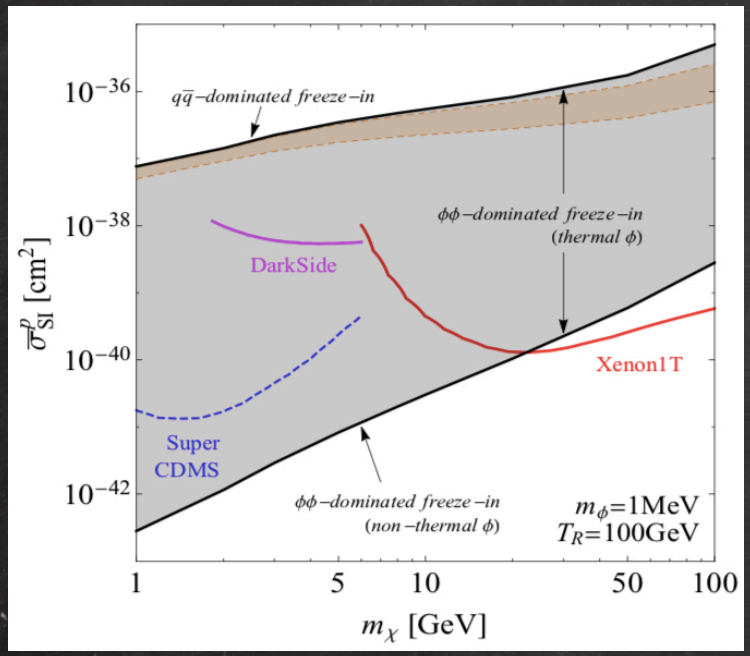


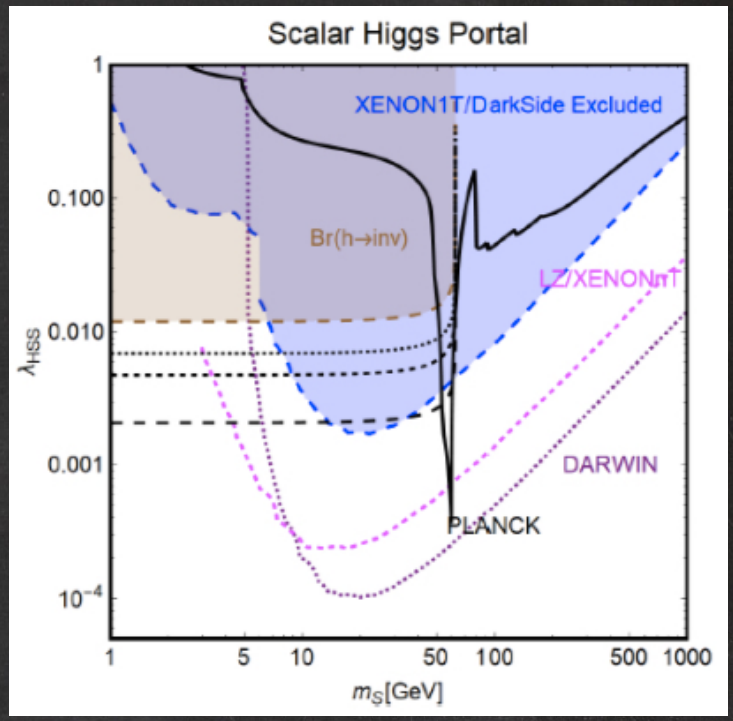
Discussion

- Dark Matter bestiary
  - What did I miss?
- Observational challenges
  - Direct and indirect detection in particle and non-particle DM models

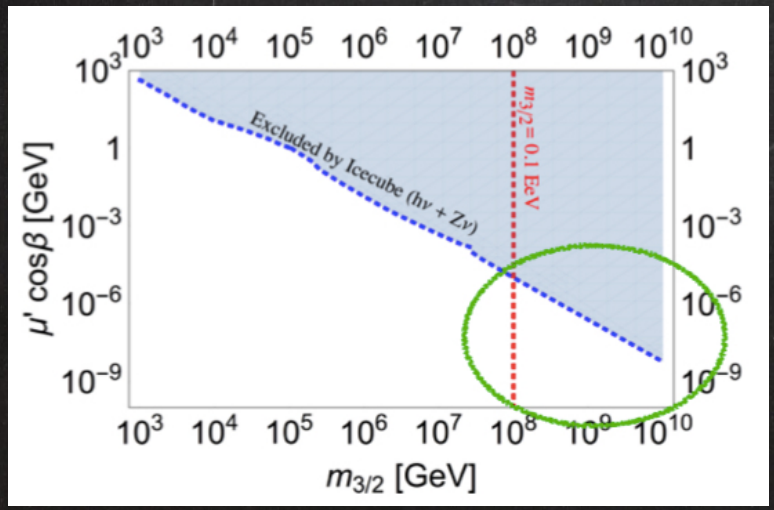
Discussion



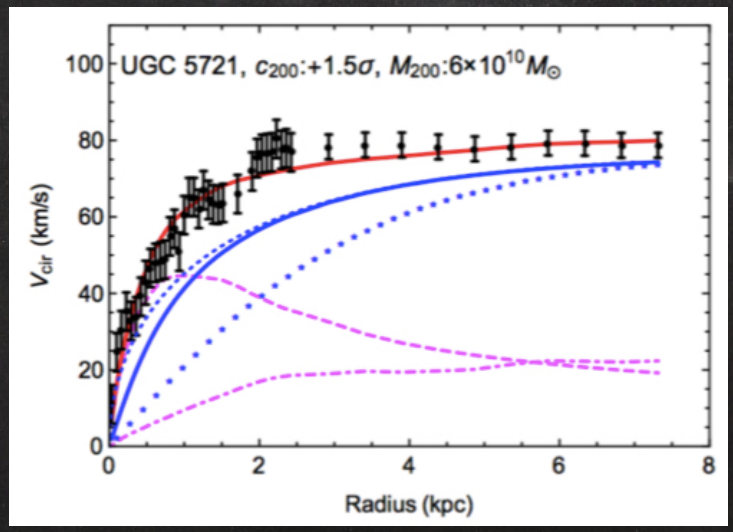
(Genèvieve's)



(Giorgio's)



(Kunio's)



(Michel's)

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- Observational challenges
  - Direct detection in particle and non-particle DM models
  - In FIMP scenarios, how to break the degeneracy? (Ω_{DM})

Discussion

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  - What did I miss?
- Observational challenges
  - Direct detection in particle and non-particle DM models
  - In FIMP scenarios, how to break the degeneracy? (Ω_{DM})
- Computational challenges
  - Toy models vs. UV completions
  - Parametrize the CMB - DM connection

Discussion

- Dark Matter bestiary
  - What did I miss?
- Observational challenges
  - Direct detection in particle and non-particle DM models
  - In FIMP scenarios, how to break the degeneracy? (Ω_{DM})
- Computational challenges
  - Toy models vs. UV completions
  - Parametrize the CMB - DM connection
- Insights from people from first part of symposium
  - Modified gravity?