The String Soundscape

what gravity wave detectors can tell us about BSM physics

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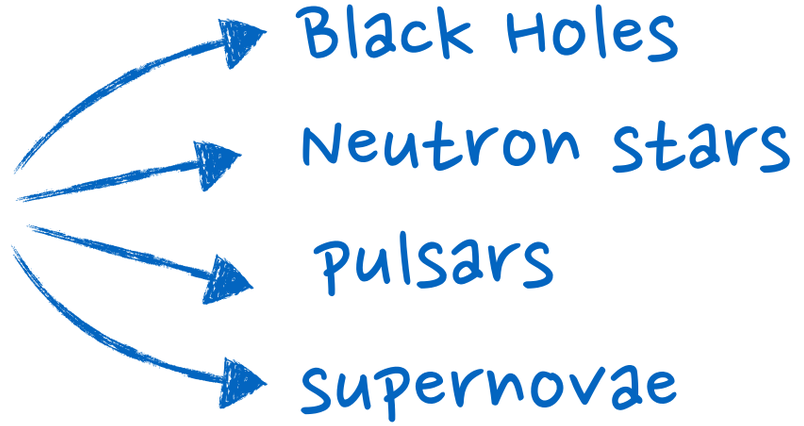
IGG, S. Krippendorf, J. March-Russell — arXiv:1607.06813

Gravitational Waves

- GW have been directly observed by LIGO, and a bunch of other detectors will be built in the future.

- The astrophysical potential of GW detectors has been deeply studied.



e.g. see Lasky *et al.* arXiv:1511.05994

- Can we use GW experiments to learn about BSM?

GW detectors for BSM

There are *a few* examples:

(but mostly very poorly explored)

- Inflation.

- Strong 1st order EW phase transition.

perfect for eLISA

a review: Caprini *et al.* arXiv:1512.06239

- Probing the existence of a QCD axion (due to BH superradiance).

with aLIGO

Arvanitaki *et al.* arXiv:1411.2263, and arXiv:1604.03958.

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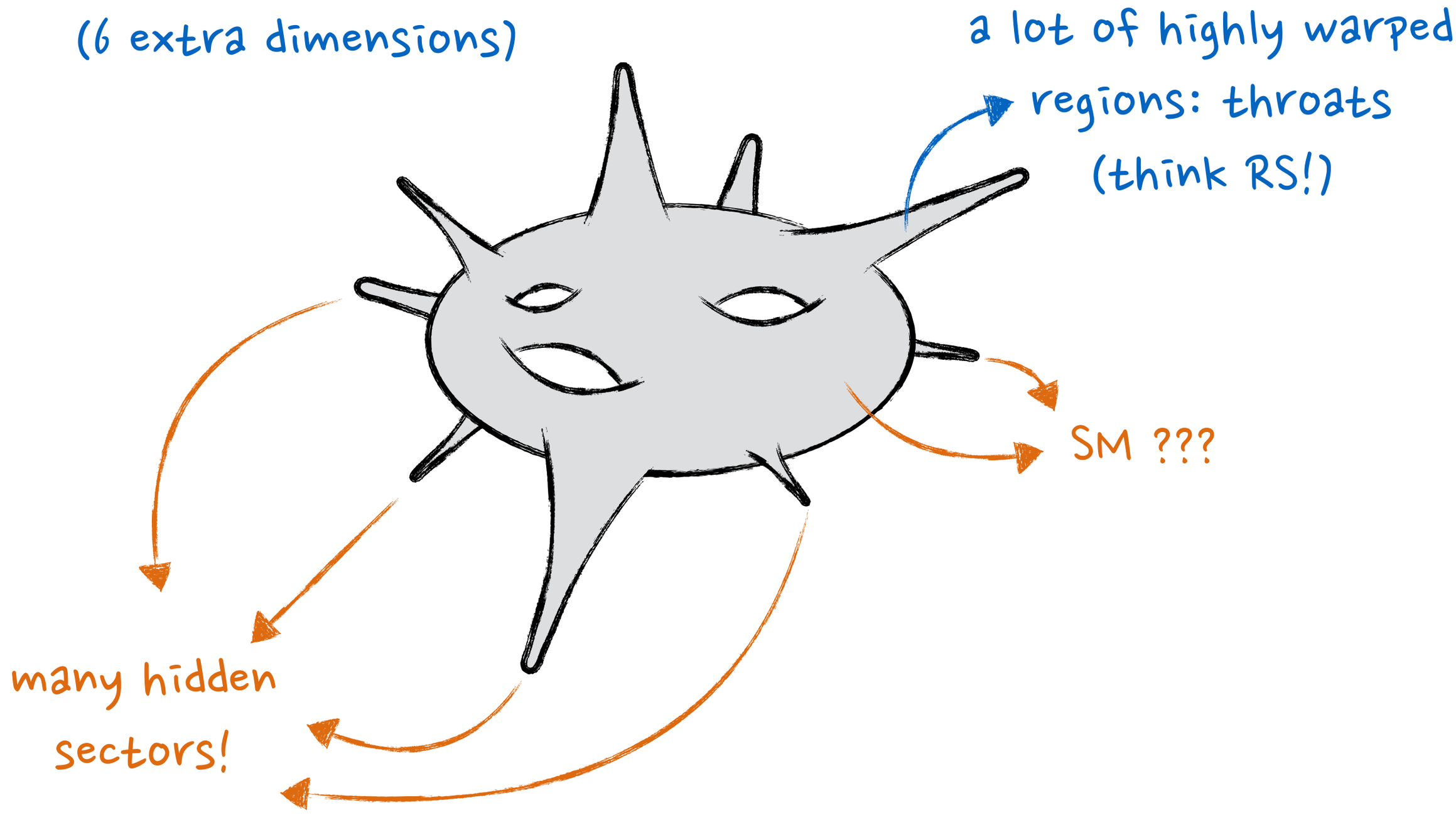
+ GW signals from vacuum decay in String Theory motivated scenarios

A String Theory Motivation

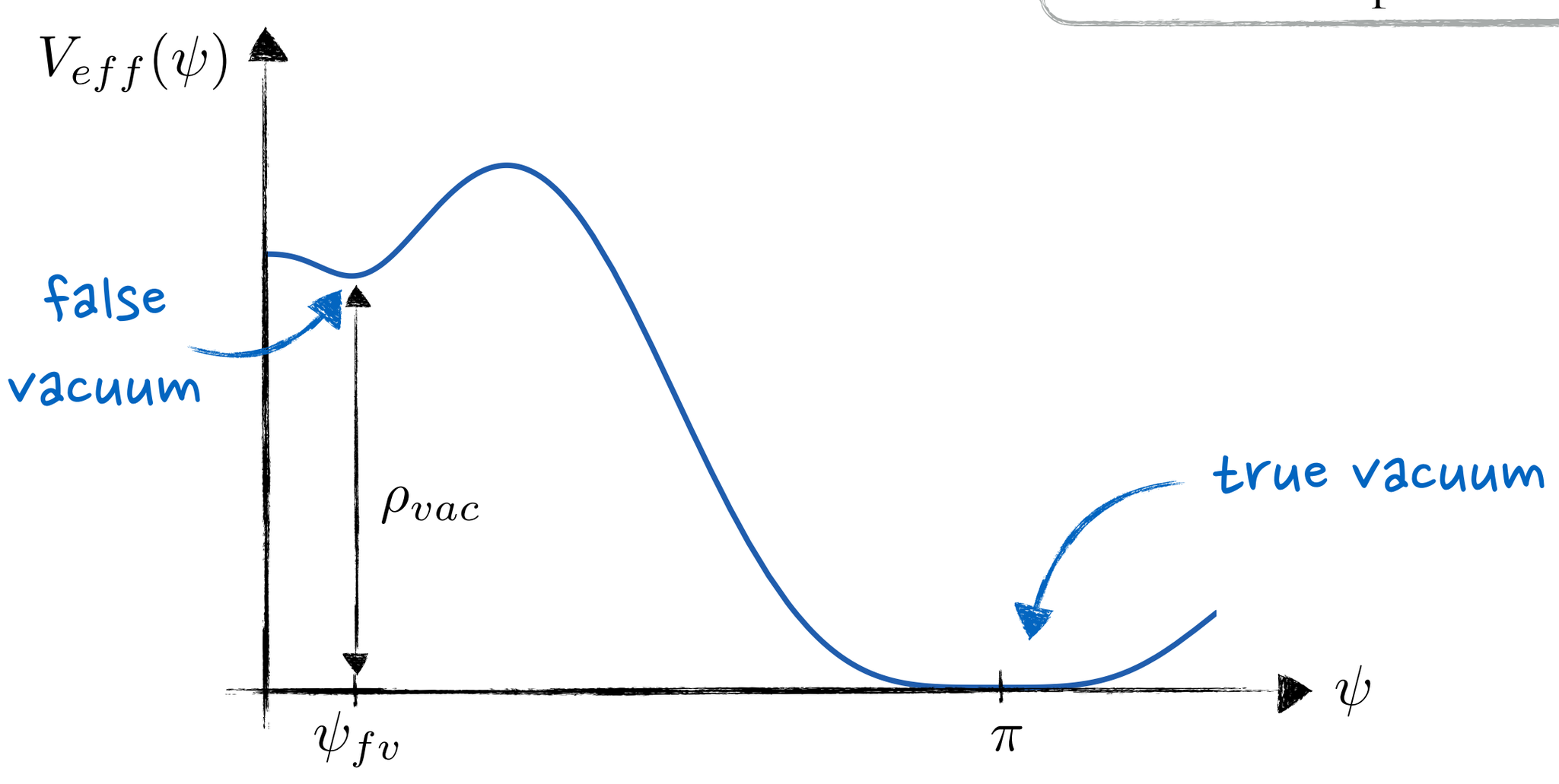
A typical stringy set-up:



A String Theory Motivation

Under some reasonable assumptions, a typical throat features a metastable (SUSY-breaking) false vacuum, as well as a true (SUSY-preserving) one.

Kachru *et al.* hep-th/0112197



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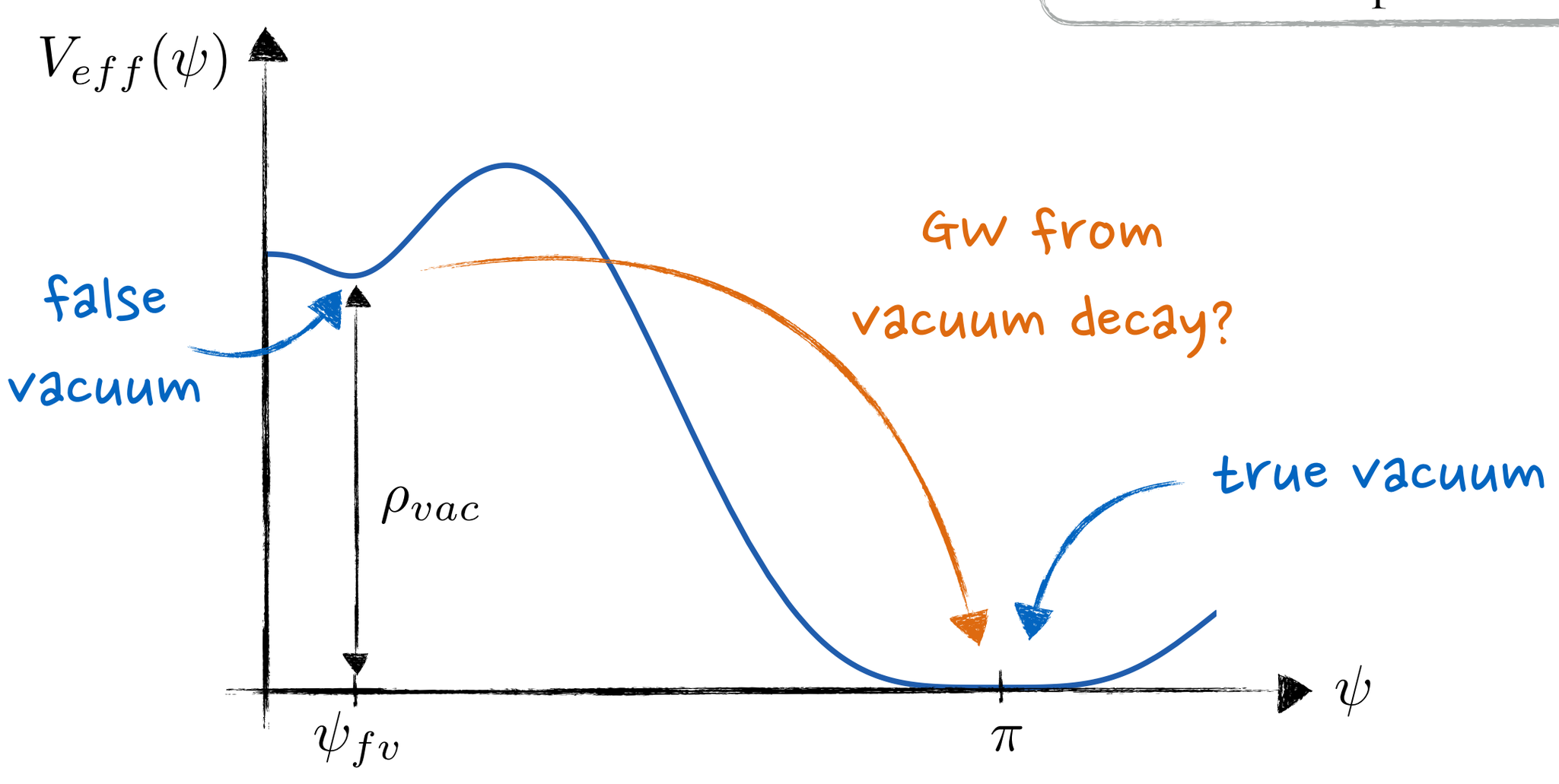


A String Theory Motivation

Assumptions:

- <u>After inflation</u>, throat in its metastable vacuum.

- Visible sector reheated at $T_{rh} \gtrsim 4\ \mathrm{MeV}$ but hidden sector left at $T_{th} \approx 0$.

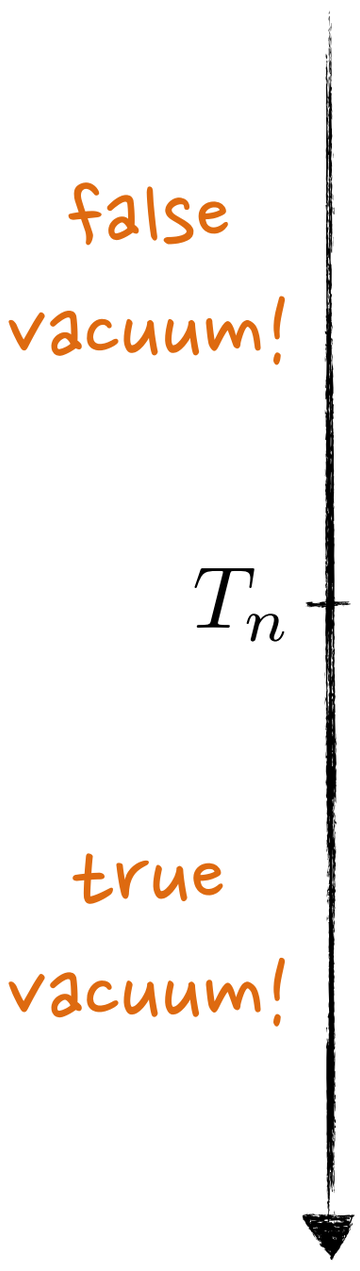
the decay must occur via quantum tunnelling

- Universe radiation dominated throughout.

(may be relaxed to include a phase of matter domination)

$$\rho_{total}(T) = \rho_{rad}(T) + \rho_{vac} \quad \text{with} \quad \alpha(T) \equiv \frac{\rho_{vac}}{\rho_{rad}(T)} \leq 1$$

Vacuum Decay



Probability of nucleating a bubble of true vacuum in a Hubble volume, in a Hubble time:

decay rate per u. volume (depends on throat)

$$\Gamma \sim \frac{\Gamma}{H(T)^4}$$

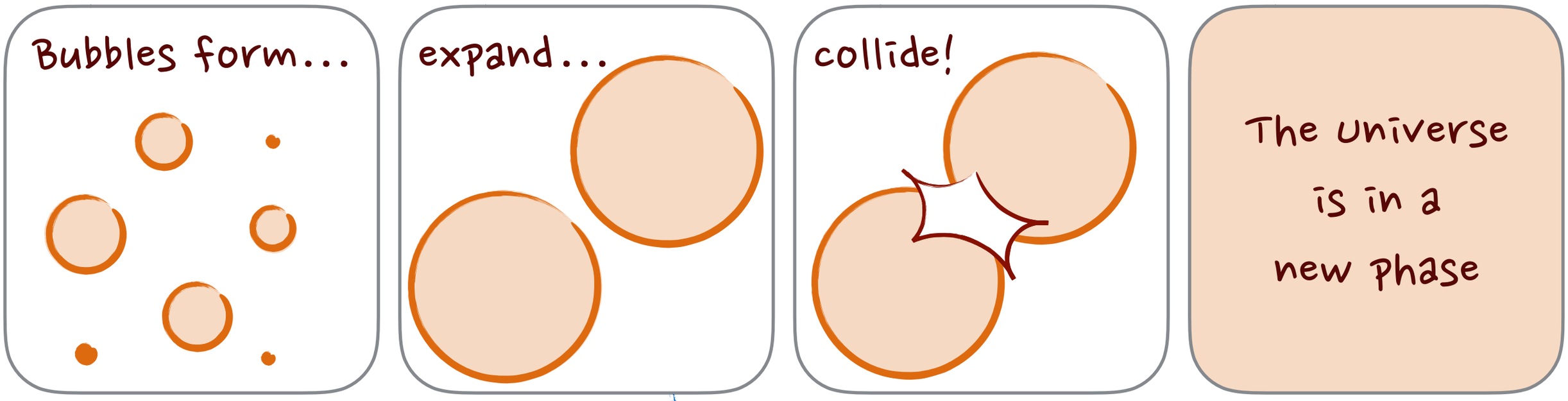
decreases as the temperature drops

with $H(T)^2 = \frac{\rho_{total}(T)}{3m_{Pl}^2}$

When $\frac{\Gamma}{H(T_n)^4} \approx 1$ the transition starts.

Vacuum Decay

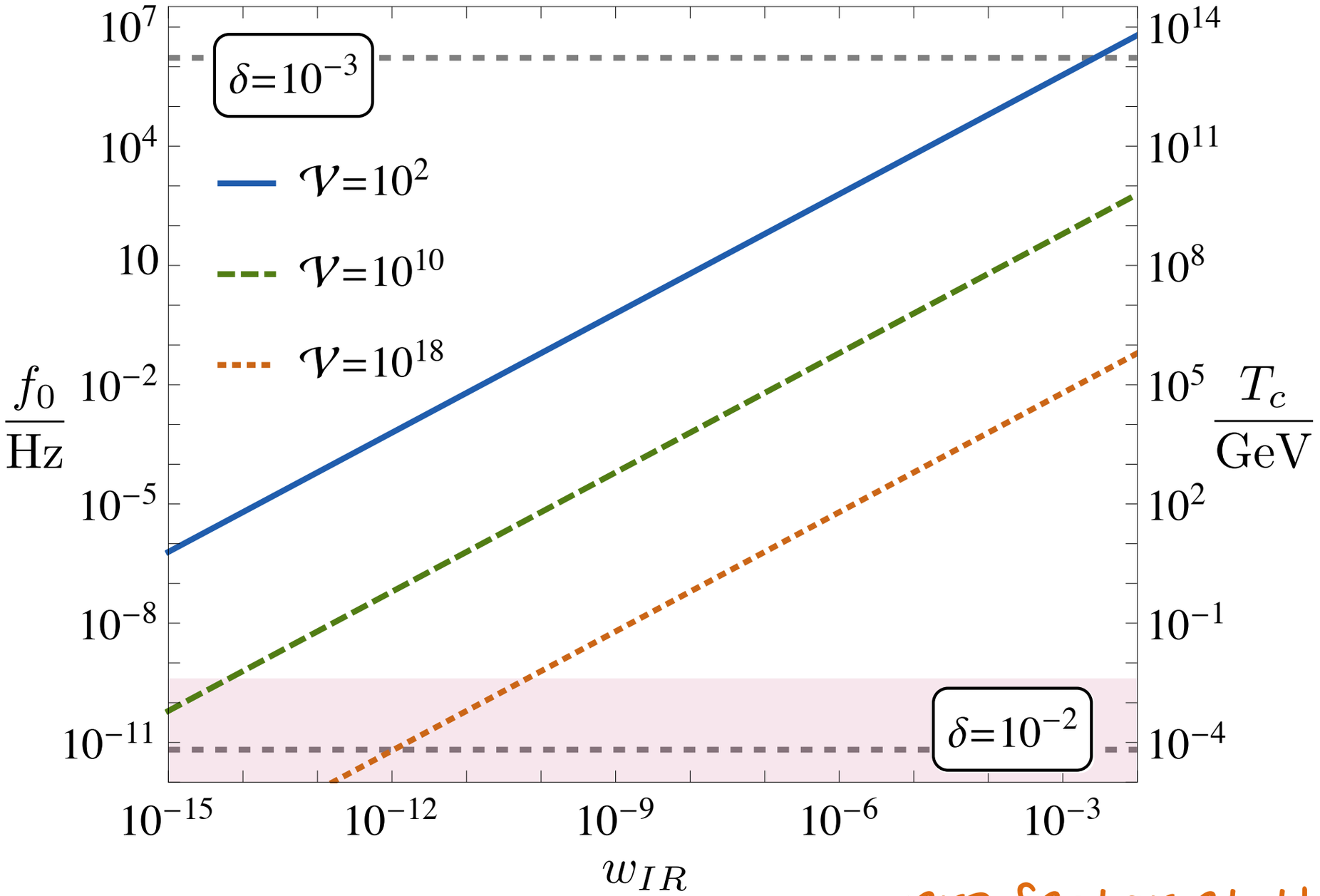
Bubbles of the true vacuum are nucleated in the early universe



They quickly start expanding at the speed of light

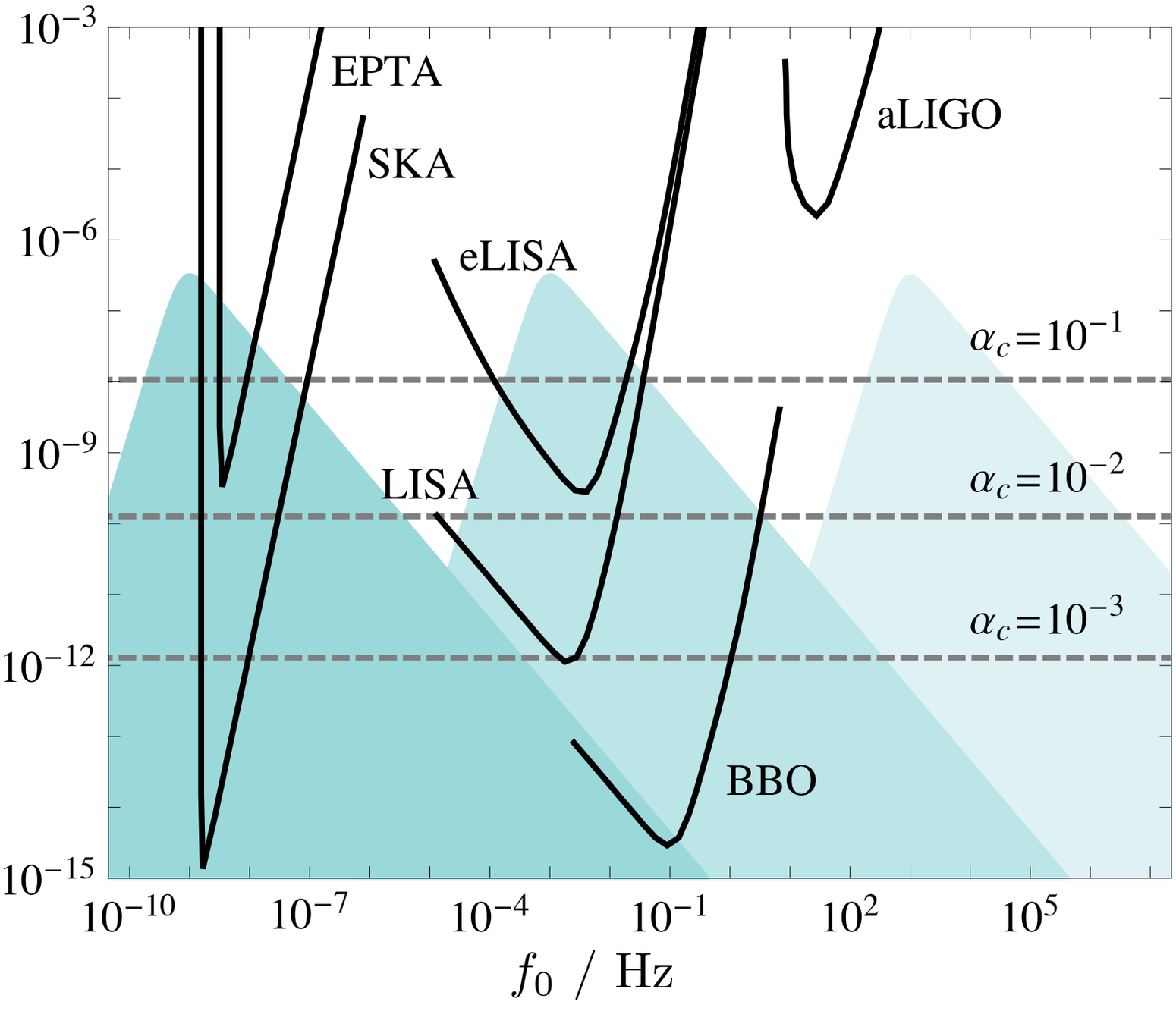
Bubbles then collide, emitting energy in the form of gravity waves

GW Signal — Frequency



warp factor at the tip of the throat

GW Signal — Strength



$$\alpha_c \equiv \frac{\rho_{vac}}{\rho_{rad}(T_c)}$$

Conclusions

- GW detectors will help shape the future of physics in the coming century.

- They can complement the information we get from particle colliders and DM detection experiments.

- GW signals from string theory is just an example of how they might help probe the highest energy scales!

exciting !!!