

OBSERVABLE GRAVITATIONAL WAVES FROM CONFORMAL SYMMETRY BREAKING

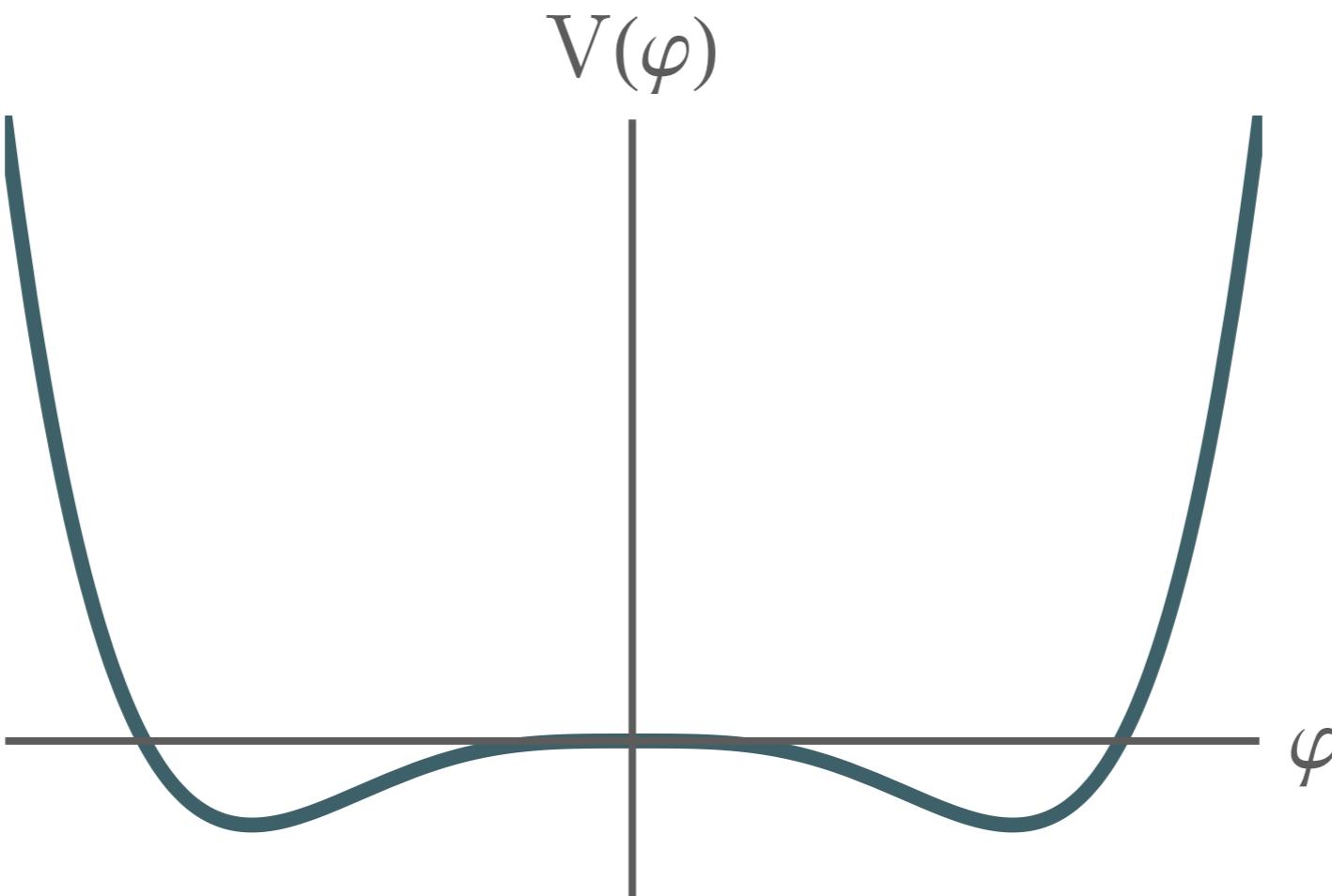
Bogumiła Świeżewska
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in collaboration with:
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Leonardo Chataignier, Jonas Rezacek

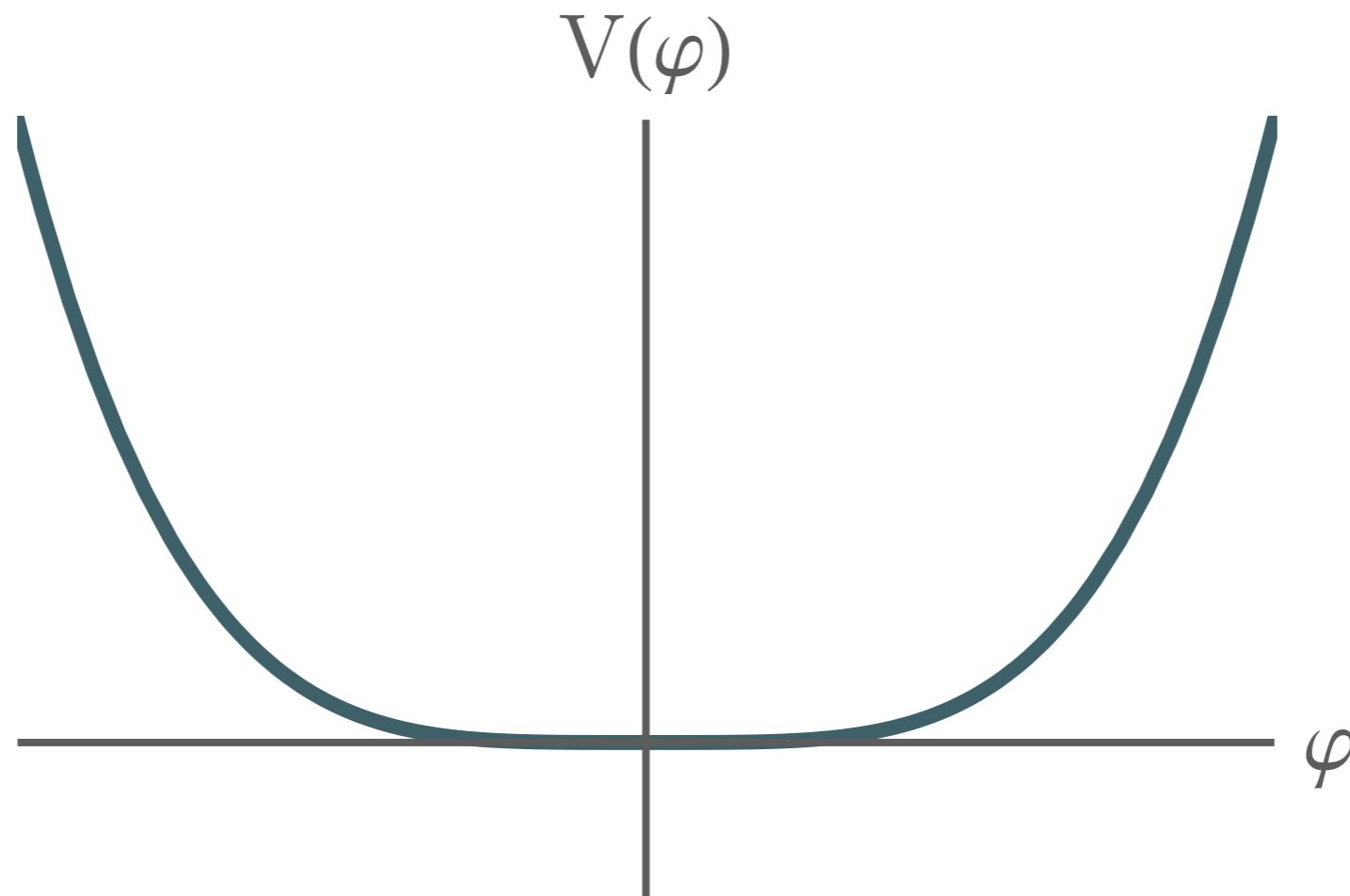
Based on
JHEP 1808 (2018) 083
arXiv:1809.11129

Harmonia Meeting, Warsaw, 8.12.2018

ELECTROWEAK SYMMETRY BREAKING IS REAL

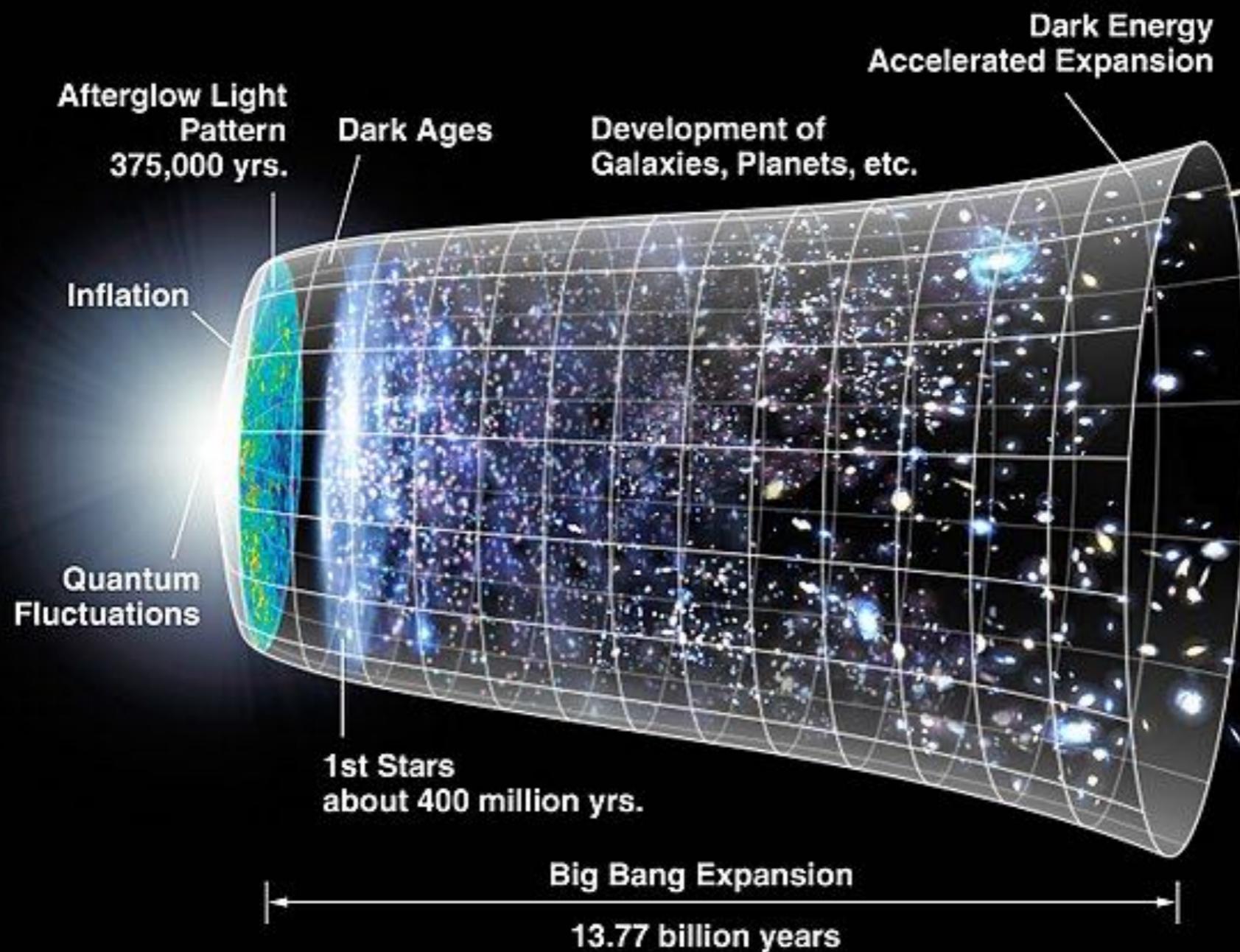


ELECTROWEAK SYMMETRY BREAKING IS REAL



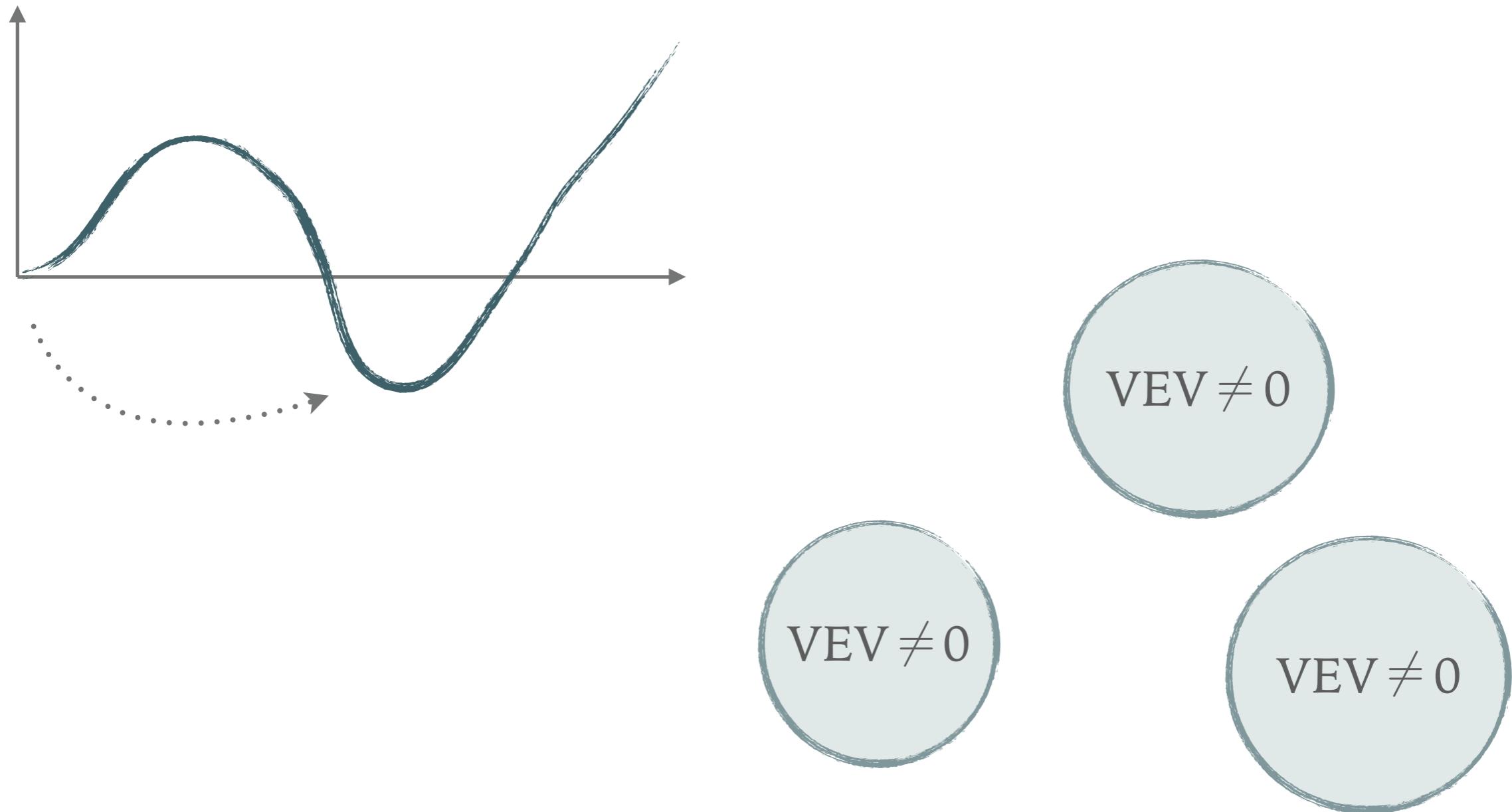
OBSERVING THE CHILDHOOD OF THE UNIVERSE?

phase transition $\sim 10^{-11}$ s



Credit: NASA

FIRST ORDER PHASE TRANSITION AND GW



LISA IS COMING!

in the 2030's

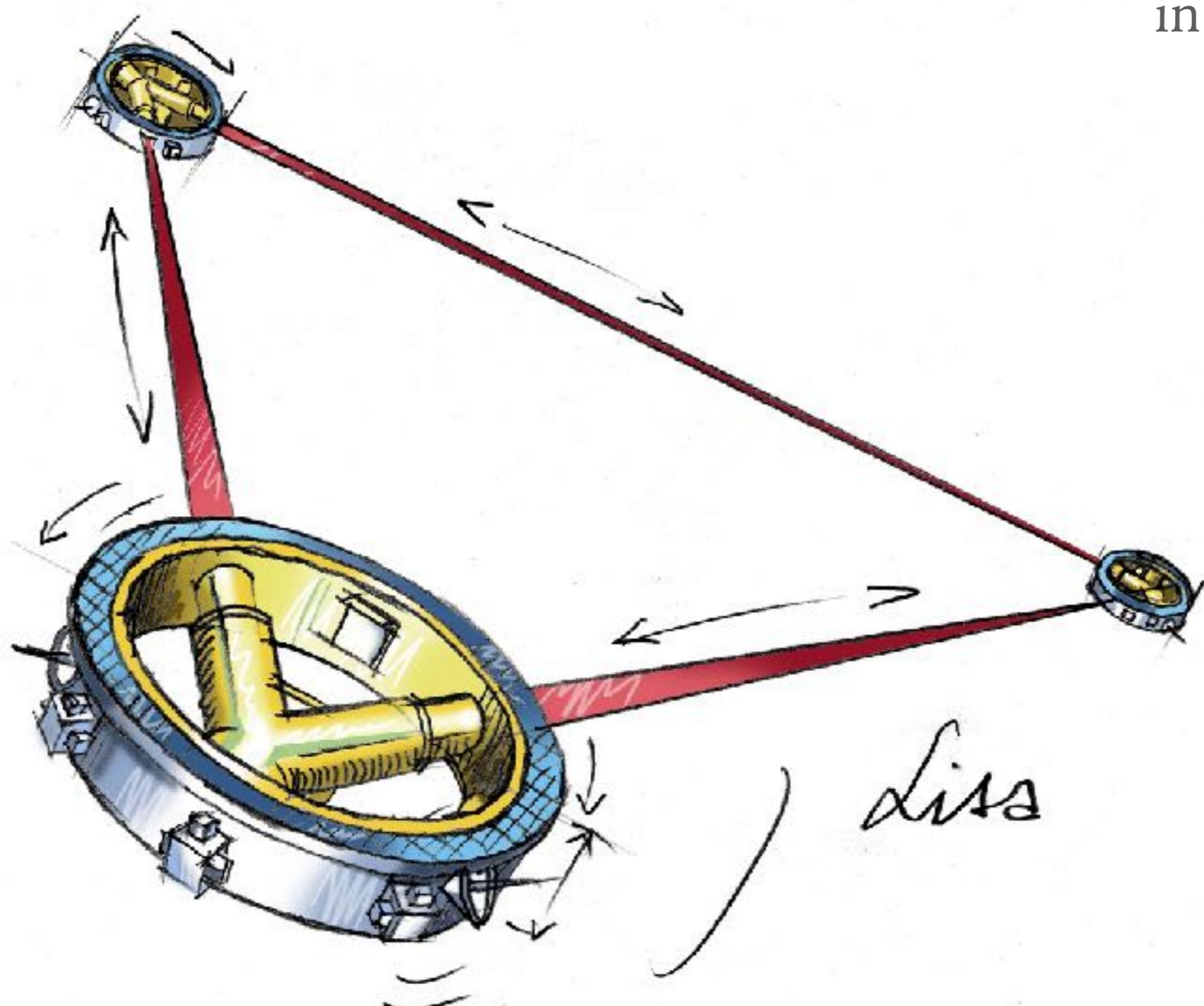


Image credit: ESA-C. Vijoux

Bogumiła Świeżewska

Observable gravitational waves from conformal symmetry breaking

CLASSICAL CONFORMAL SYMMETRY

WHY CLASSICAL CONFORMAL SYMMETRY?

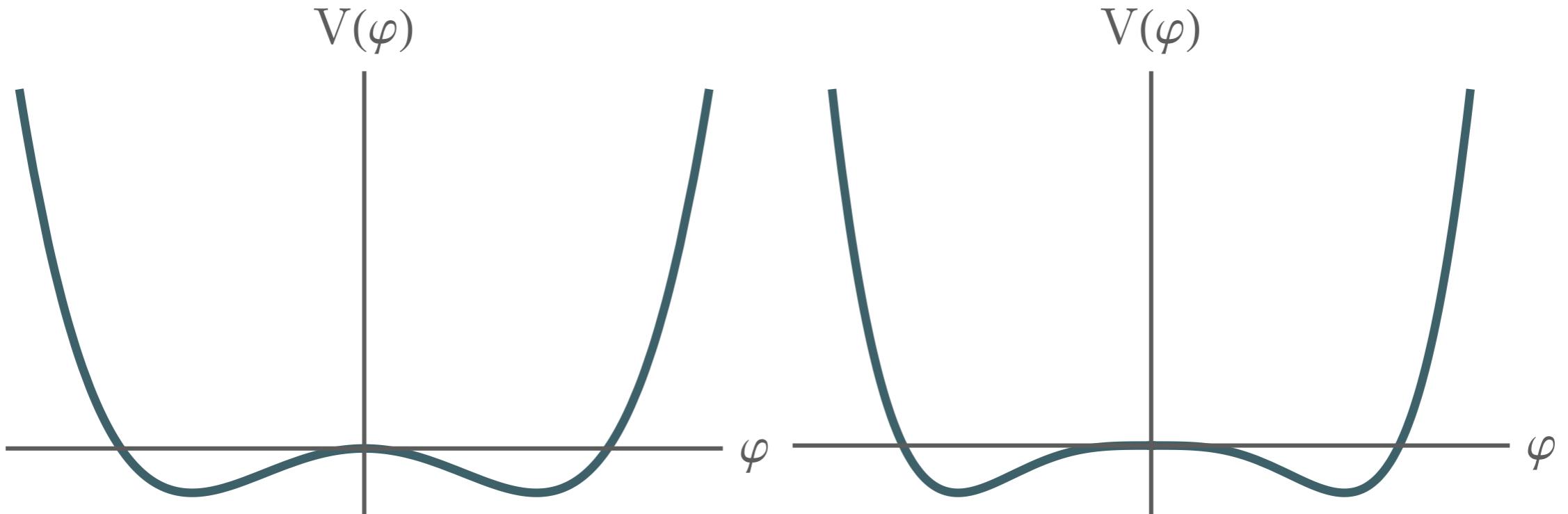
dynamical
generation of all
mass scales

alleviation of the
hierarchy problem

predictivity

phase
transitions

CONFORMAL VS “NORMAL” POTENTIAL



The thermal barrier can last until low temperatures



Potential for supercooling and strong transition

SU(2)CSM



$$V^{(0)}(\Phi, \Psi) = \lambda_1 (\Phi^\dagger \Phi)^2 + \lambda_2 (\Phi^\dagger \Phi) (\Psi^\dagger \Psi) + \lambda_3 (\Psi^\dagger \Psi)^2,$$

Perturbative, stable
and self-consistent up
to the Planck scale

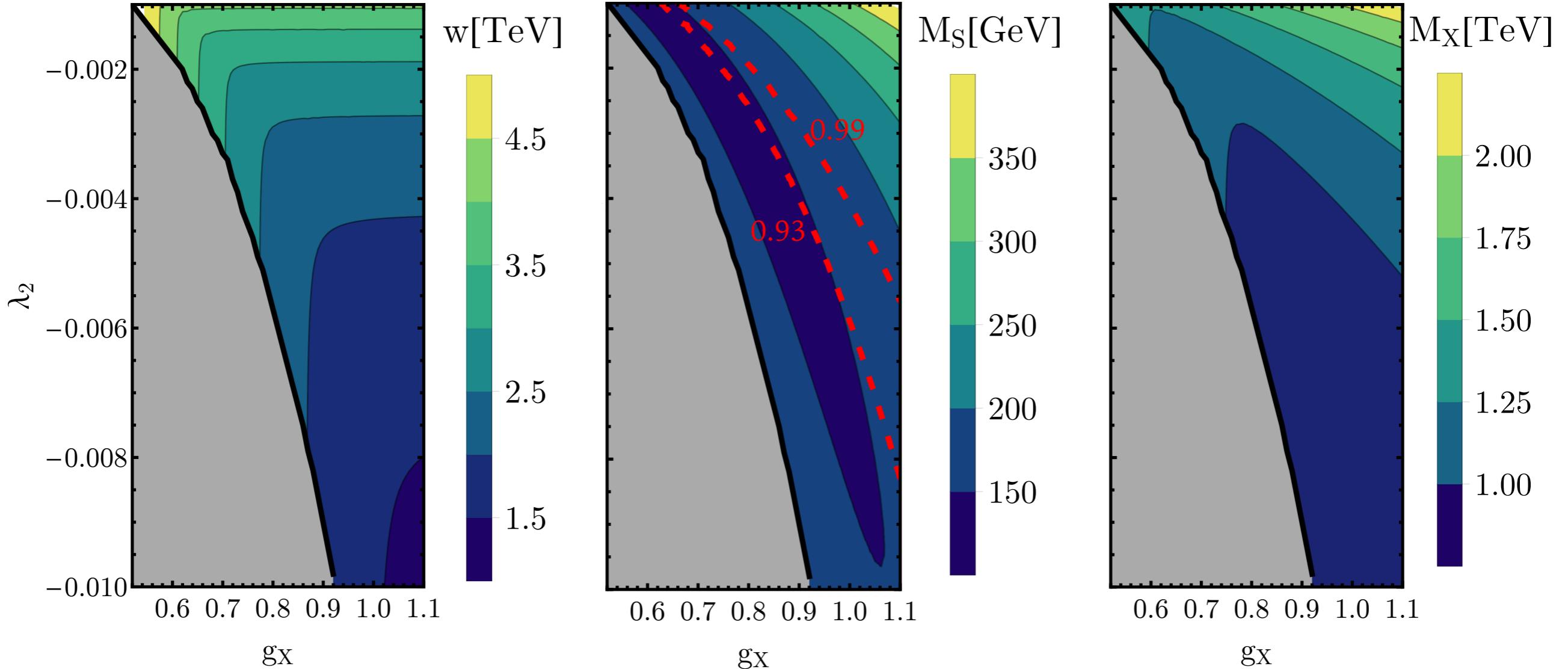
DM candidate

All masses generated radiatively

Observable gravitational waves
from symmetry breaking

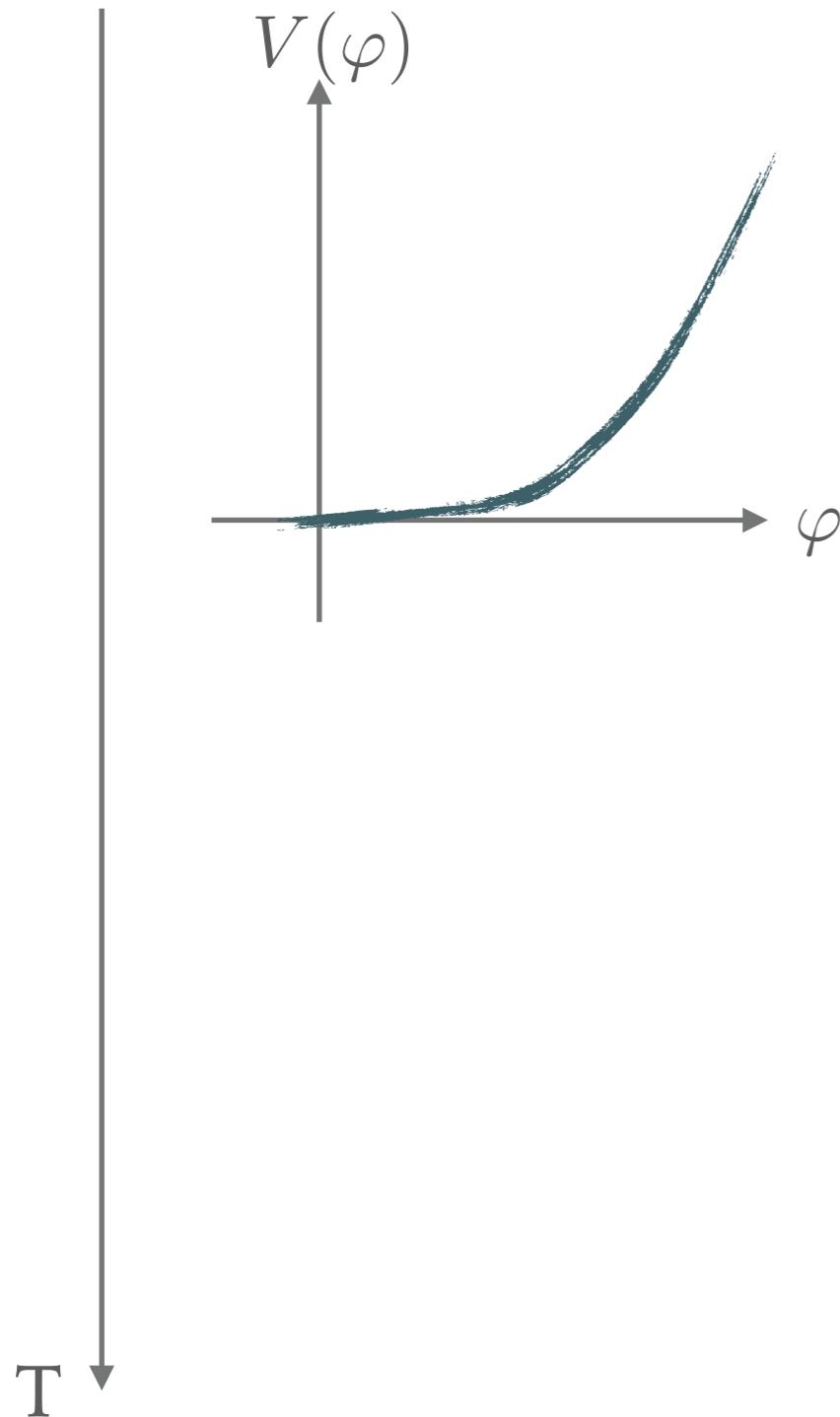
[See also: T.Hambye, A.Strumia, PRD88 (2013) 055022, C.D.Carone, R.Ramos, PRD88 (2013) 055020, V.V.Khoze, C.McCabe, G.Ro, JHEP 08 (2014) 026]

RADIATIVE SYMMETRY BREAKING IN SU(2)CSM

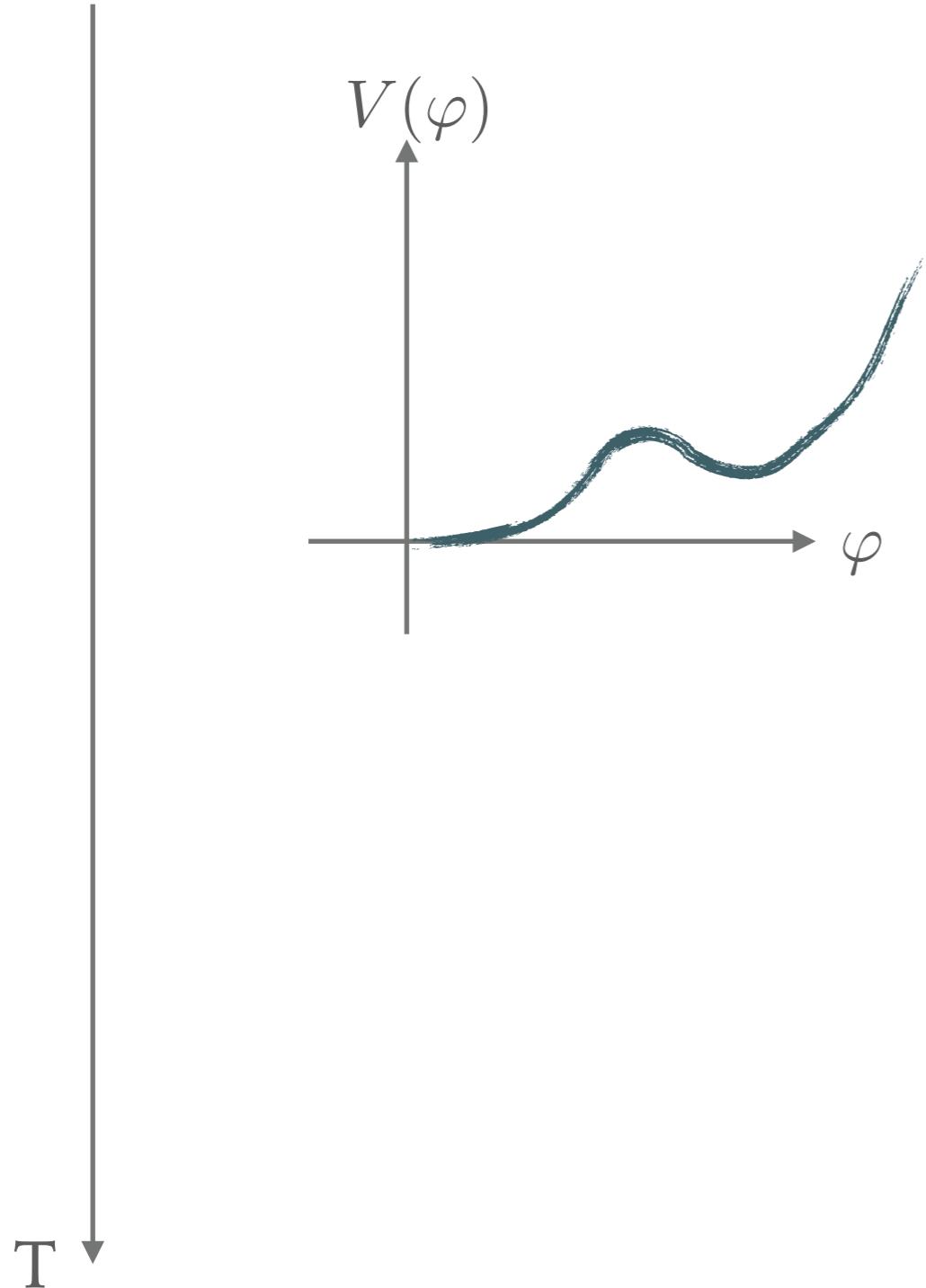


PHASE TRANSITION

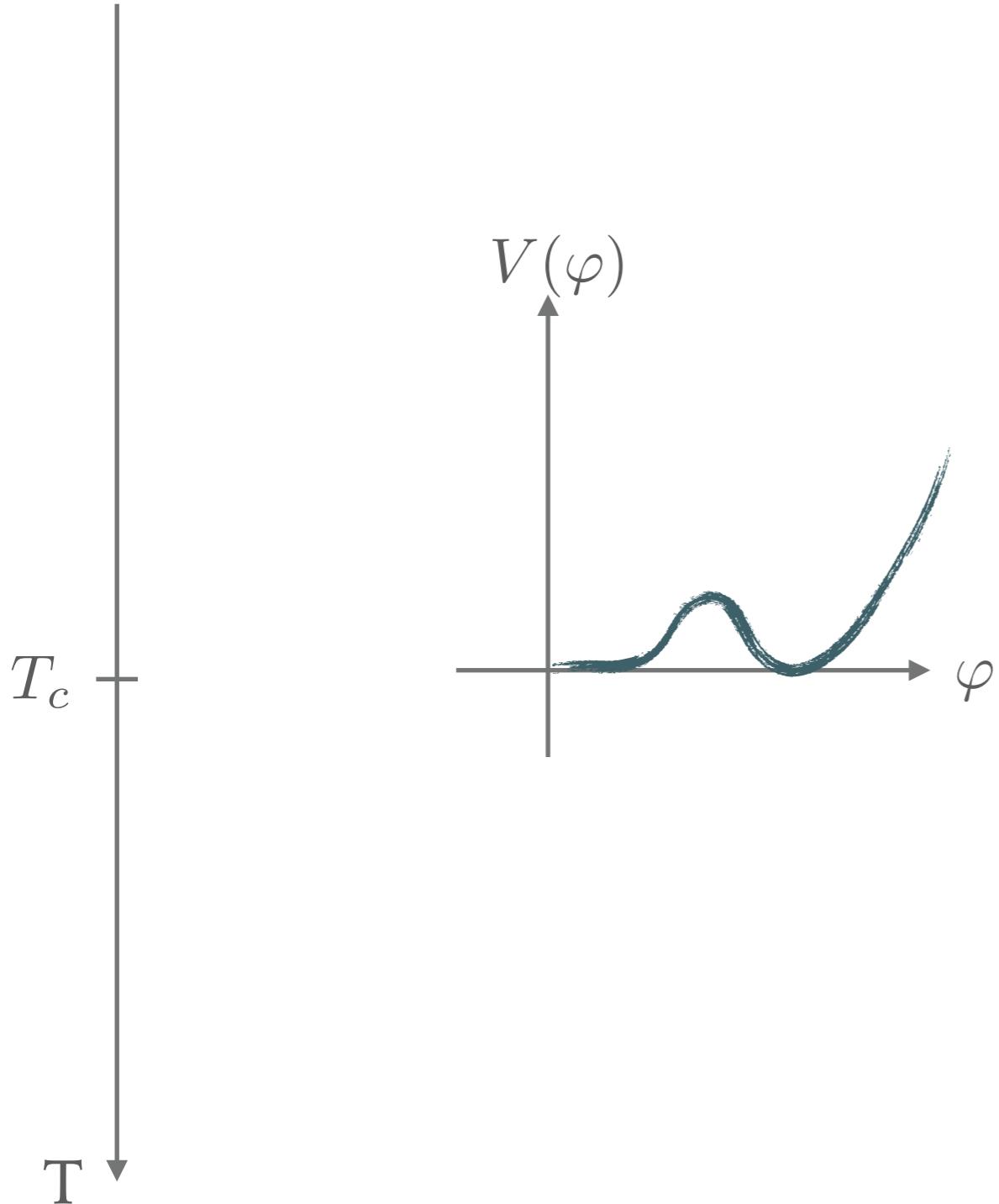
TEMPERATURE EVOLUTION



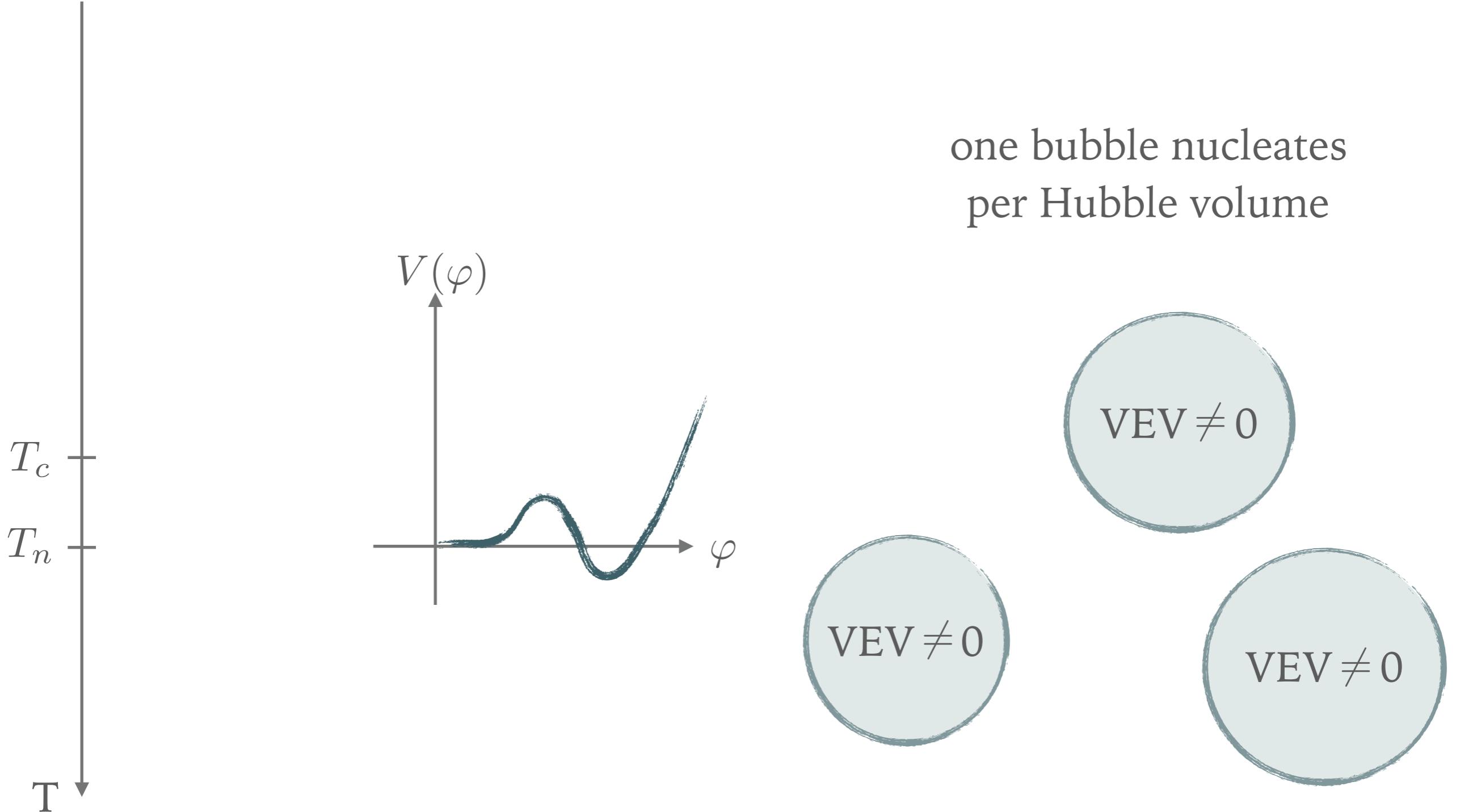
TEMPERATURE EVOLUTION



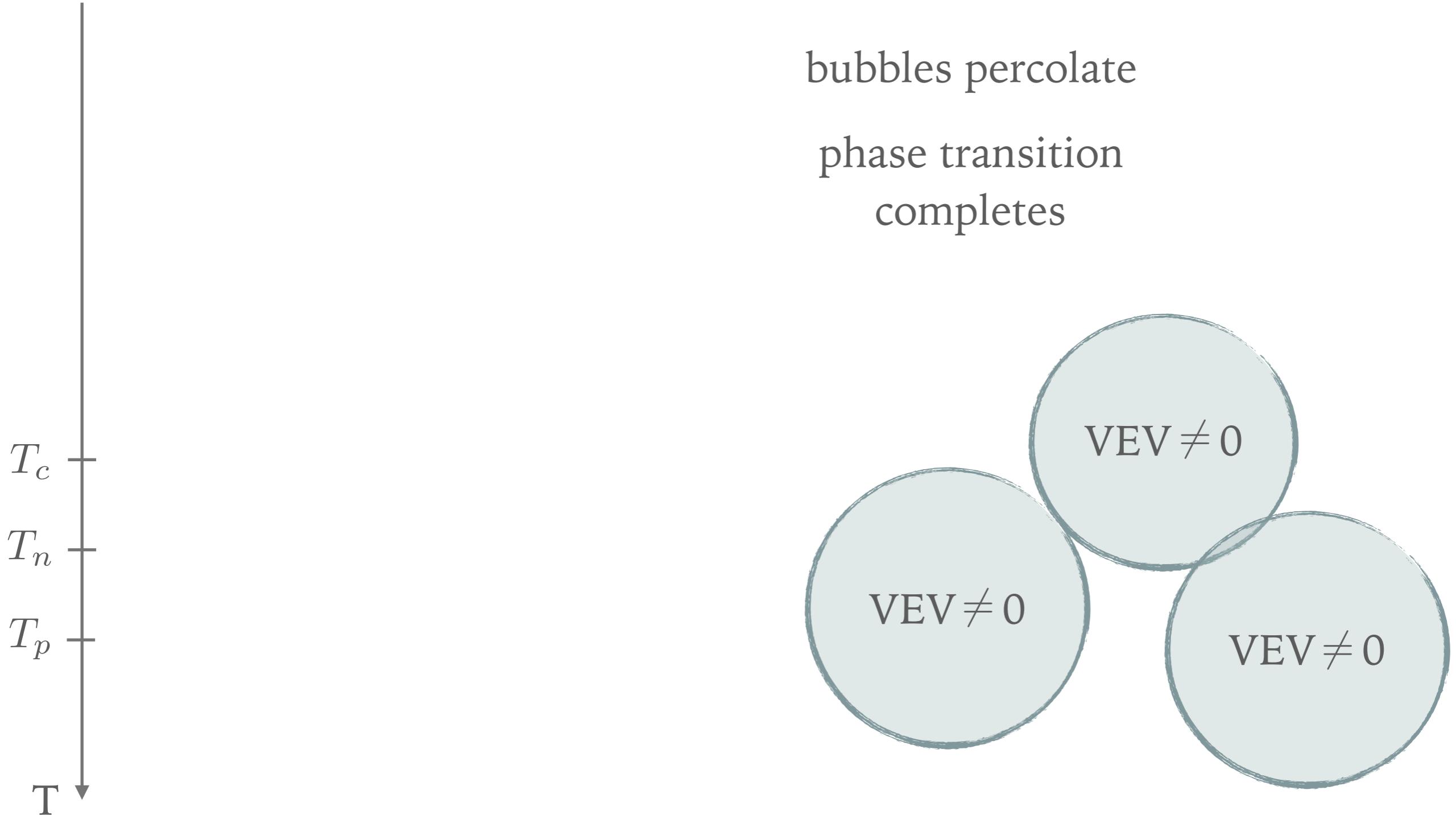
TEMPERATURE EVOLUTION



TEMPERATURE EVOLUTION



TEMPERATURE EVOLUTION



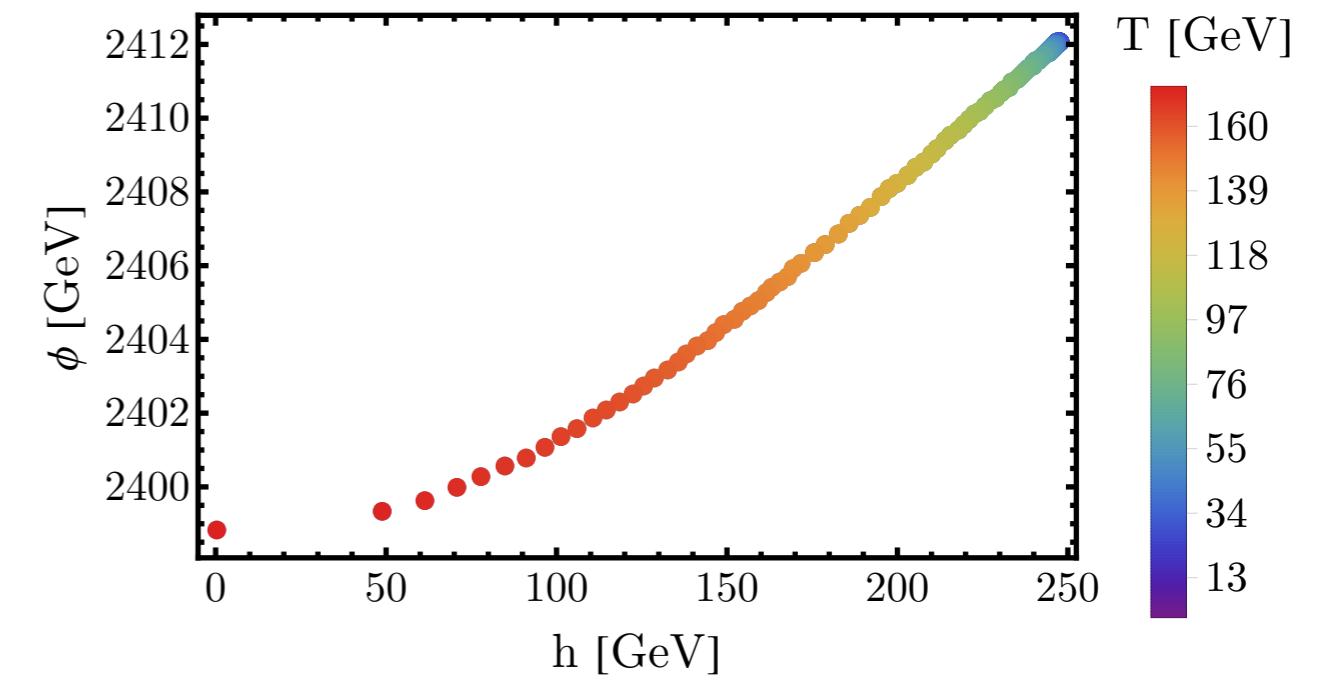
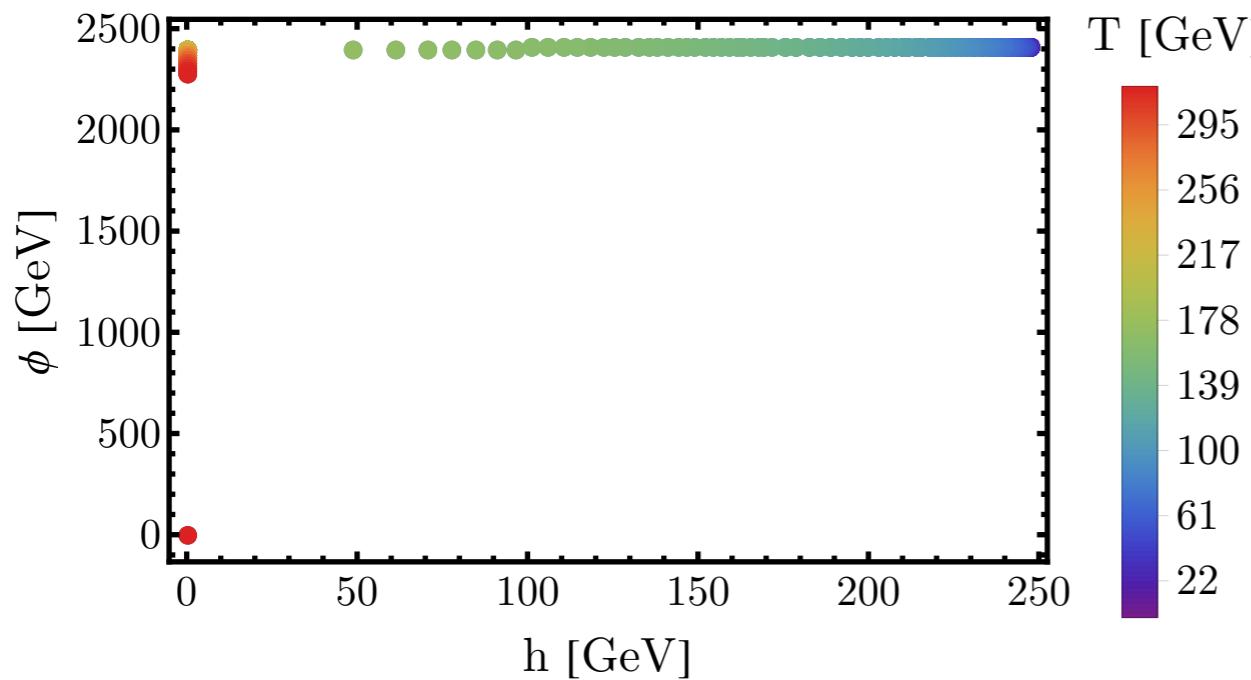
BENCHMARK POINTS

#	λ_1	λ_2	λ_3	g_X	w [GeV]	T_c [GeV]	T_n [GeV]	β/H_*	α
1	0.175	-0.0049	-0.0038	0.83	2200	281	22	449	597
2	0.149	-0.0065	-0.0058	0.94	1774	256	27	323	213
3	0.119	-0.0013	-0.0136	1.01	3611	568	64	238	131
4	0.122	-0.0050	-0.0104	1.05	1860	302	34	300	137
5	0.166	-0.0083	-0.0063	0.97	1648	244	25	327	210
6	0.120	-0.0019	-0.0079	0.92	2991	428	39	419	345
7	0.124	-0.0030	-0.0047	0.85	2411	318	28	434	361
8	0.139	-0.0095	-0.0093	1.08	1426	236	29	250	87

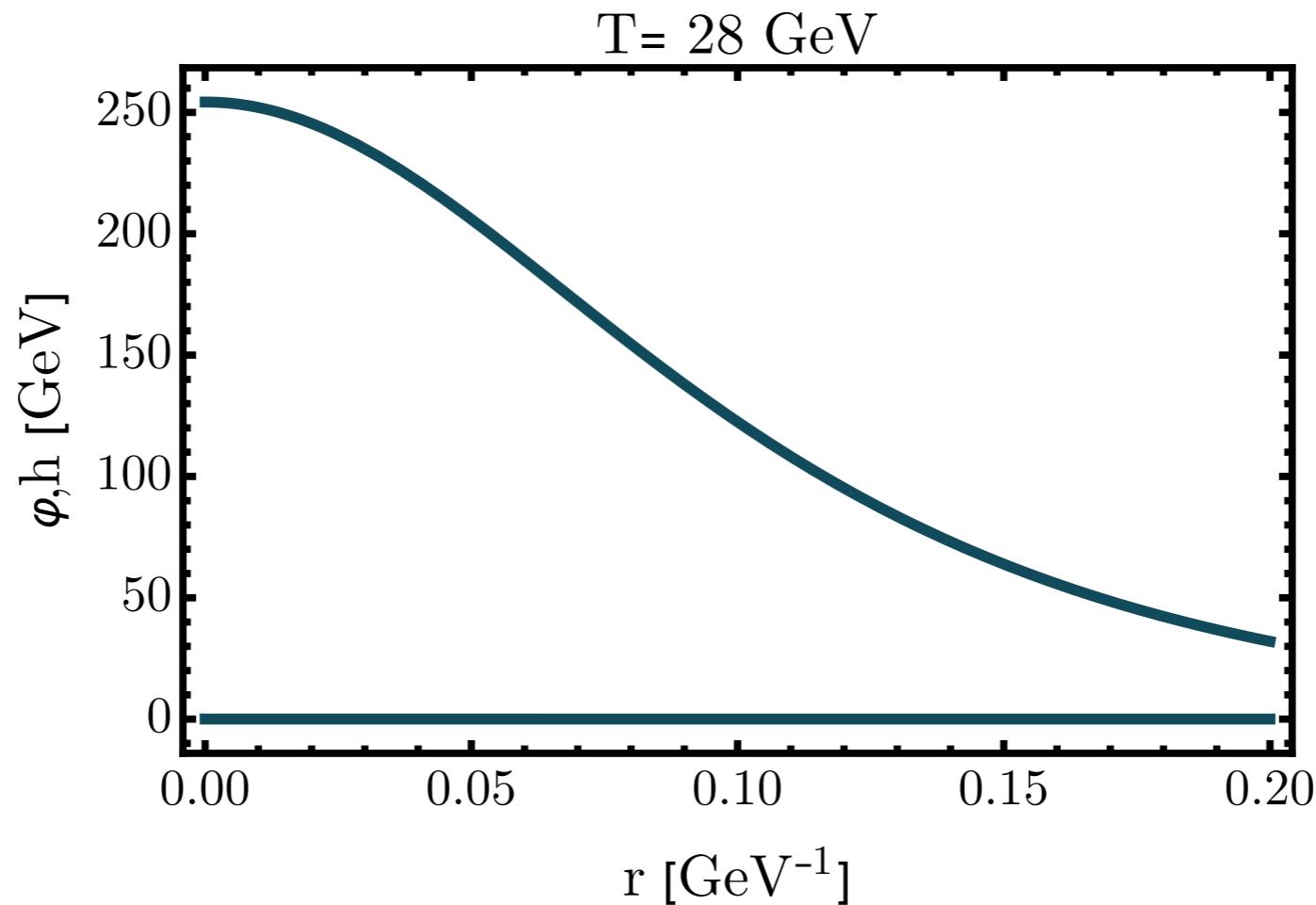
$$\alpha \approx \frac{\Delta V}{\rho_r}$$

$$\Gamma(t) \sim e^{-\beta t}$$

LOCATION OF THE GLOBAL MINIMUM



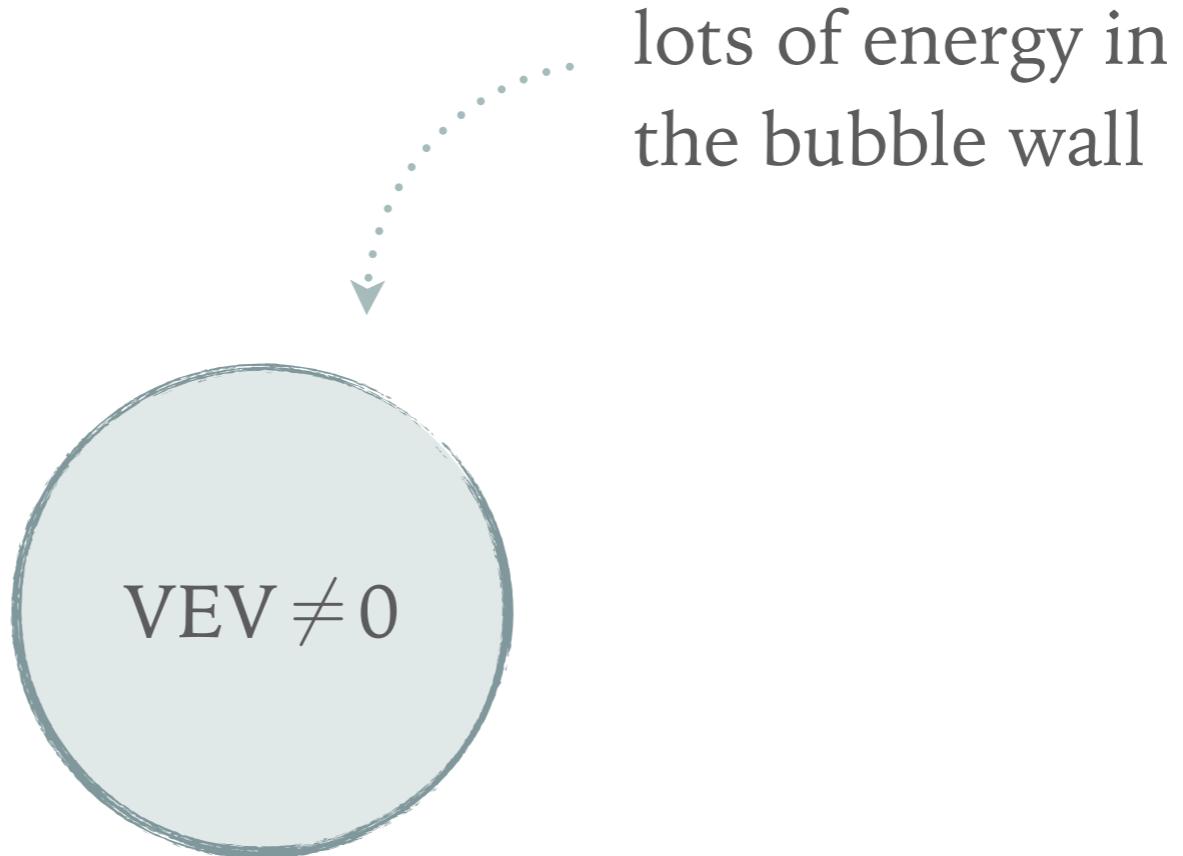
BUBBLE PROFILE



Tunnelling only along the new scalar
Exit point far from the minimum

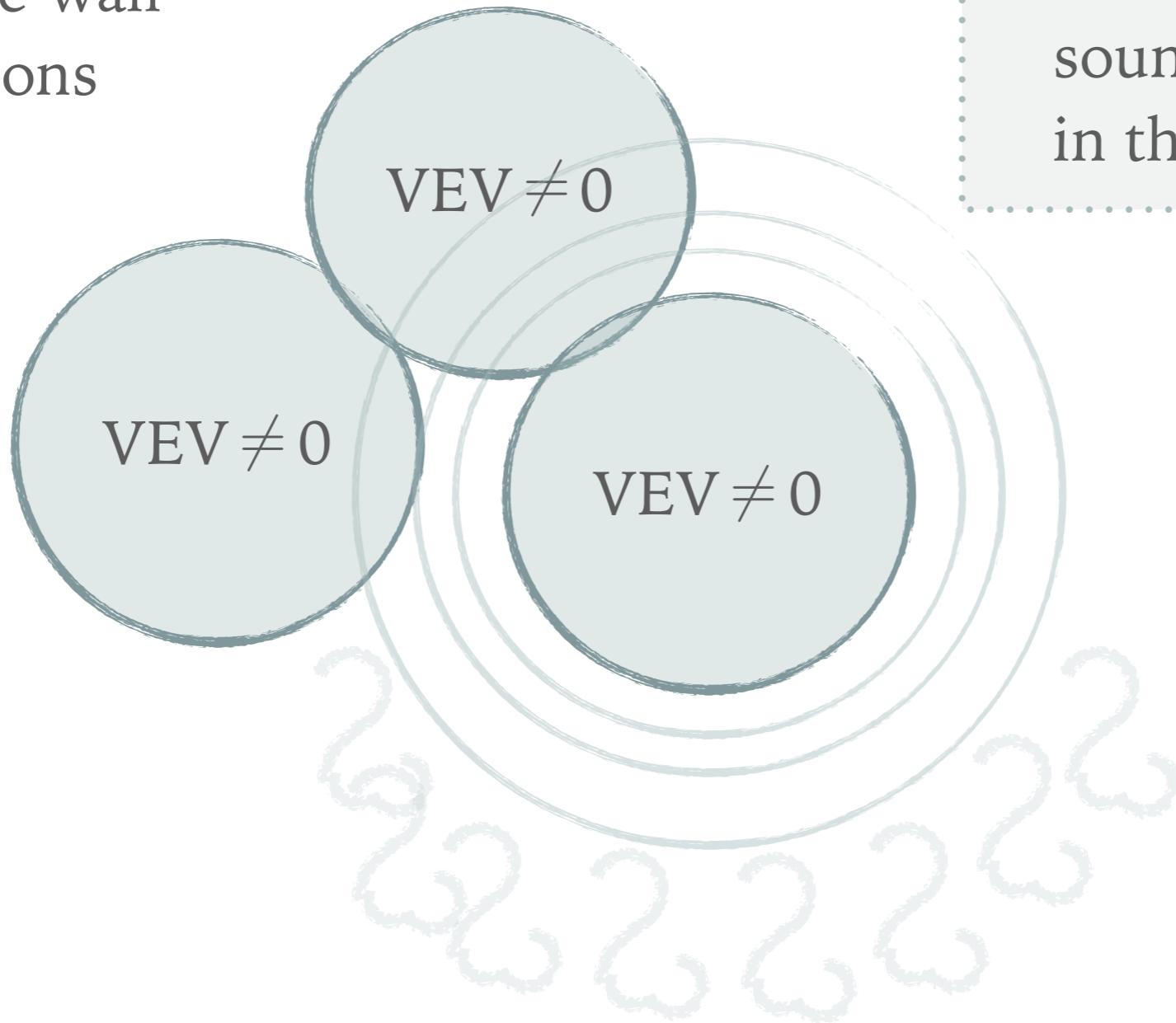
GRAVITATIONAL WAVES

SOURCES OF GRAVITATIONAL WAVES



SOURCES OF GRAVITATIONAL WAVES

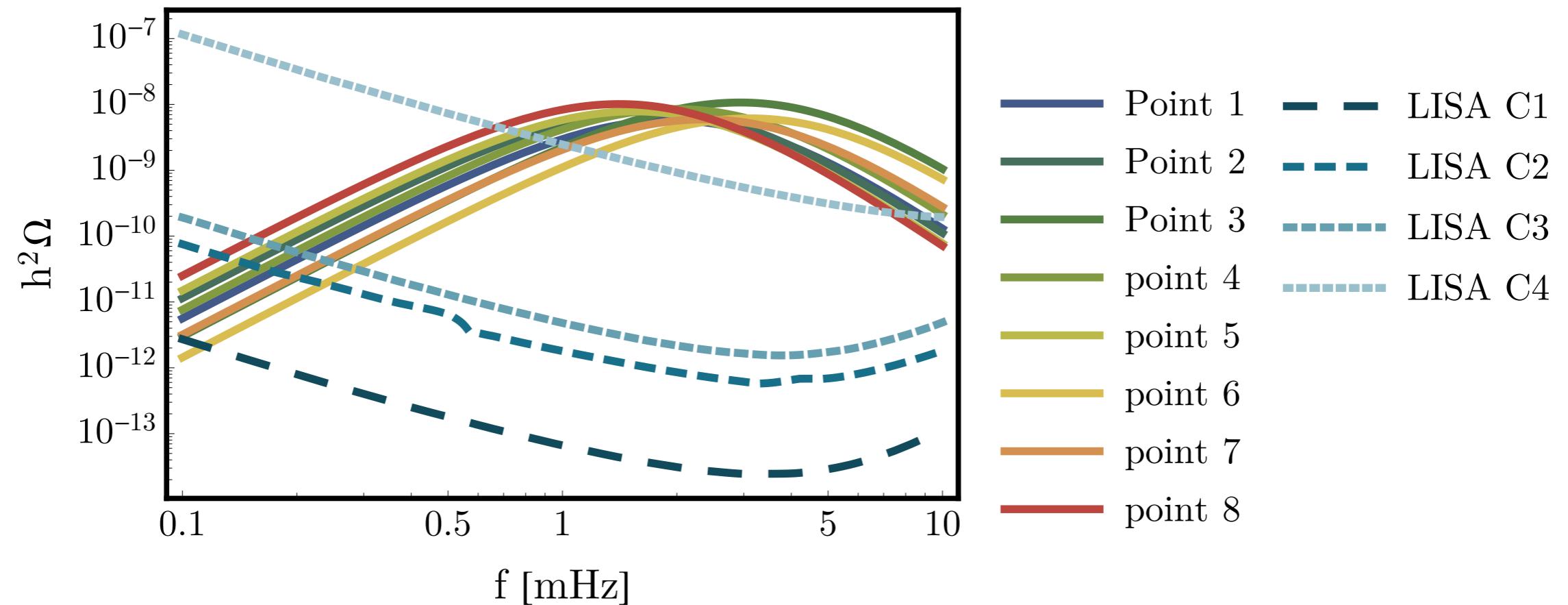
bubble-wall
collisions



sound waves
in the plasma

turbulence in
the plasma

SU(2)CSM SIGNAL



OUTLOOK

thermal inflation

bubble walls?

dark matter

resummations

[*J.Ellis, M.Lewicki, J.M. No, 1809.08242, I.Baldes, C.Garcia-Cely, 1809.01198, T.Hambye, A.Strumia, D.Teresi,
JHEP 1808 (2018) 188*]

SUMMARY

We might hear the phase transition
from conformal models in the future!

POTENTIAL AT NUCLEATION TEMPERATURE

