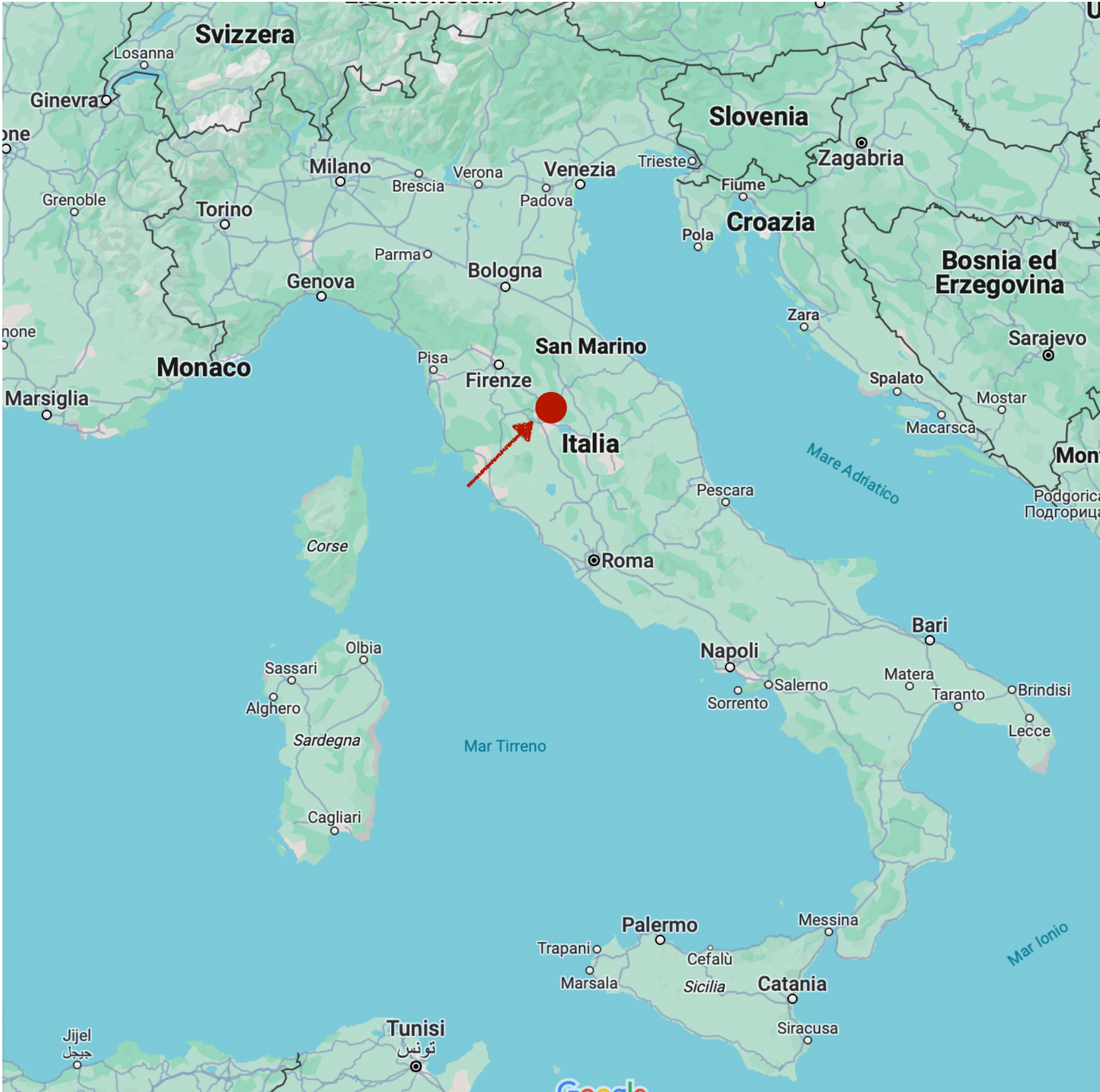




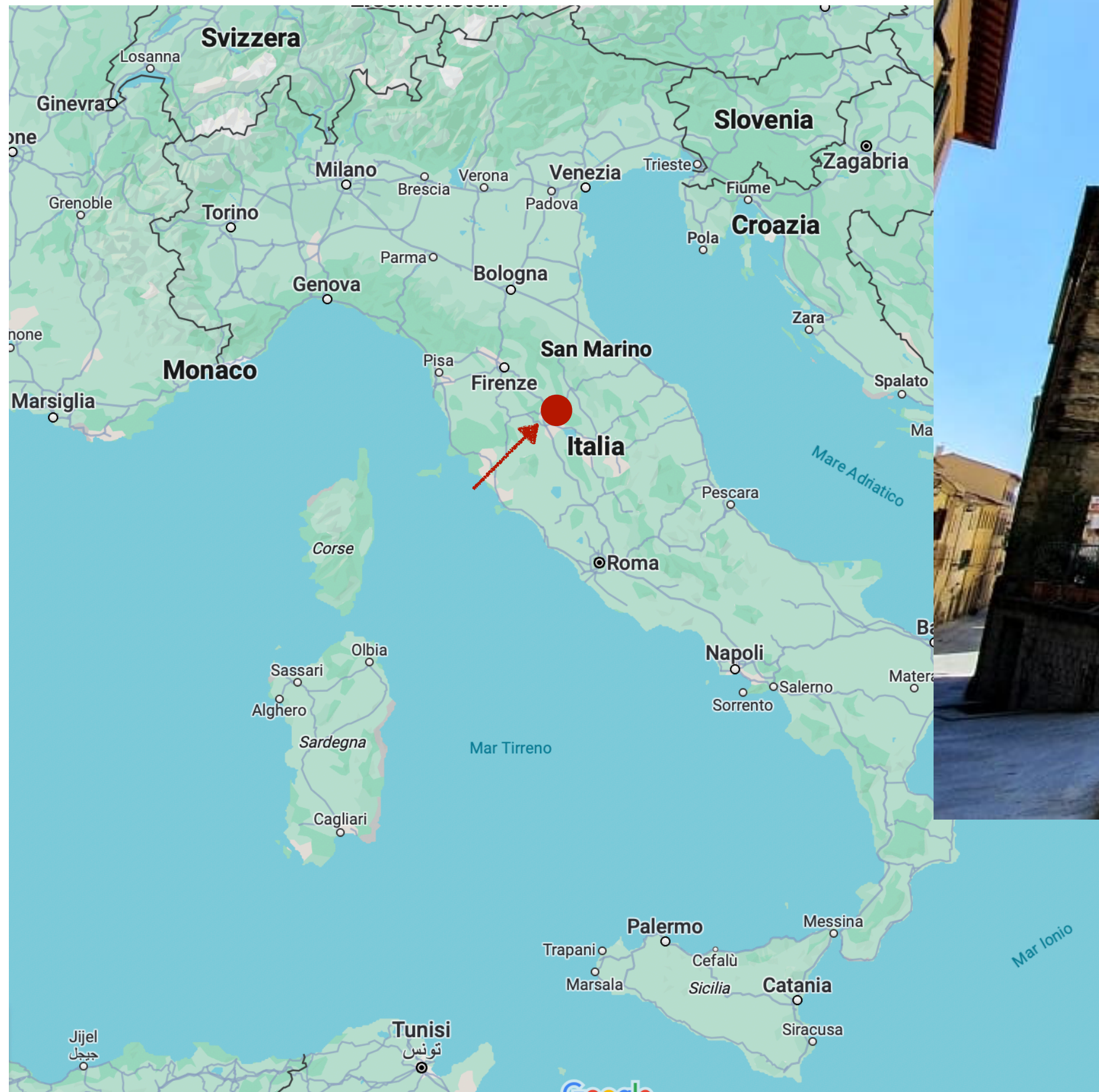
Gravitational waves from seeded phase transitions

Simone Blasi

Arezzo, Tuscany

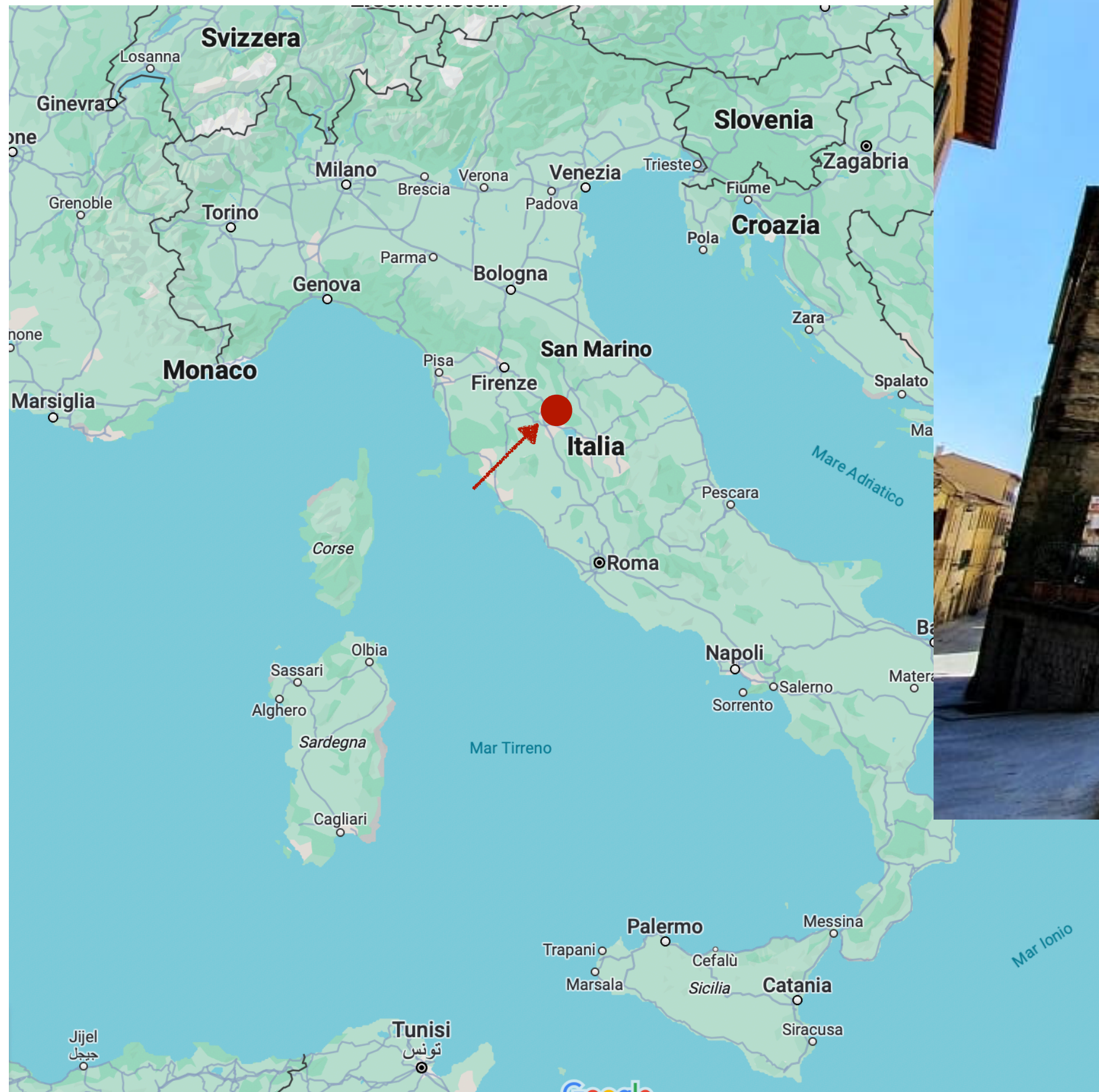


Arezzo, Tuscany



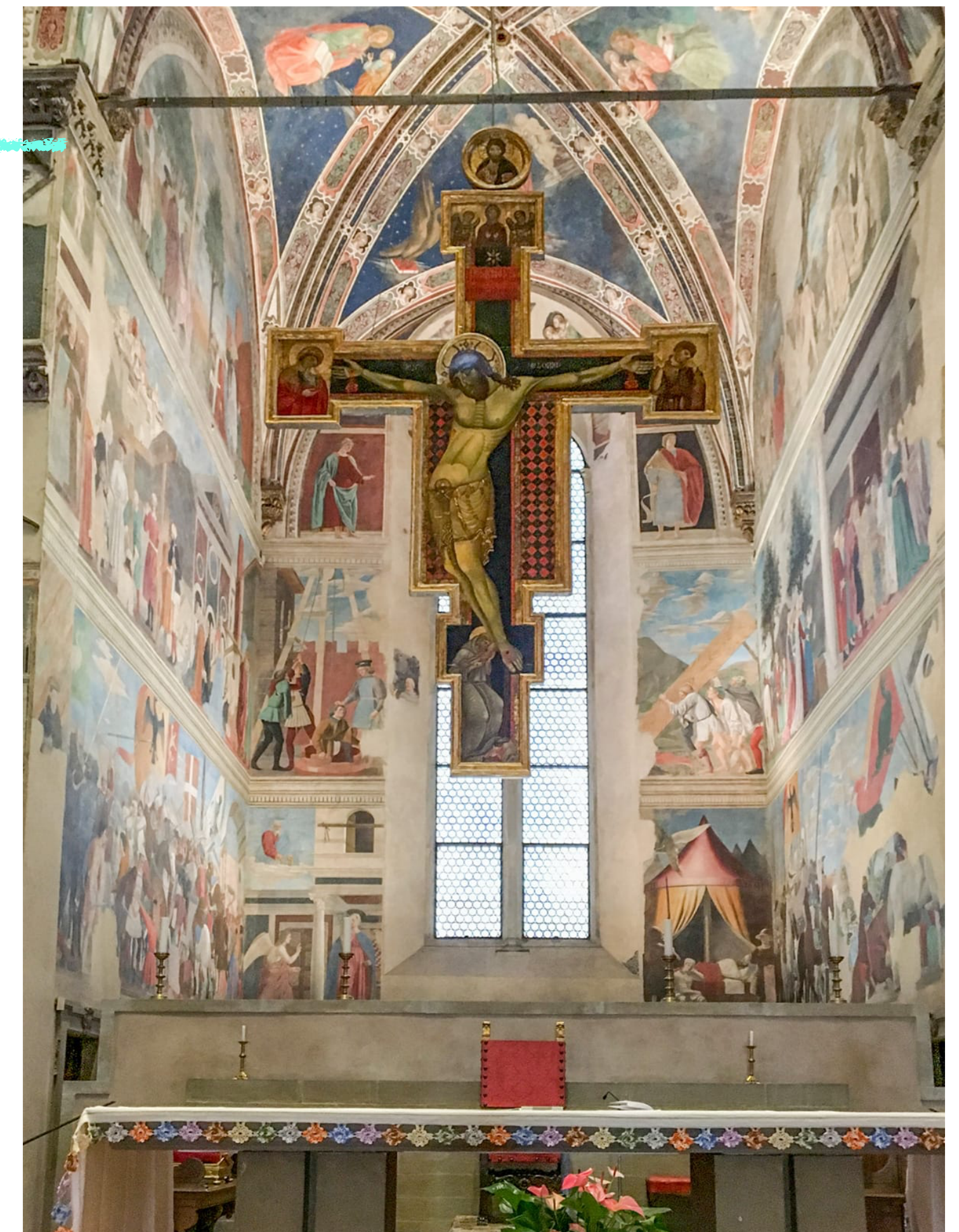
Basilica di San Francesco, Arezzo

Arezzo, Tuscany



Basilica di San Francesco, Arezzo

Piero della Francesca
(1412-1492)

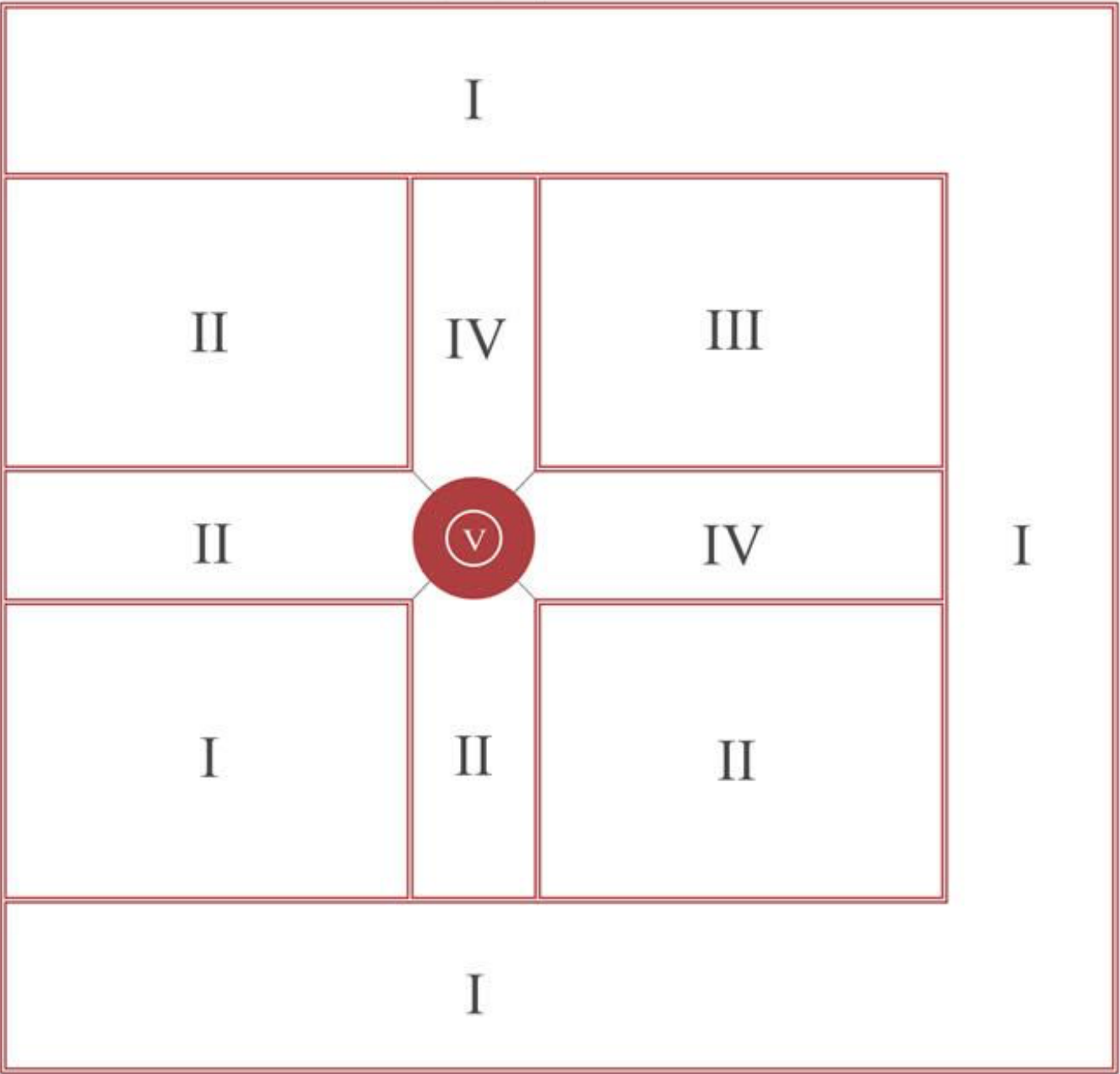


Storia della vera croce, Cappella Maggiore

City joust

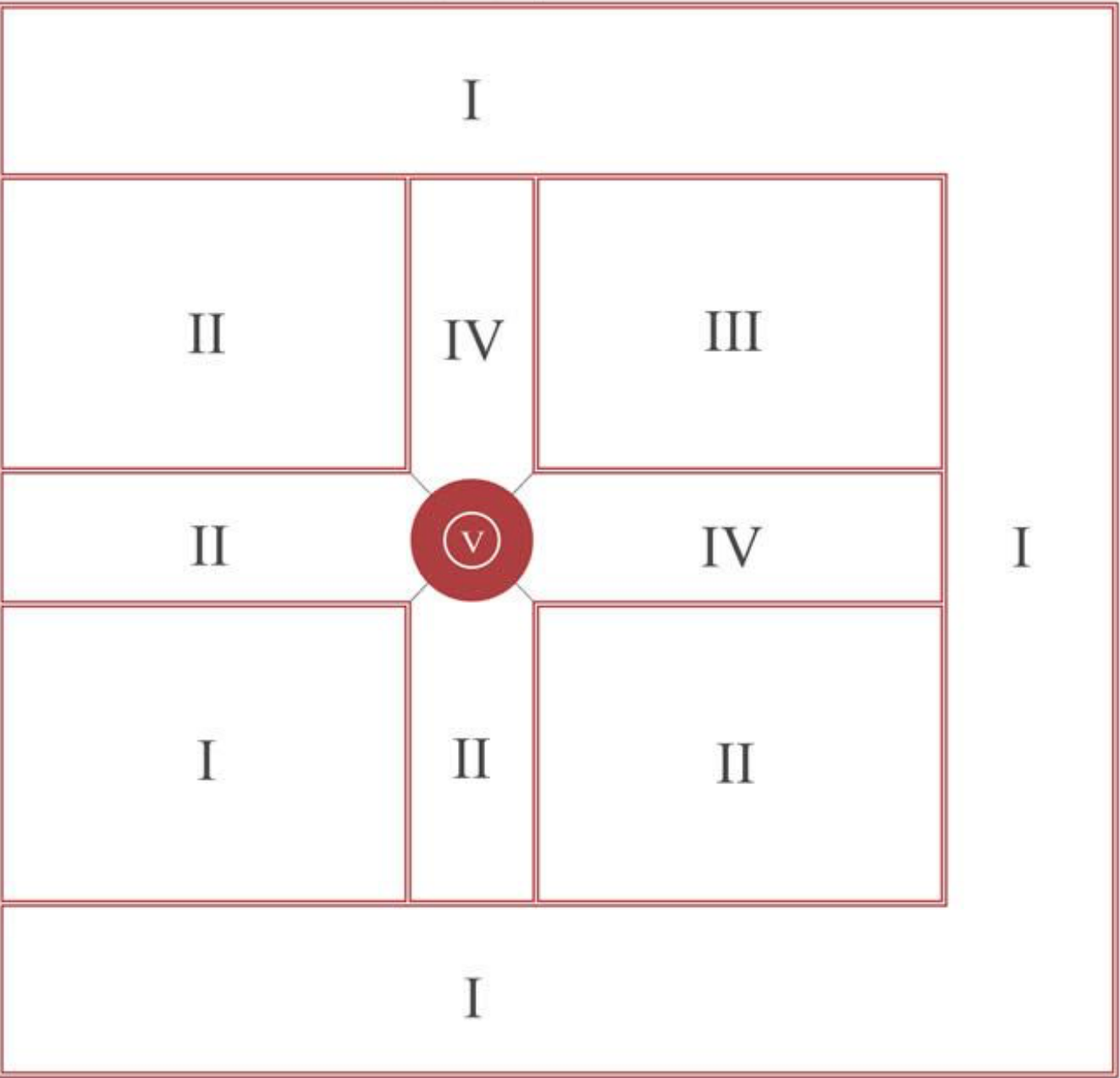


City joust



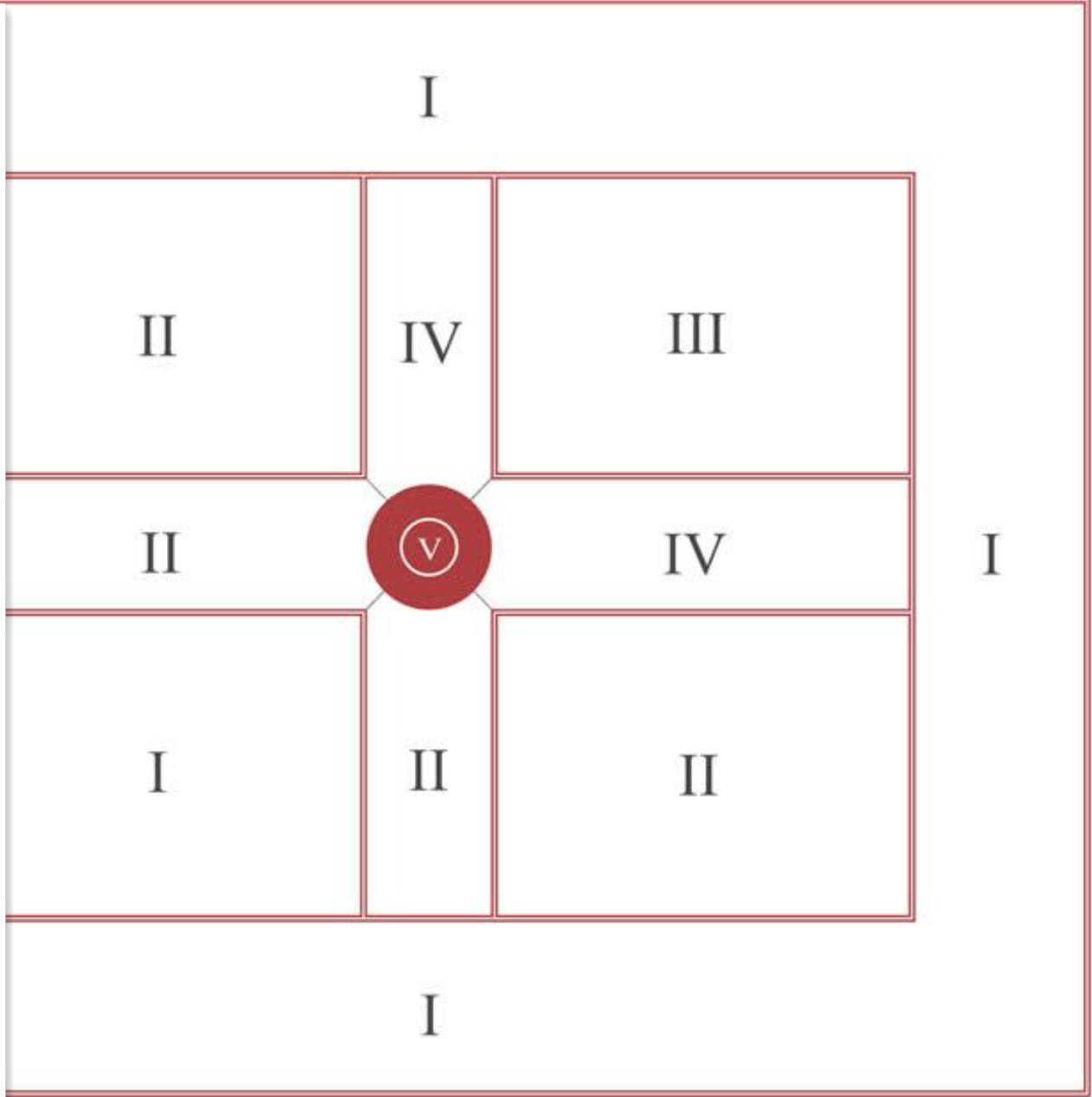
Target and points.

City joust



Target and points.

City joust



Target and points.

Free time

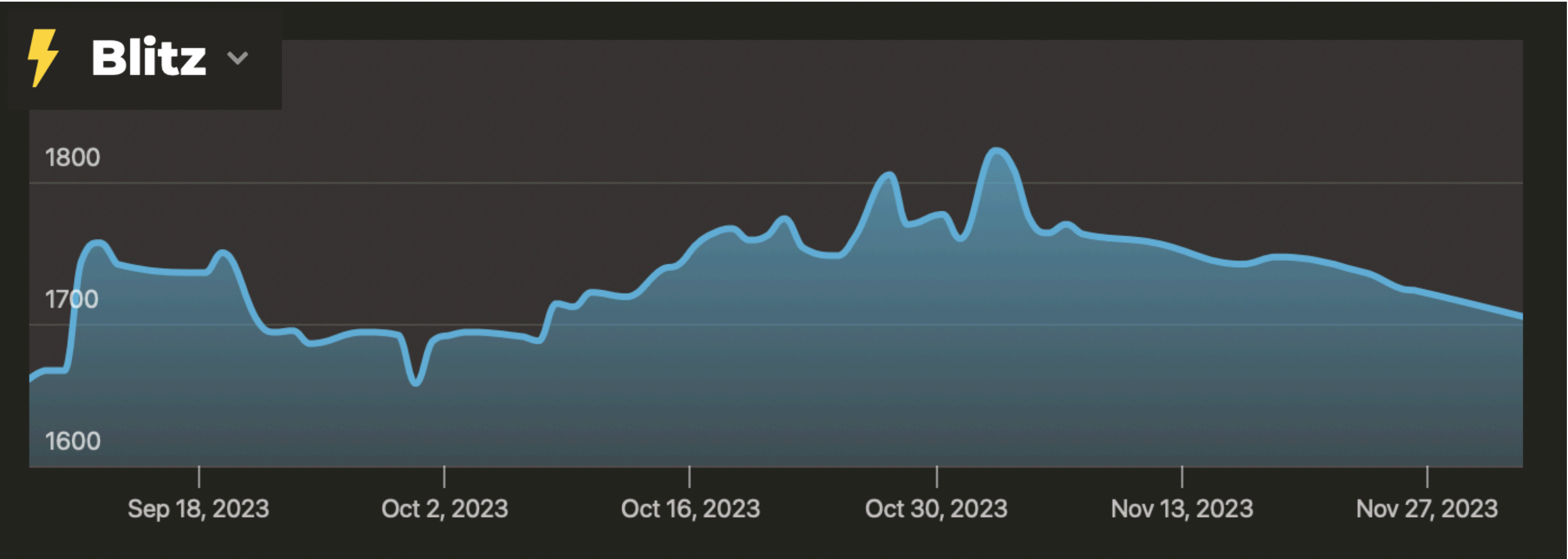


Game on 02.12.23

Free time



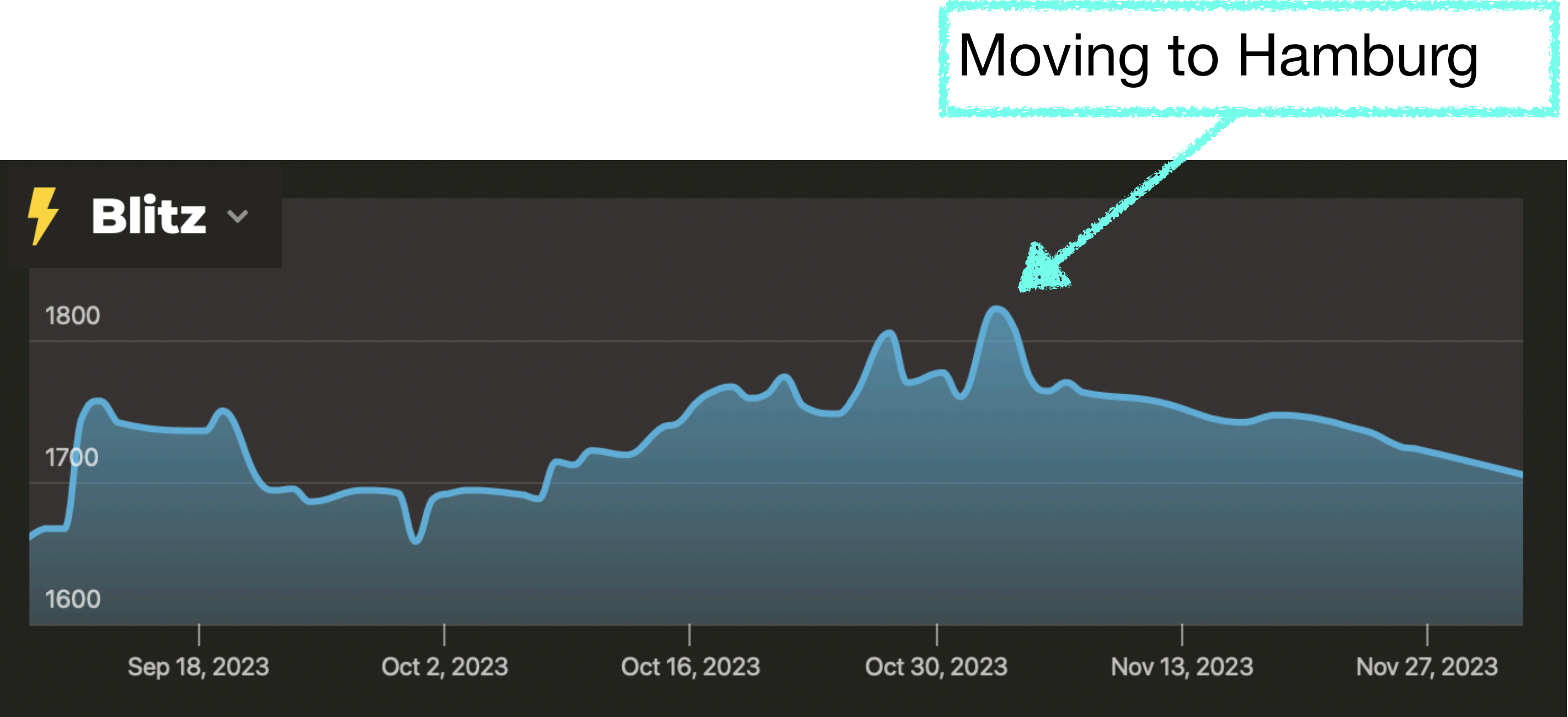
Game on 02.12.23



Free time



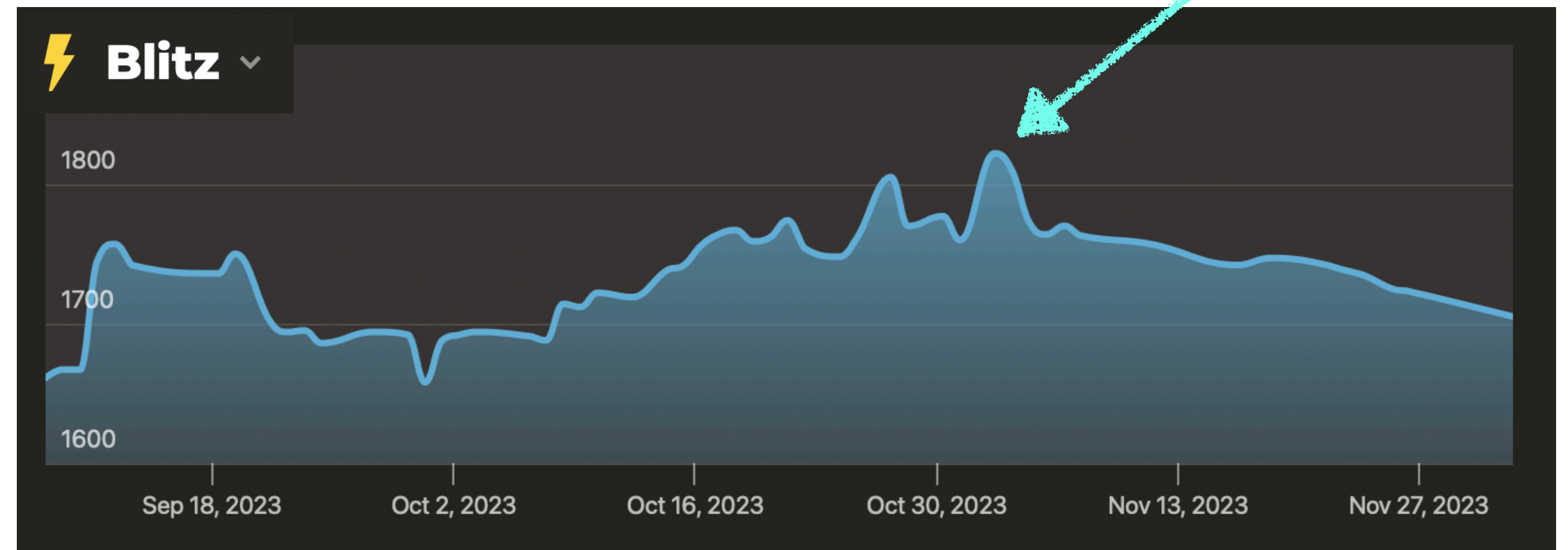
Game on 02.12.23



Free time



Game on 02.12.23



Also very interested in the cheating drama

Free time



Squash



Table tennis



Badminton

Free time



Squash

Table tennis

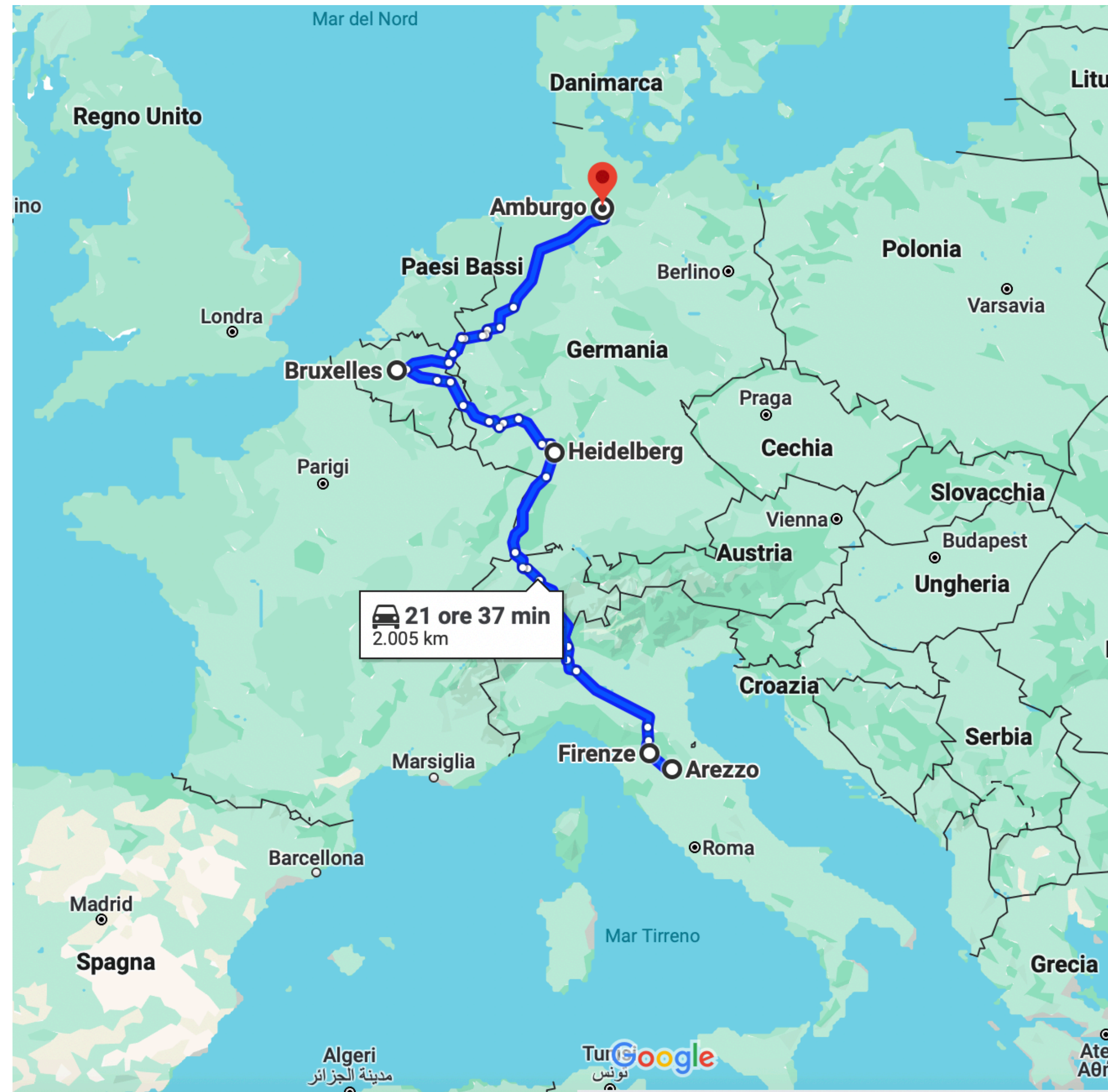


Badminton

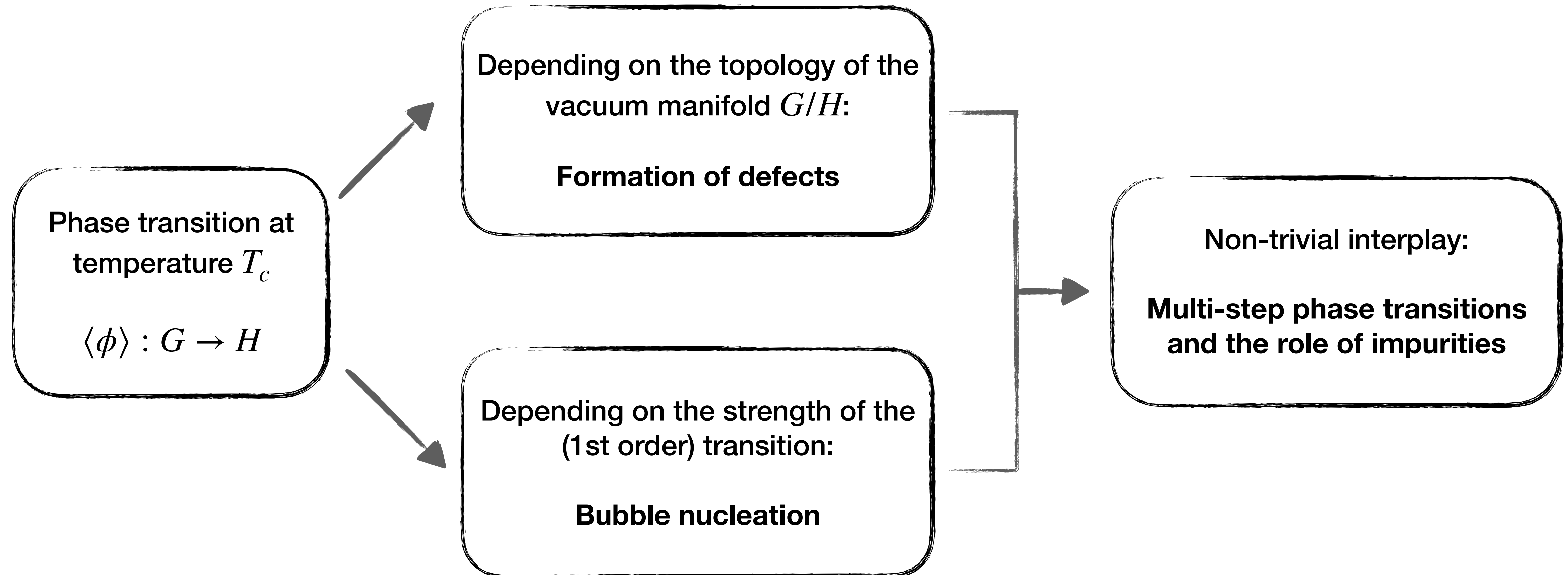


EMBL, Heidelberg

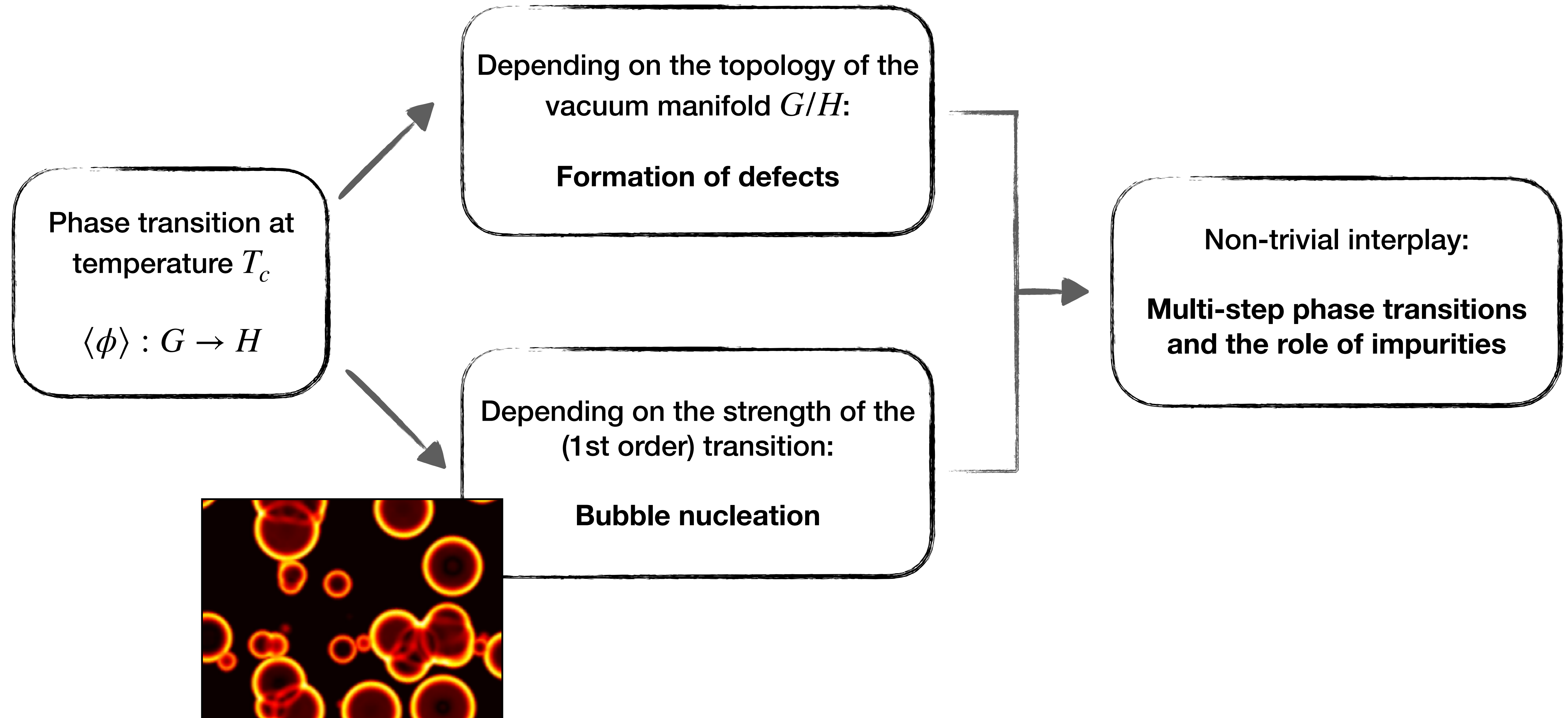
Physics



Outline



Outline



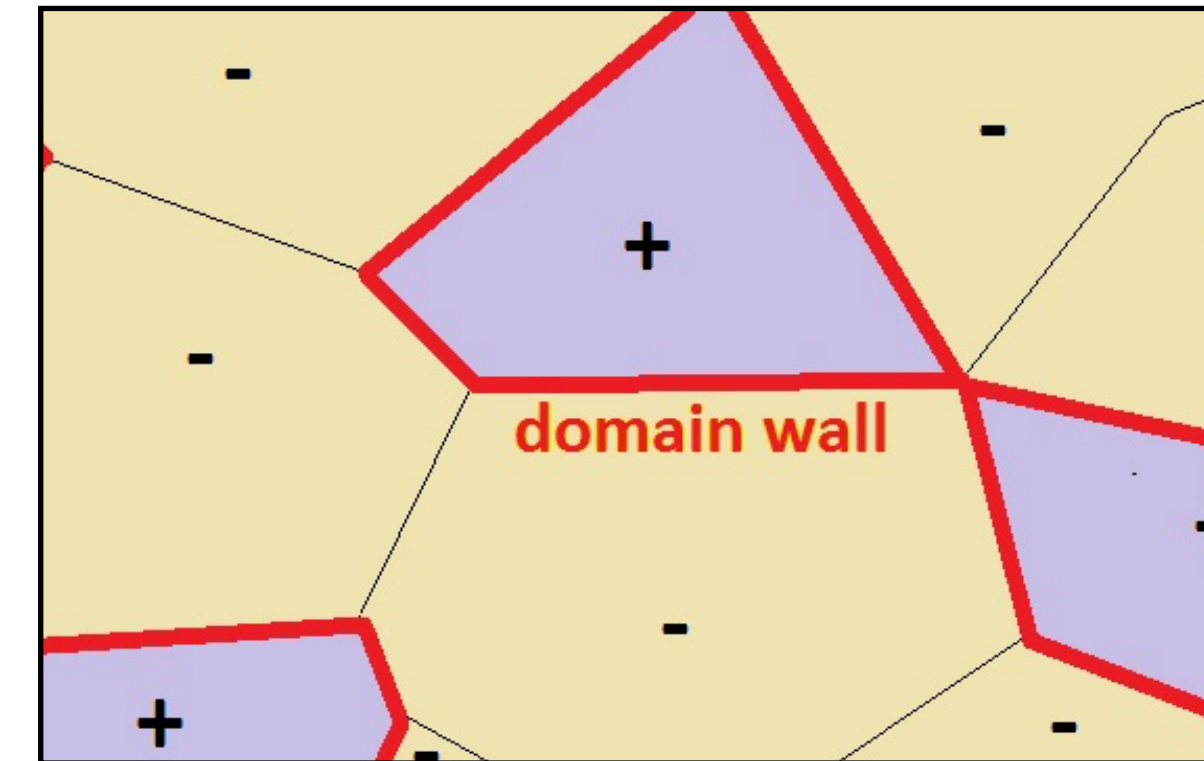
Outline

Phase transition at
temperature T_c

$$\langle \phi \rangle : G \rightarrow H$$

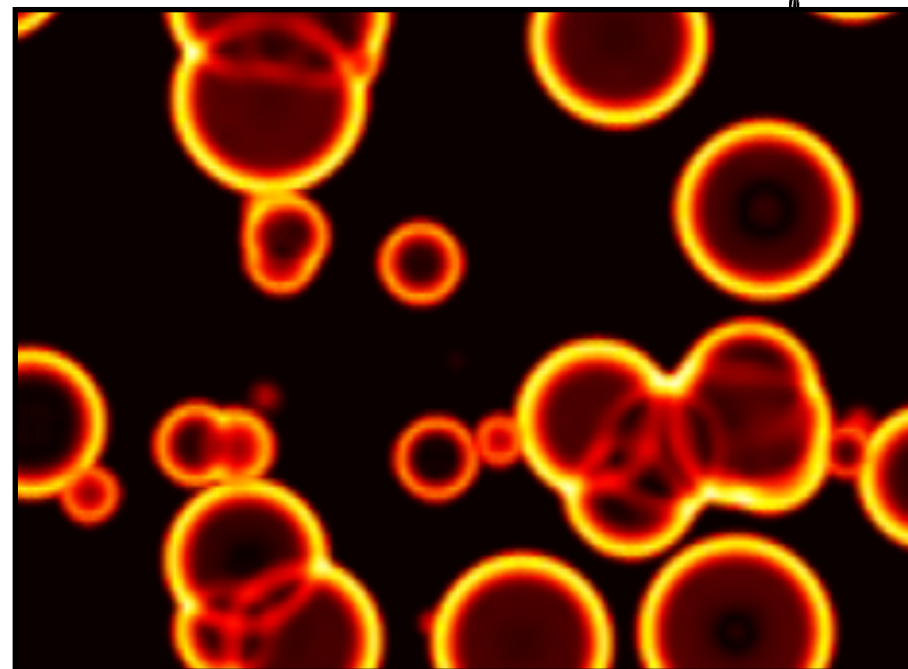
Depending on the topology of the
vacuum manifold G/H :

Formation of defects



Depending on the strength of the
(1st order) transition:

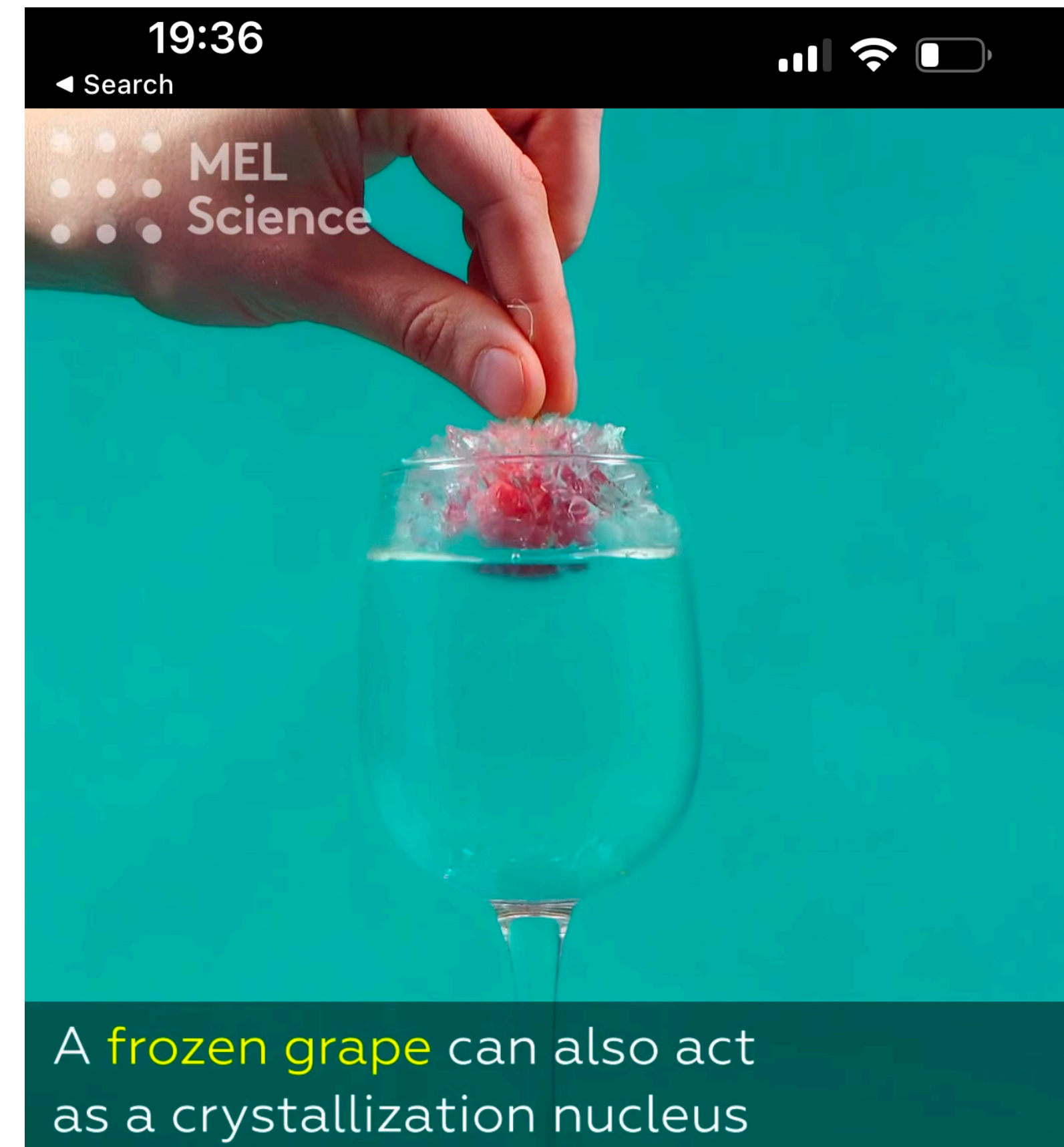
Bubble nucleation



Non-trivial interplay:

**Multi-step phase transitions
and the role of impurities**

Nucleation sites



A supercool experiment

82K views 3 yr ago ...more



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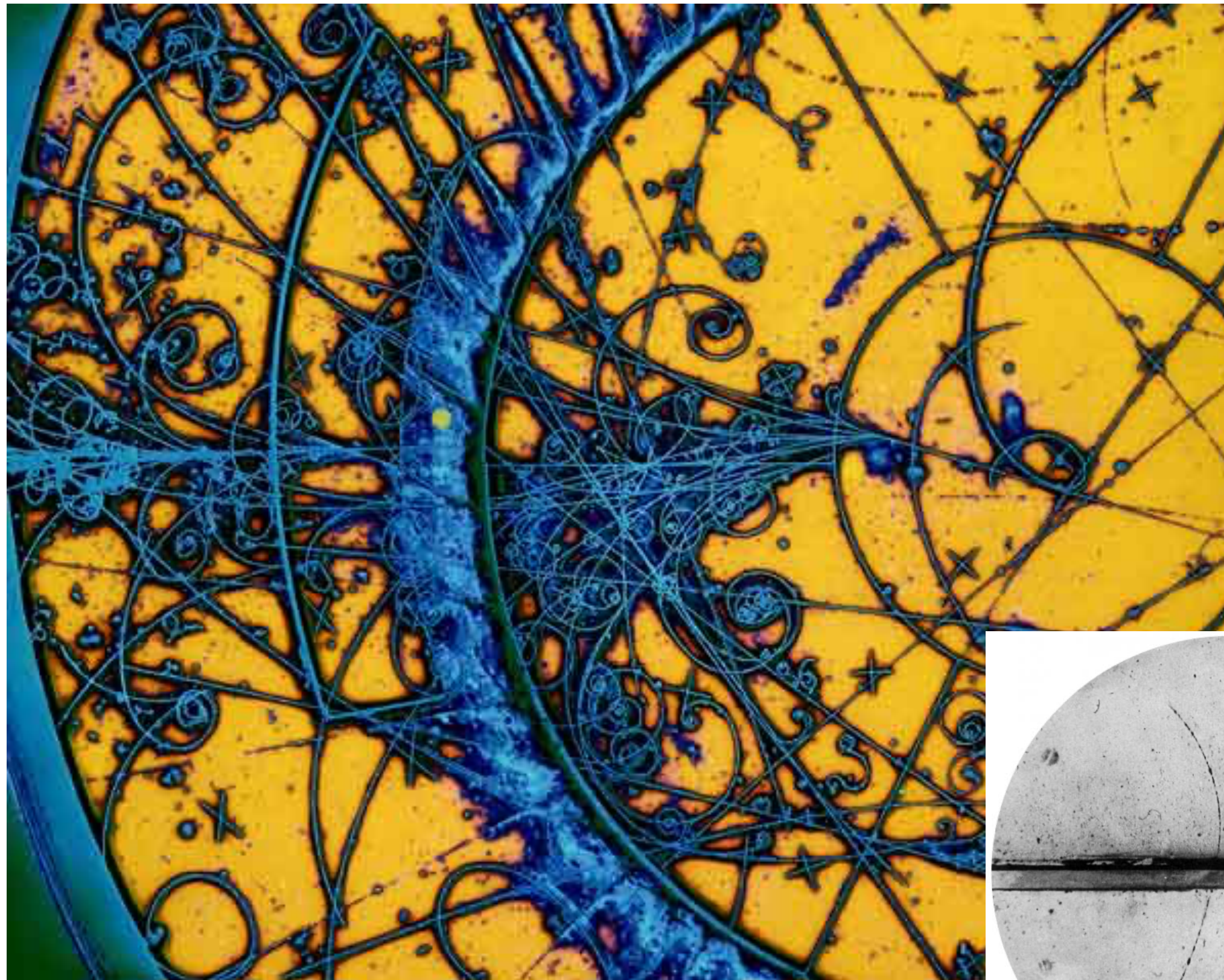


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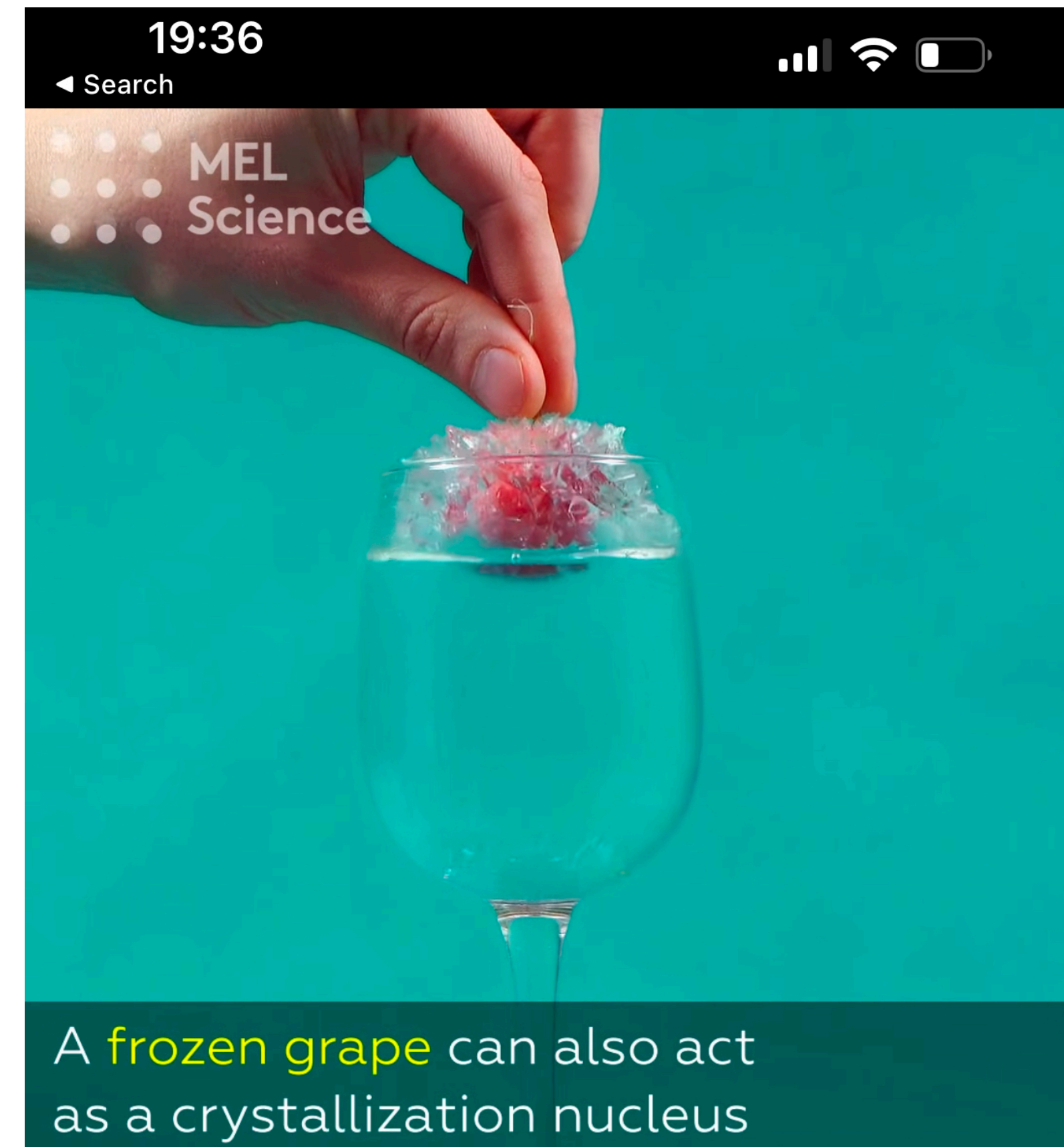
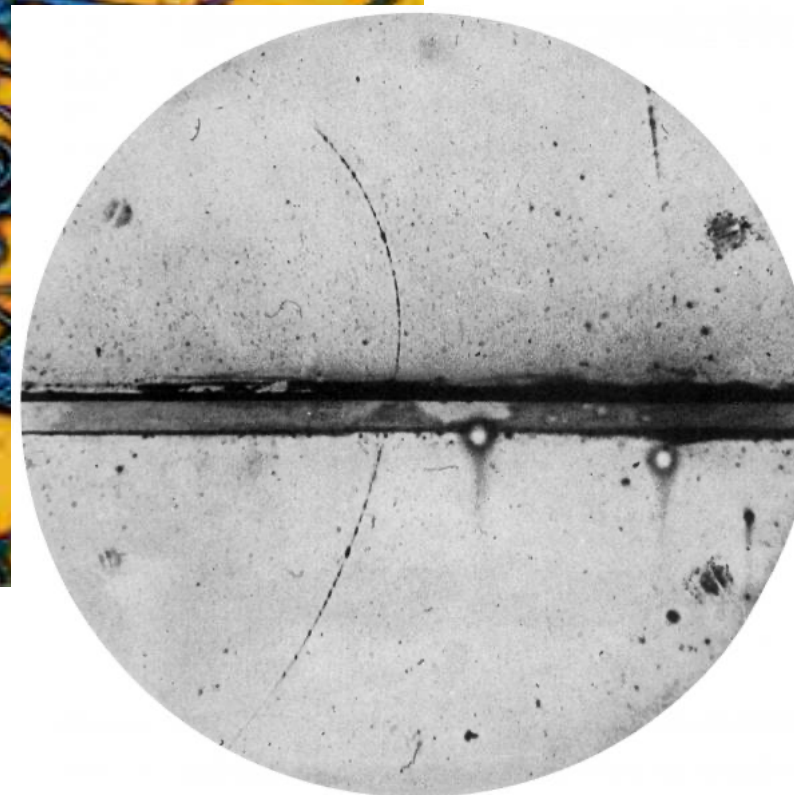


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Nucleation sites



Bubble chamber



A supercool experiment

82K views 3 yr ago ...more

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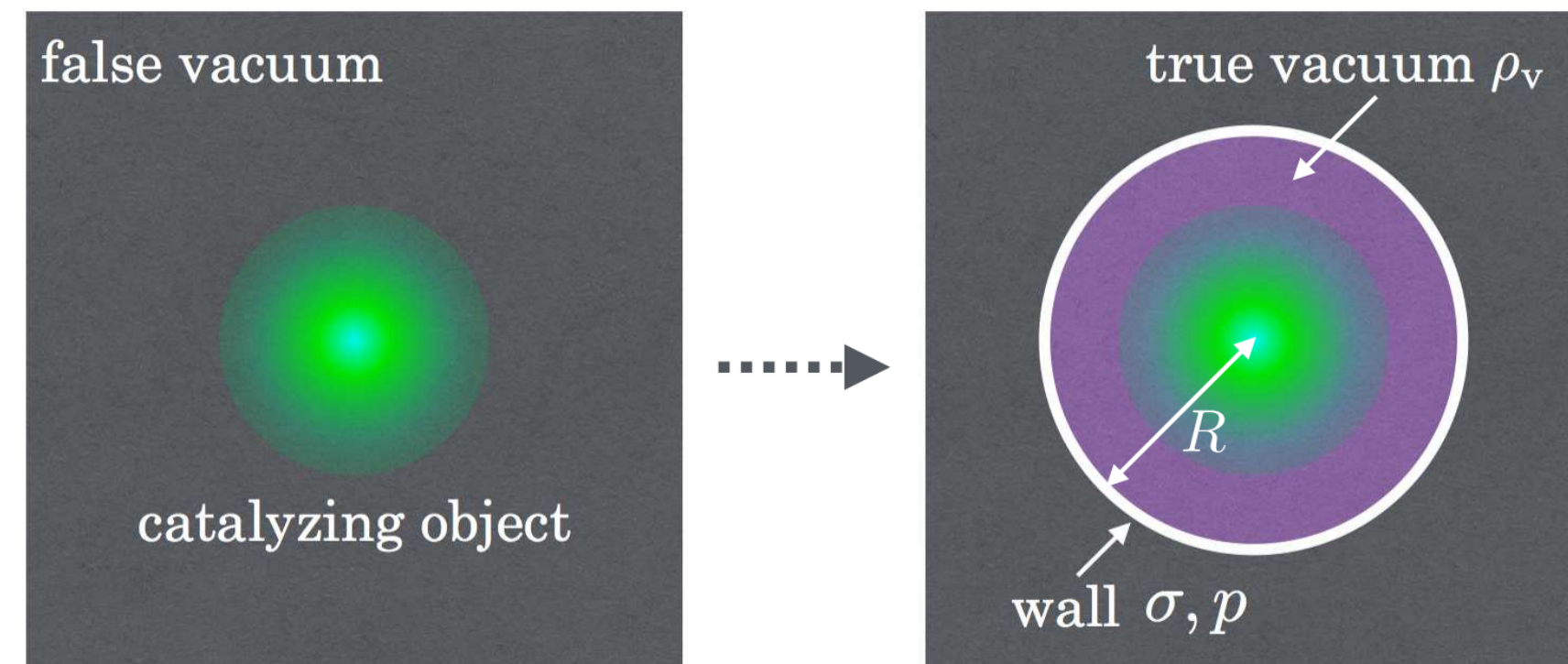
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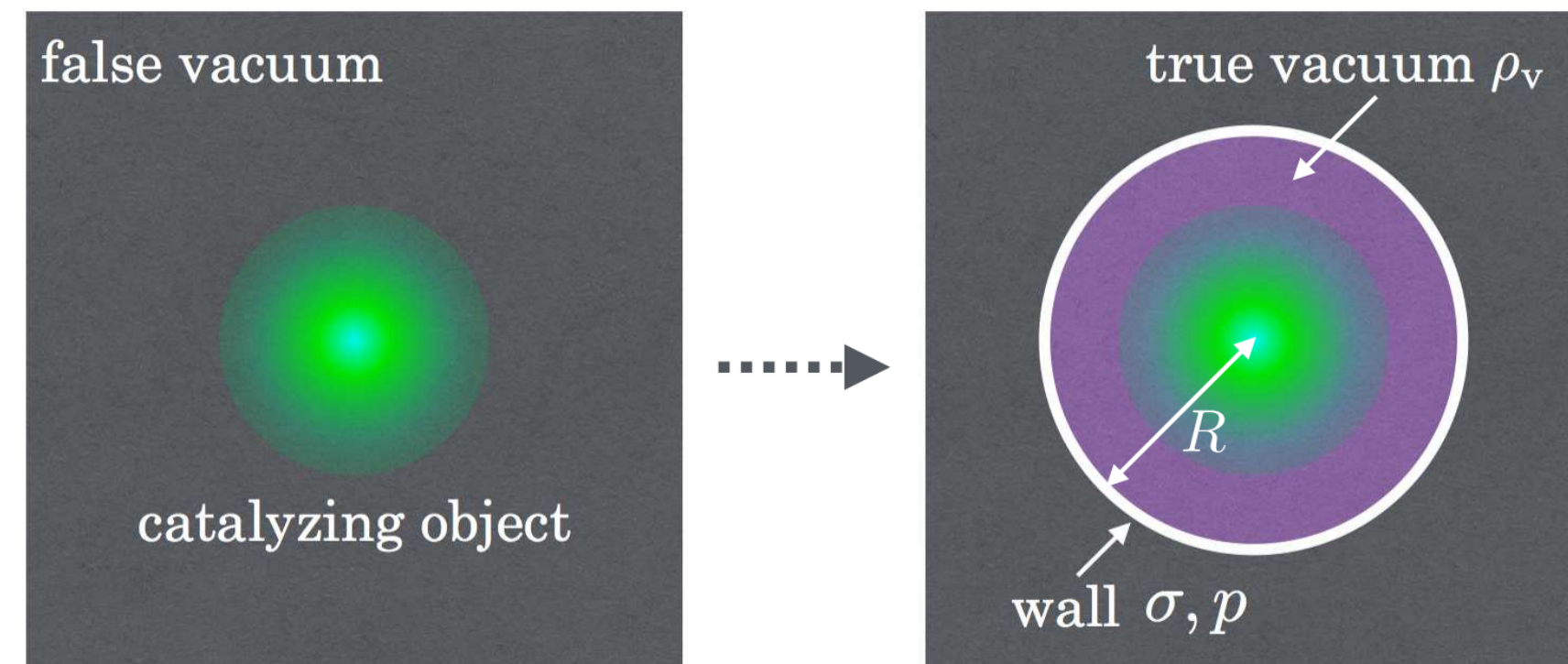
Impurities in the early Universe

- Compact objects

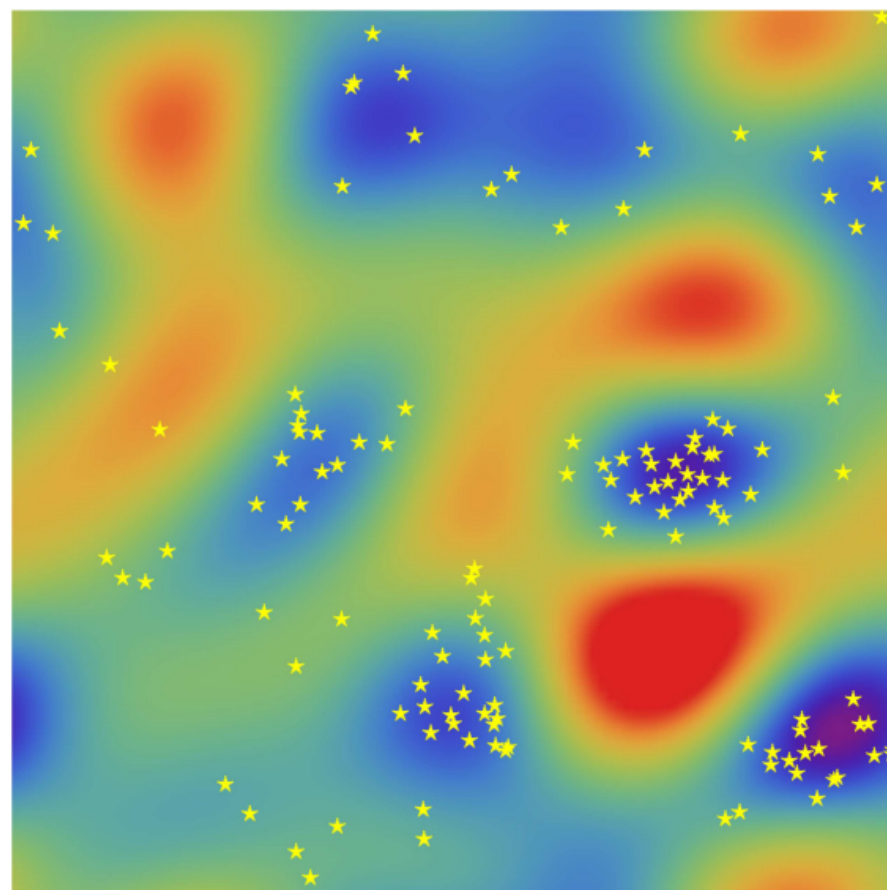


Impurities in the early Universe

- Compact objects

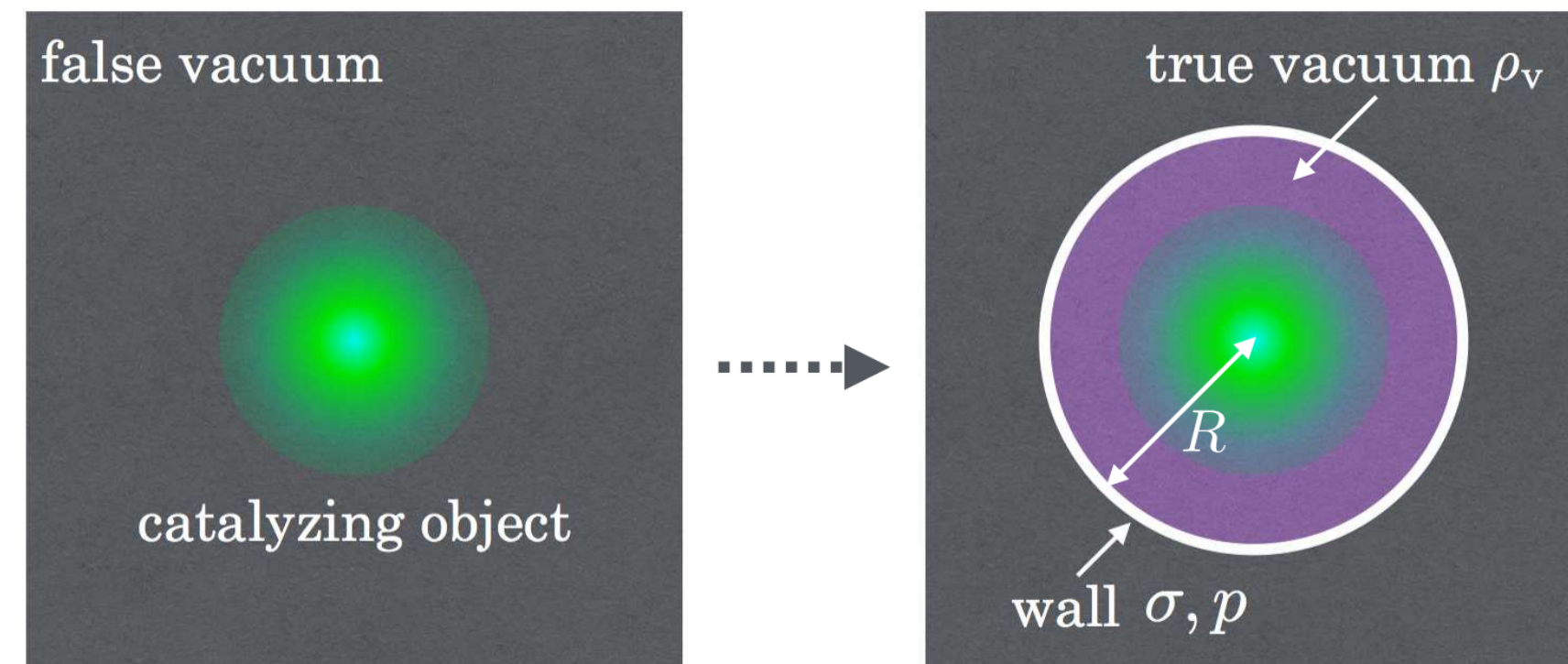


- Primordial density fluctuations

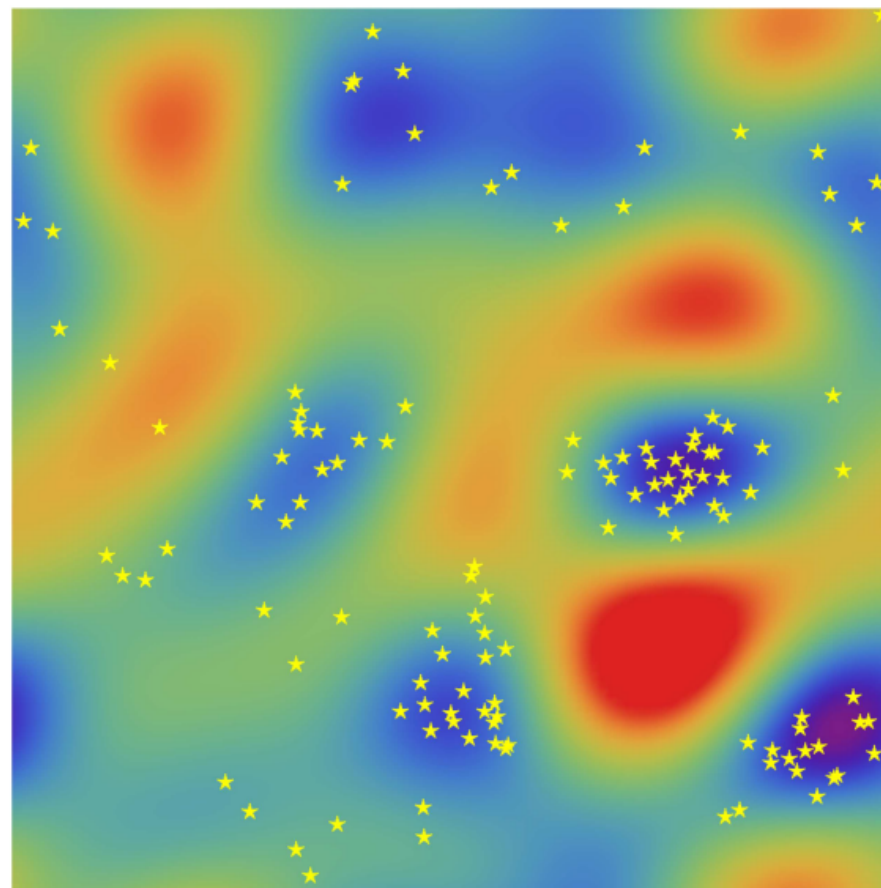


Impurities in the early Universe

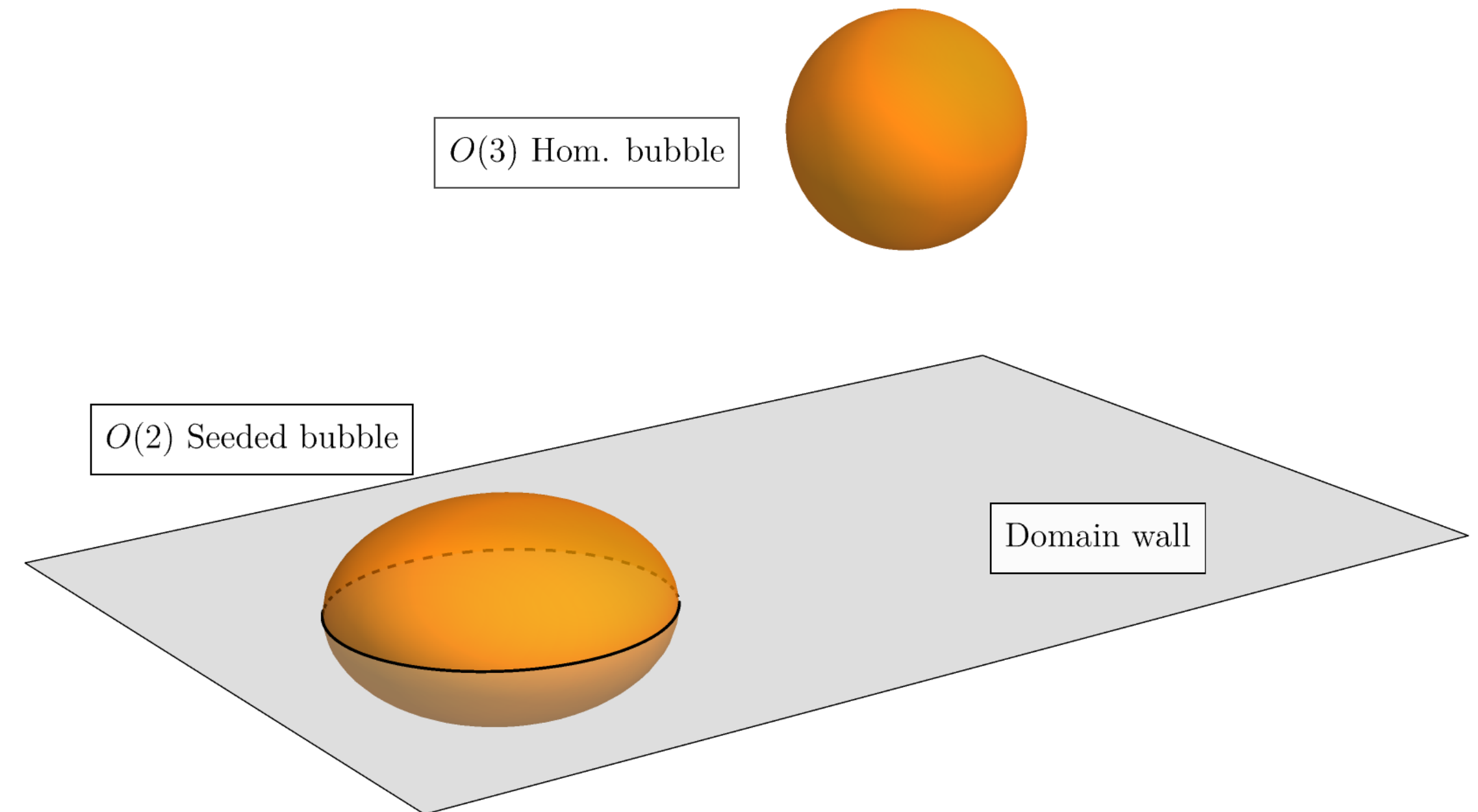
- Compact objects



- Primordial density fluctuations



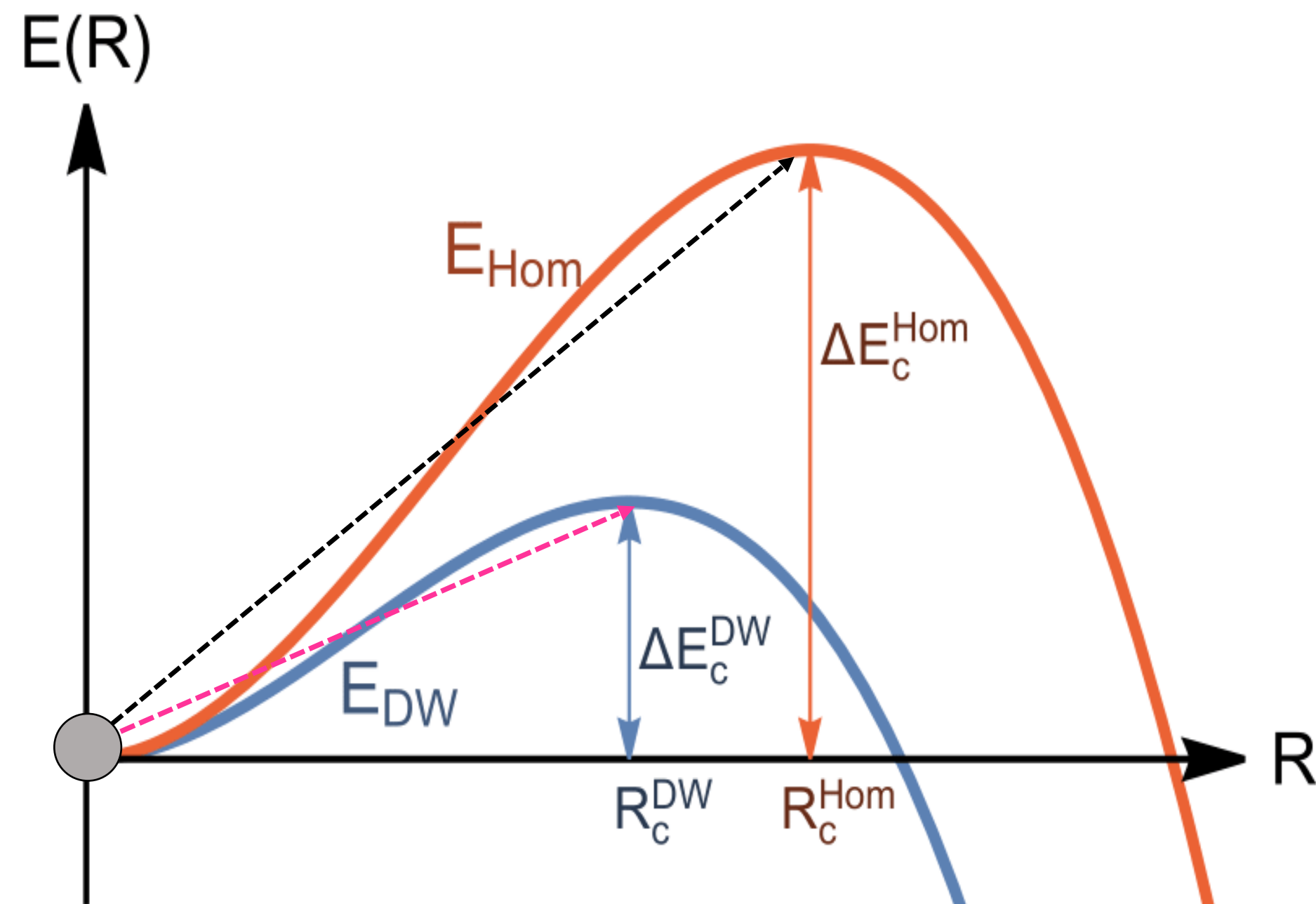
- Topological defects



Two-step electroweak phase transition in the xSM!

SB, Mariotti [2203.16450], PRL
Agrawal, **SB**, Mariotti, Nee, to appear.

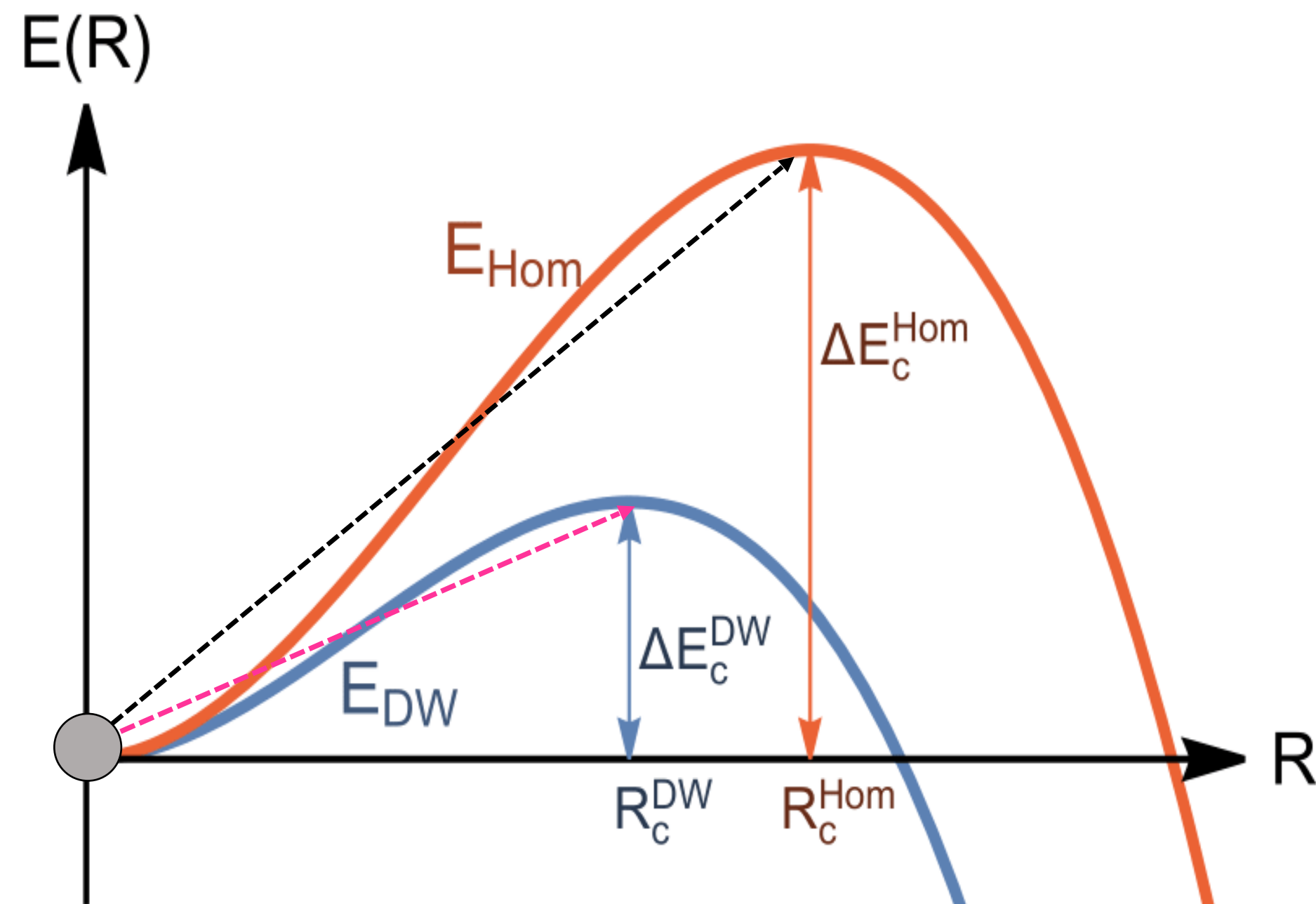
Impurities in the early Universe



$$E(R) \simeq 4\pi R^2 \sigma_B - \frac{4}{3}\pi R^3 \epsilon - \pi R^2 \sigma_{\text{DW}}$$

Gain by eating up
domain wall surface

Impurities in the early Universe



$$E(R) \simeq 4\pi R^2 \sigma_B - \frac{4}{3}\pi R^3 \epsilon - \pi R^2 \sigma_{\text{DW}}$$

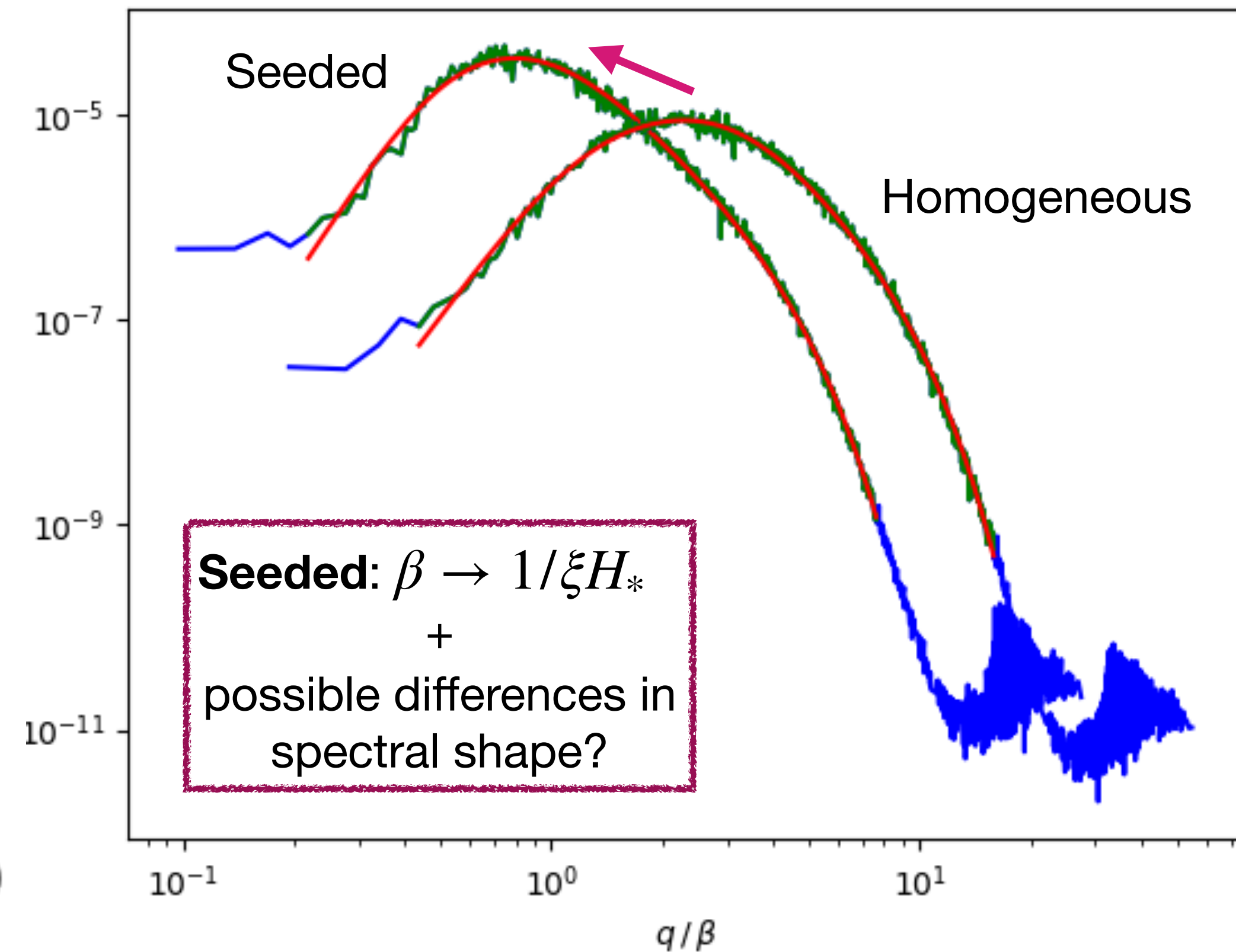
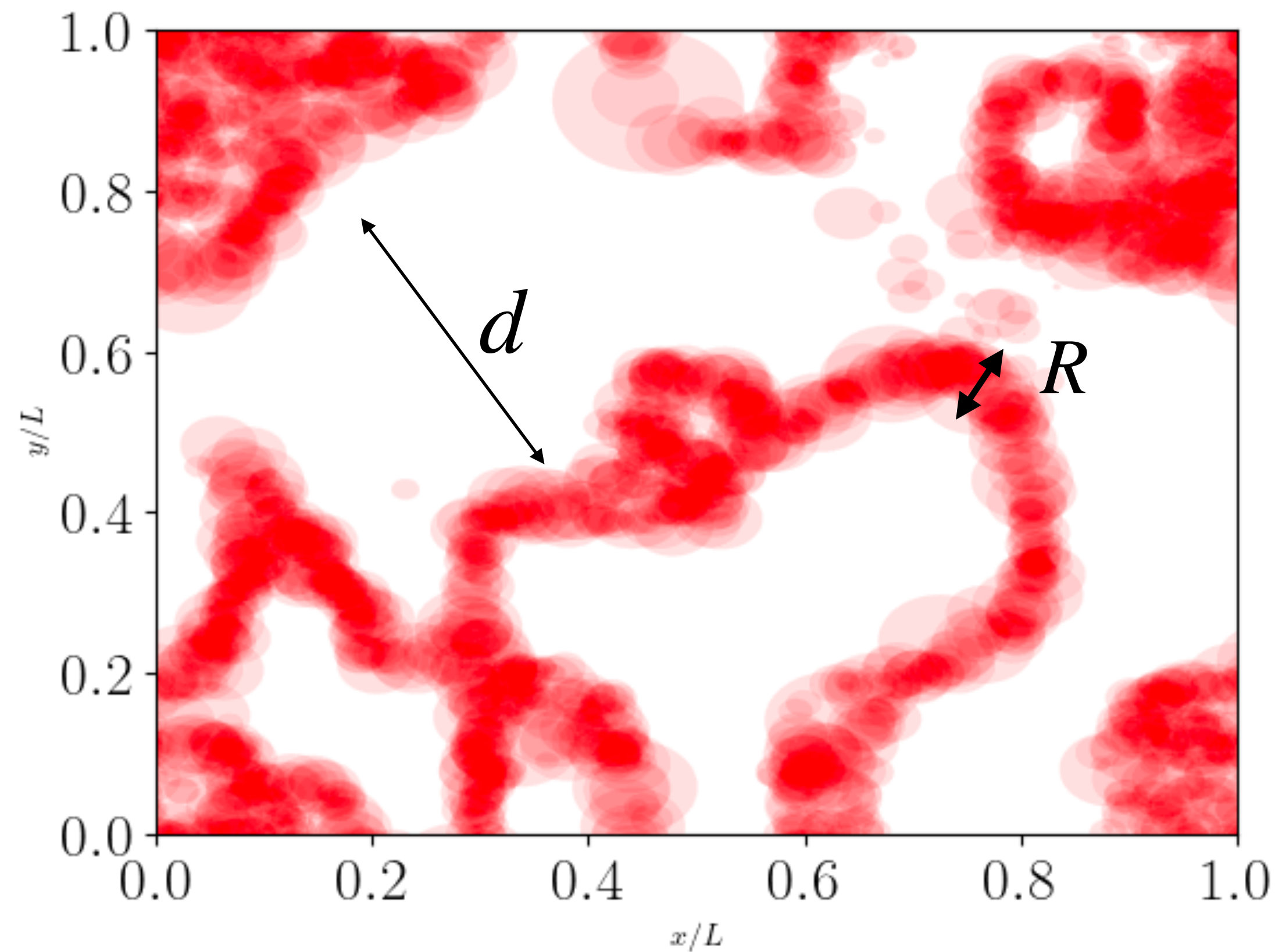
Gain by eating up
domain wall surface



**HOMOGENEOUS
NUCLEATION**

**NUCLEATION
AROUND
IMPURITIES**

Implications for gravitational waves



SB, Jinno, Konstandin, Rubira,
Stomberg [2302.06952], JCAP

Summary

- Formation of defects during multi-step phase transitions can dramatically affect the dynamics of bubble nucleation by providing new channels for vacuum decay.
- We have presented a minimal working example for a seeded electroweak phase transition in the xSM due to the presence of $\mathbb{Z}_2$ domain walls. As a result, the parameter space leading to successful nucleation is enlarged.
- Implications of seeded phase transitions in terms of gravitational waves (and possibly other relics) still largely unexplored.
- Different extensions of the SM may involve other types of defects such as strings or monopoles, with possibly different phenomenology.

Thank you!