Cosmological production of DM in the Universe and in the laboratory

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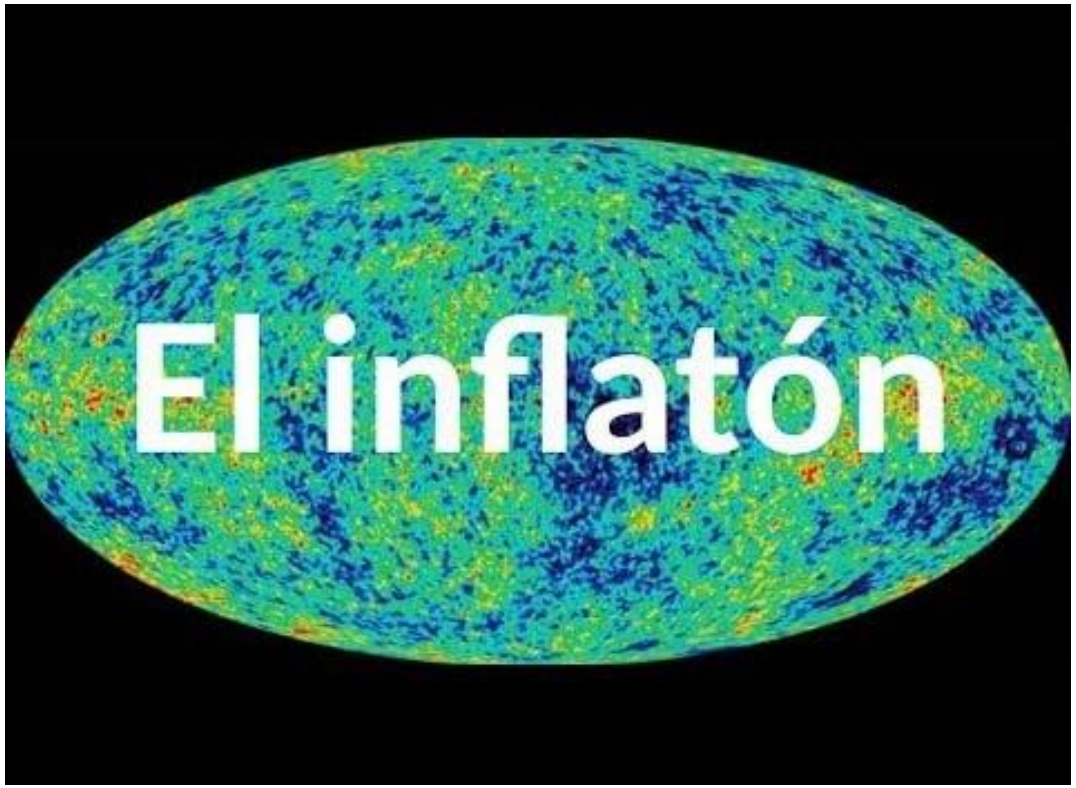
El inflatón

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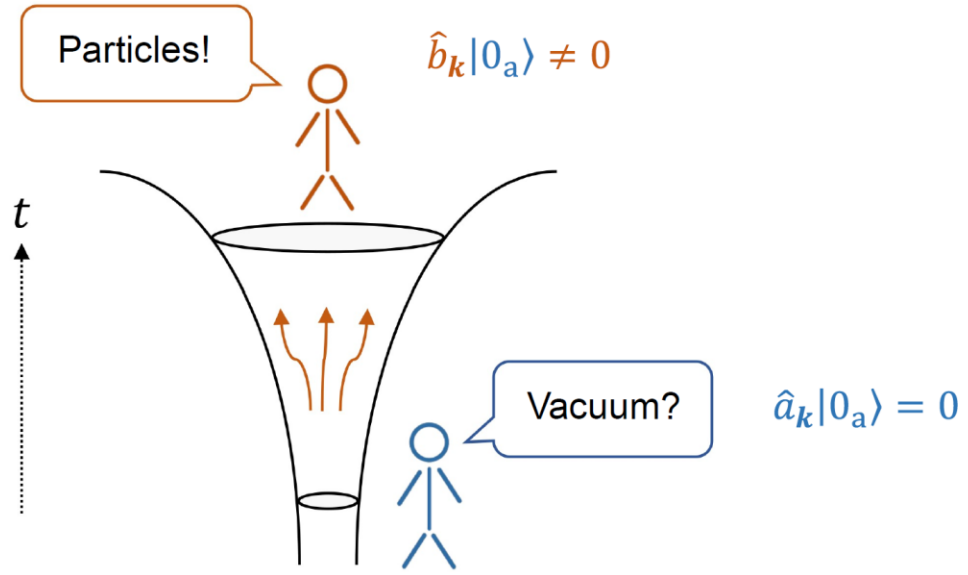
- We denote by cosmological the gravitational production due to a time-dependent geometry, affecting all fields on top of the expanding background

- The more *violent* the expansion, the more important the production (early Universe)



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- Observations tell us that most matter in the universe is dark
- This is incorporated into the Standard Cosmological Model phenomenologically
- Cosmological production seems a suitable mechanism for dark matter production

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- This is incorporated into the Standard Cosmological Model phenomenologically
- Cosmological production seems a suitable mechanism for dark matter production
- These scenarios can not be reproduced experimentally, but analog gravity experiments that can be realized in the laboratory are an interesting alternative

How many ‘particles’ have been produced?

What a problematic question...

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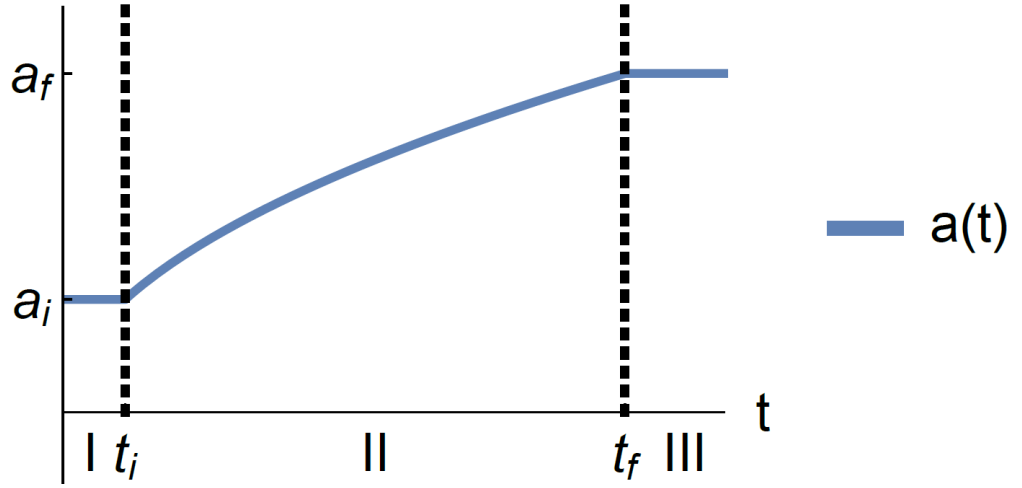
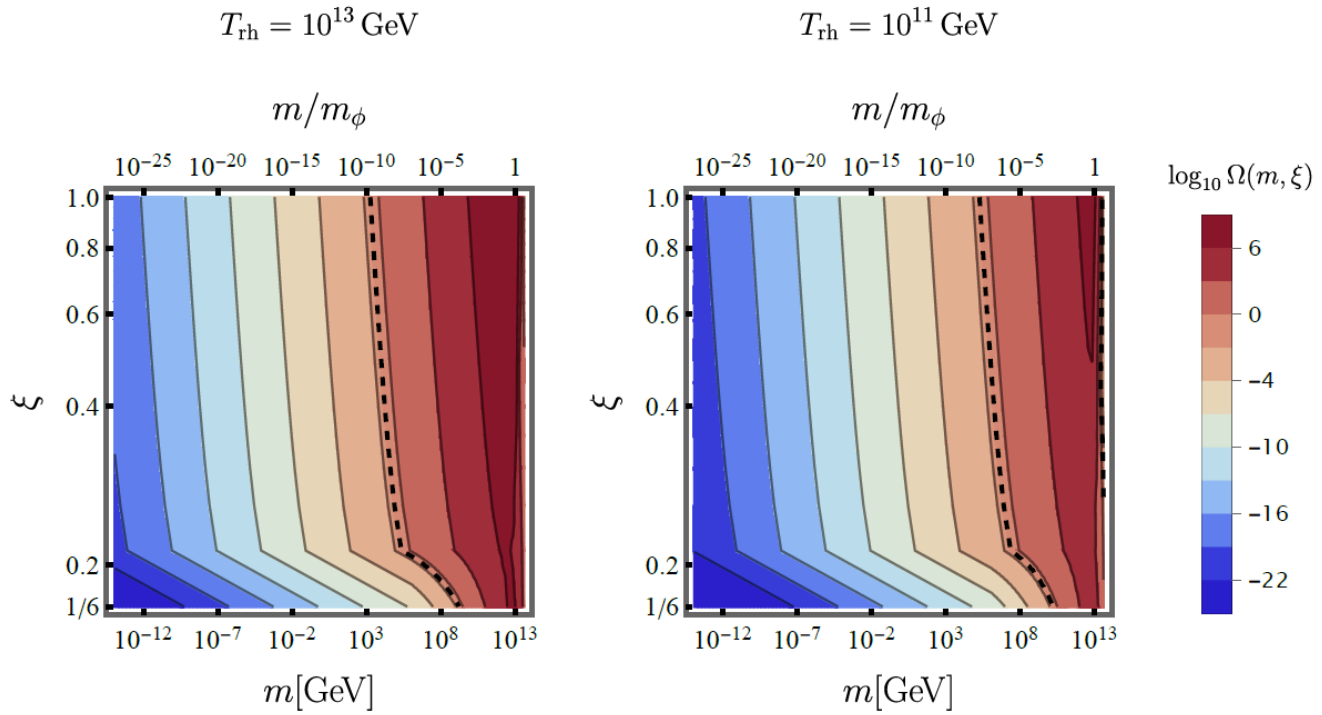
Consider the following realization

- Preferred vacuum in I, $\hat{a}_{\boldsymbol{k}}|0_{\mathrm{a}}\rangle = 0$
- There is no preferred vacuum in II
- Preferred vacuum in III, $\hat{b}_{\boldsymbol{k}}|0_{b}\rangle = 0$



- If the spectator field does not interact, the produced density leads to a relic abundance
- For a given temperature at the end of reheating, the abundance can be extrapolated to today

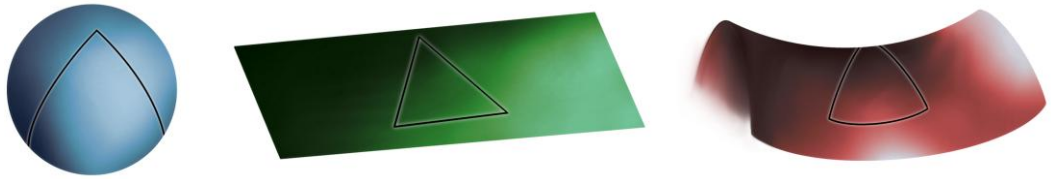


Experimental realization

- Reproducing strong curvature effects predicted by QFTCS is hard
- Analog gravity systems have mathematical similarities and can be realized in the lab
- Focus on (1+2)-dimensional Bose-Einstein condensates

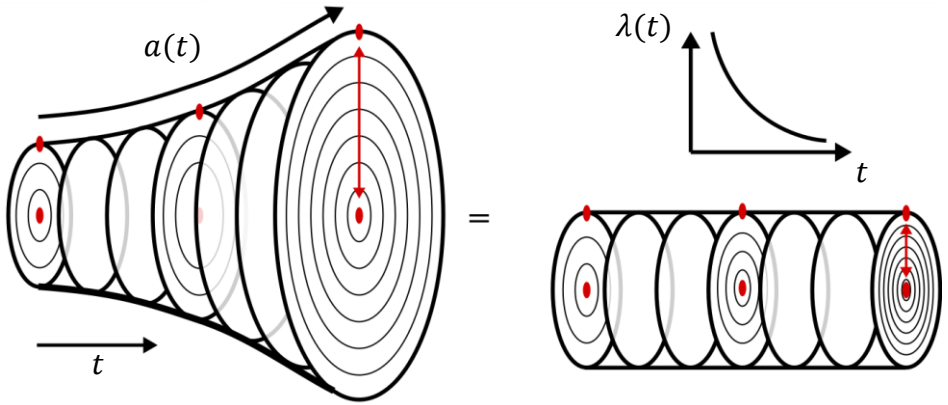
Real world	BEC experiment
Spacetime geometry	Background parameters
FLRW metric	Acoustic metric
Massless scalar particles	Phonons

- Spatial curvature depends on the density profile, engineered through the trapping potential



$\kappa > 0$ $\kappa = 0$ $\kappa < 0$

- Scale factor is realized by changing the interaction strength



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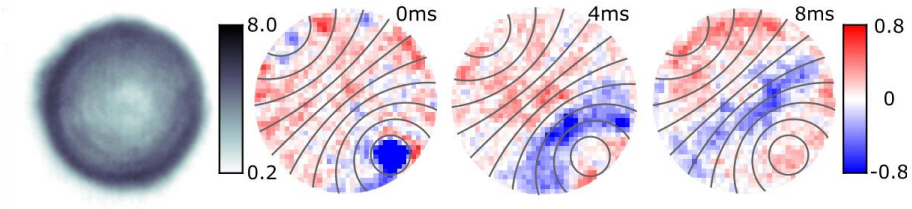

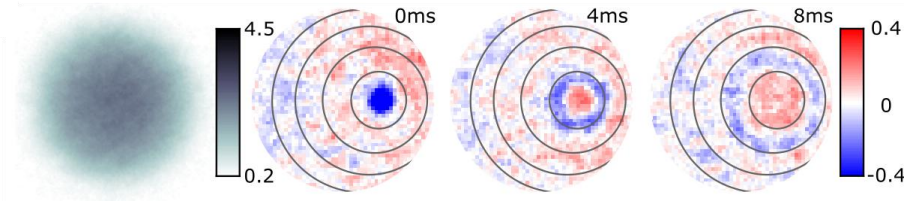

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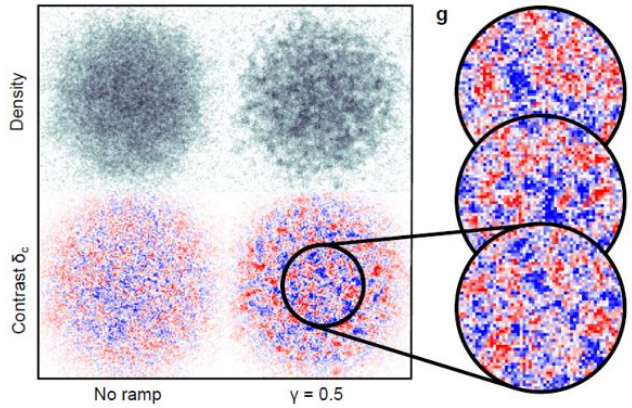

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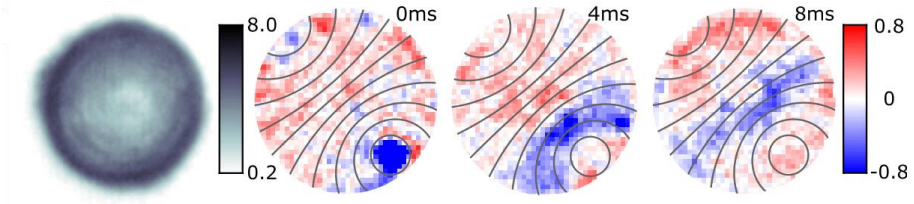

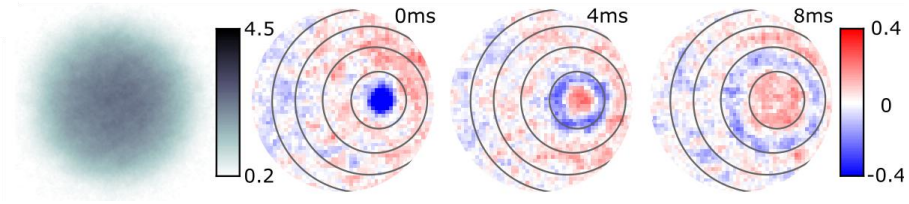

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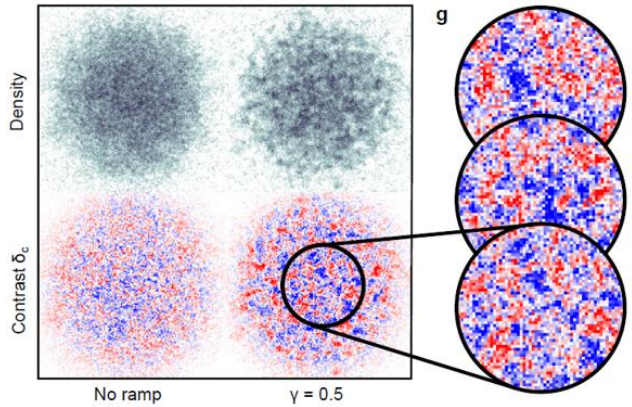

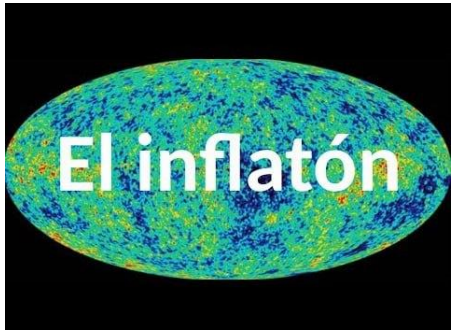

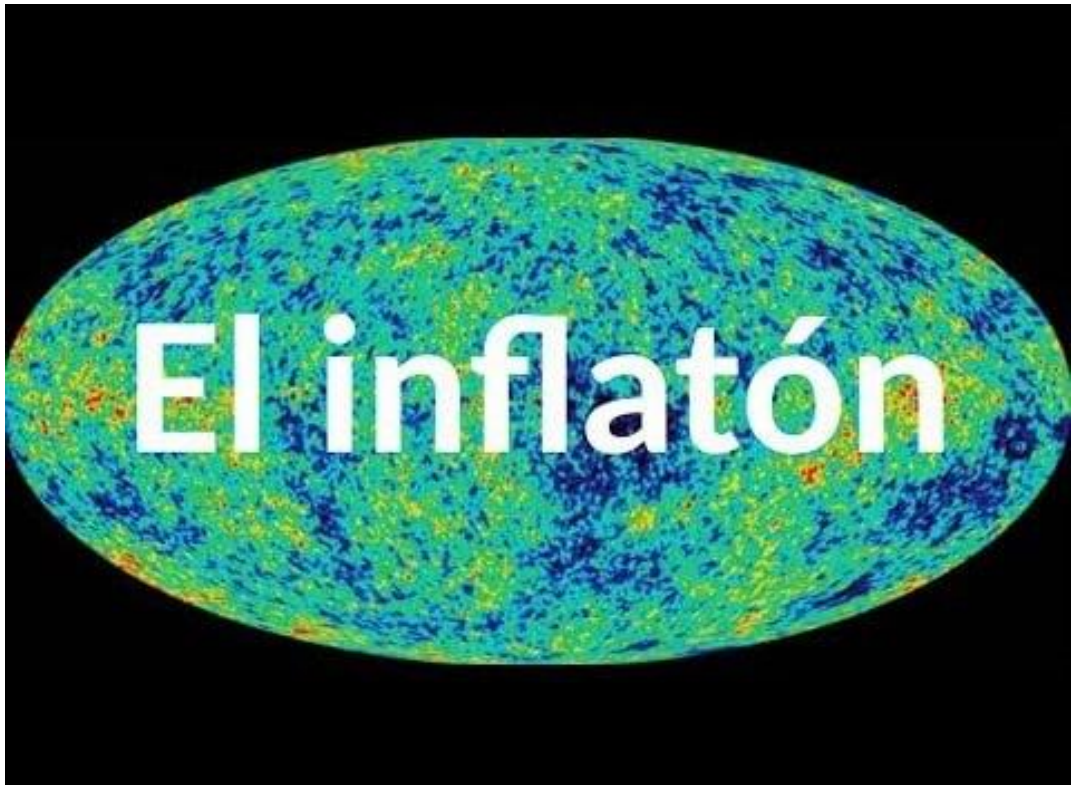
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