

Cosmic strings

with some applications to  
astrophysics

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main question: what are cosmic strings?

why do we care? (about the strings, not in general)

what are they?

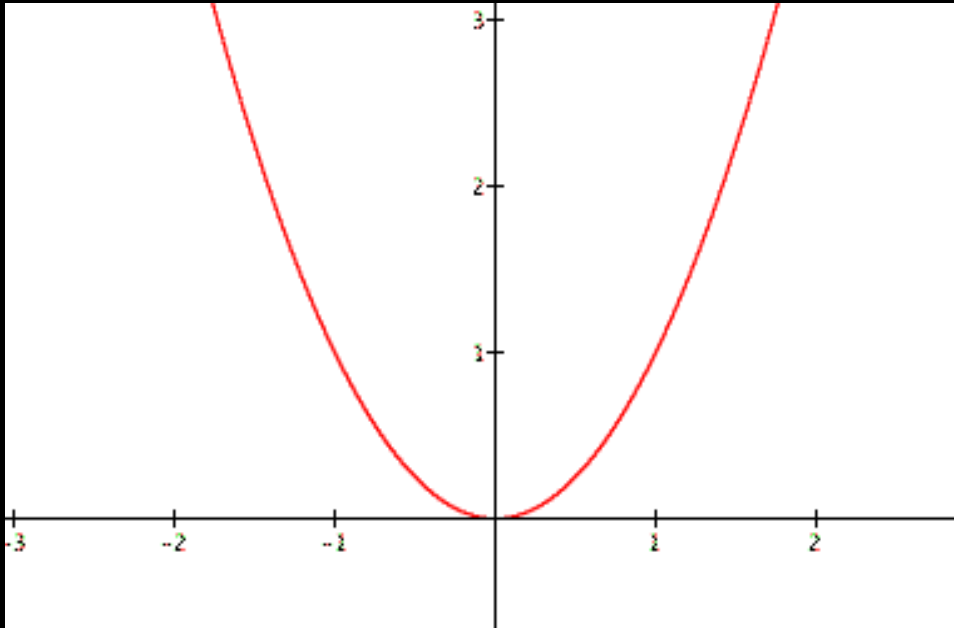
the result of making thin  
noodles by cooling down a non-  
noodley soup

what are they?

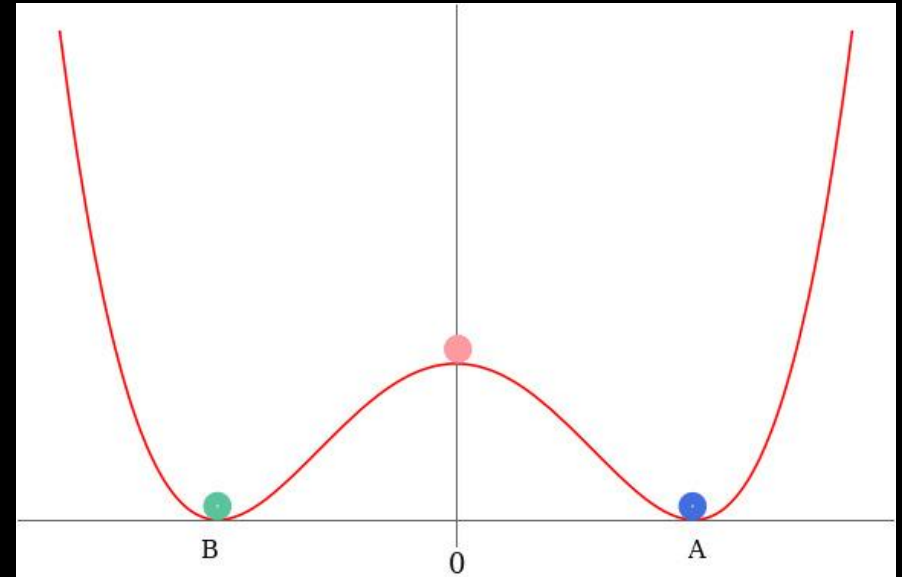
line (1D) topological defects  
formed from GUT phase  
transitions involving the  
spontaneous symmetry breaking  
of the Higgs field

# symmetry breaking

$$\begin{aligned} V(x) &= \mu^2 x^2 + x^4 \\ &= x^2(\mu^2 + x^2) \end{aligned}$$

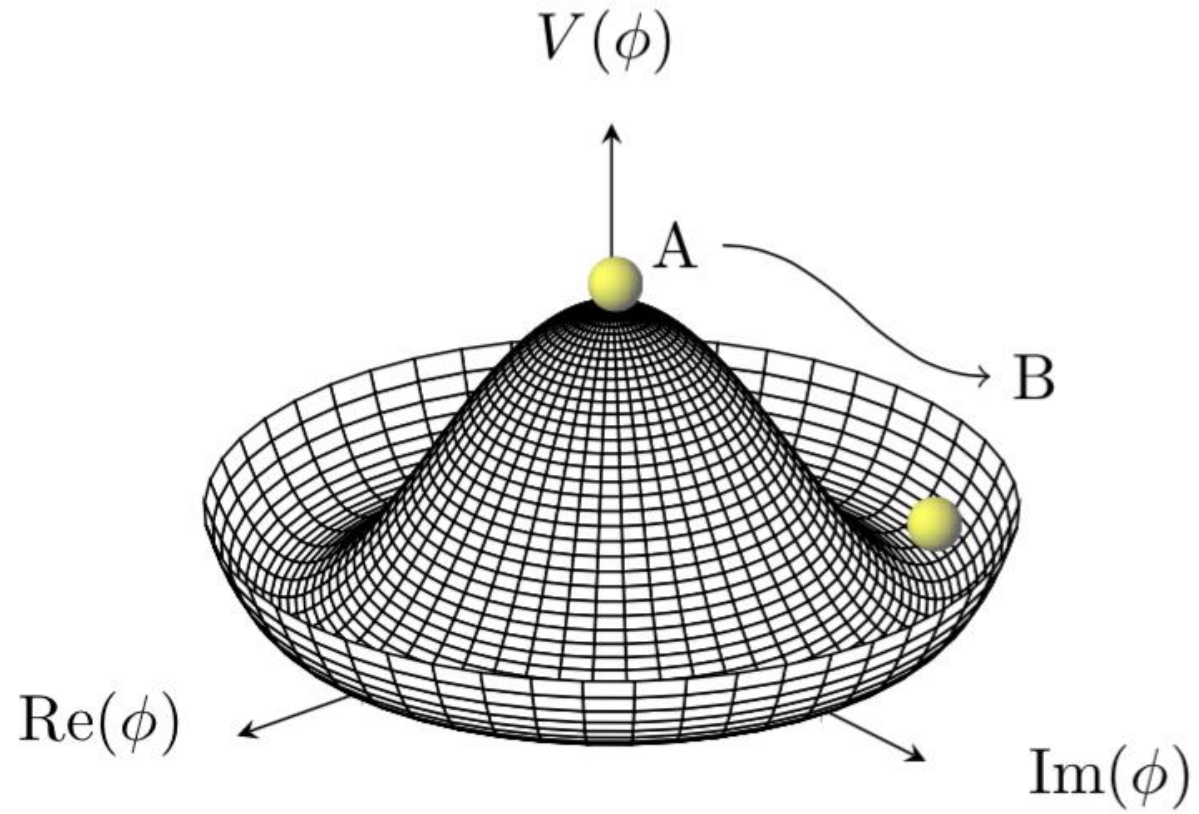


$\mu^2 > 0$



$\mu^2 < 0$

# The Mexican hat potential





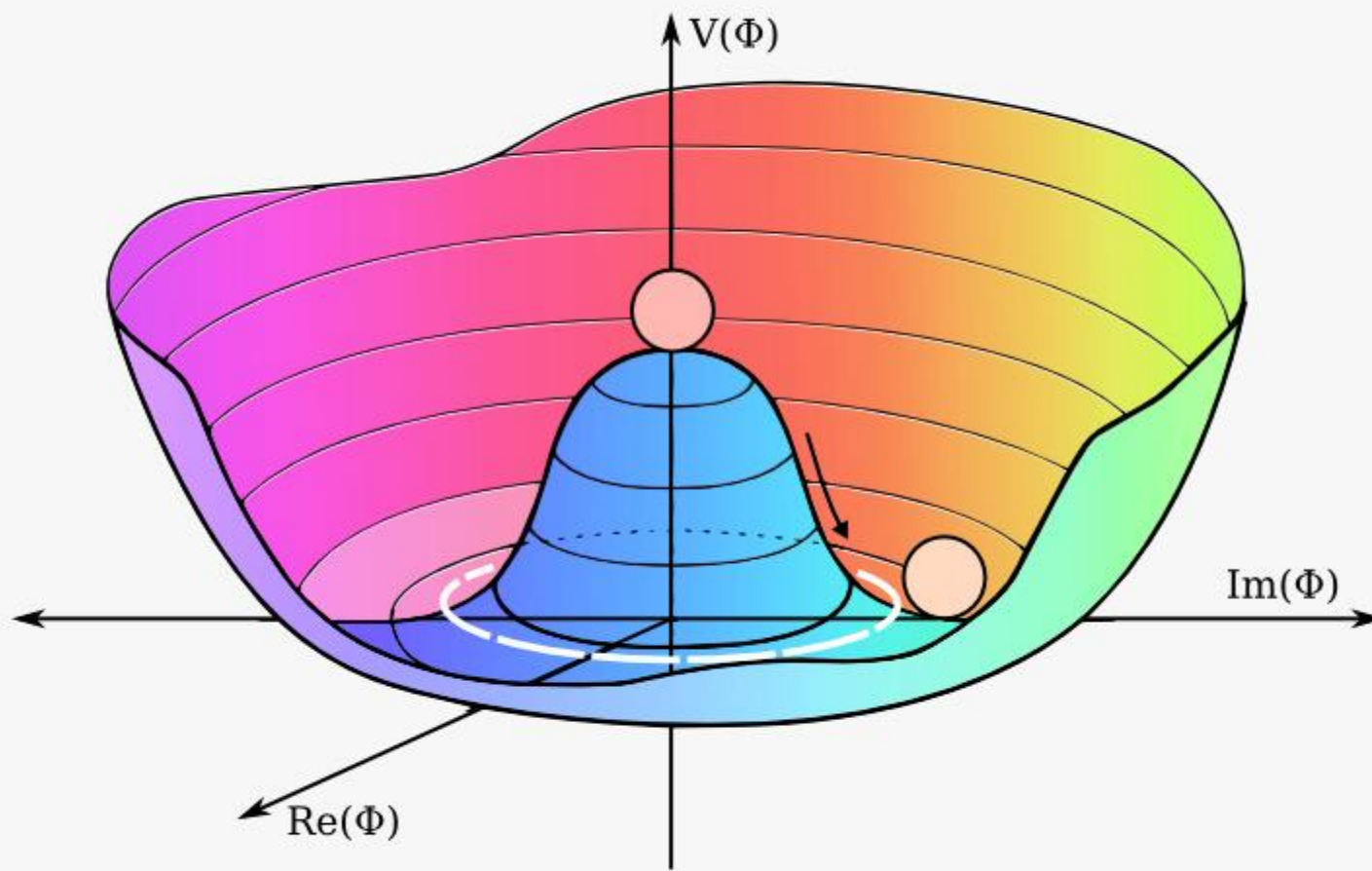


Figure credit: Anna Kormu (Uni of Helsinki)



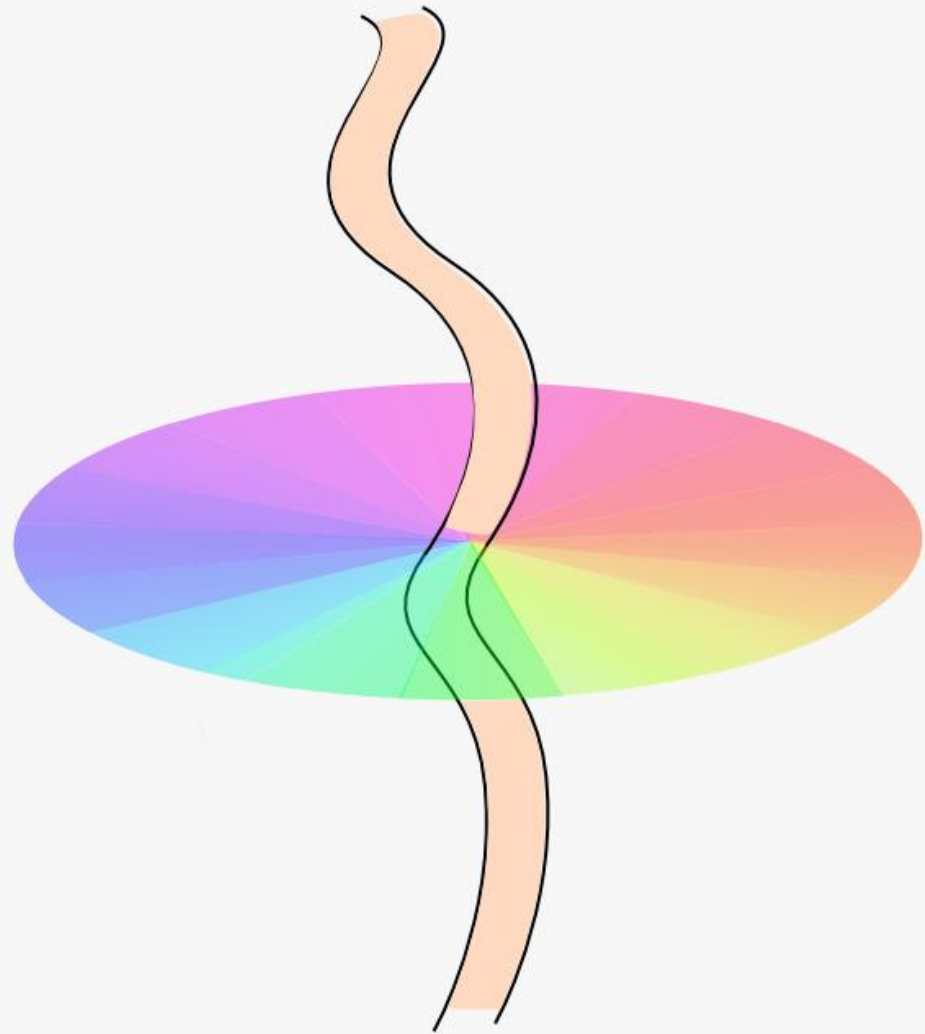
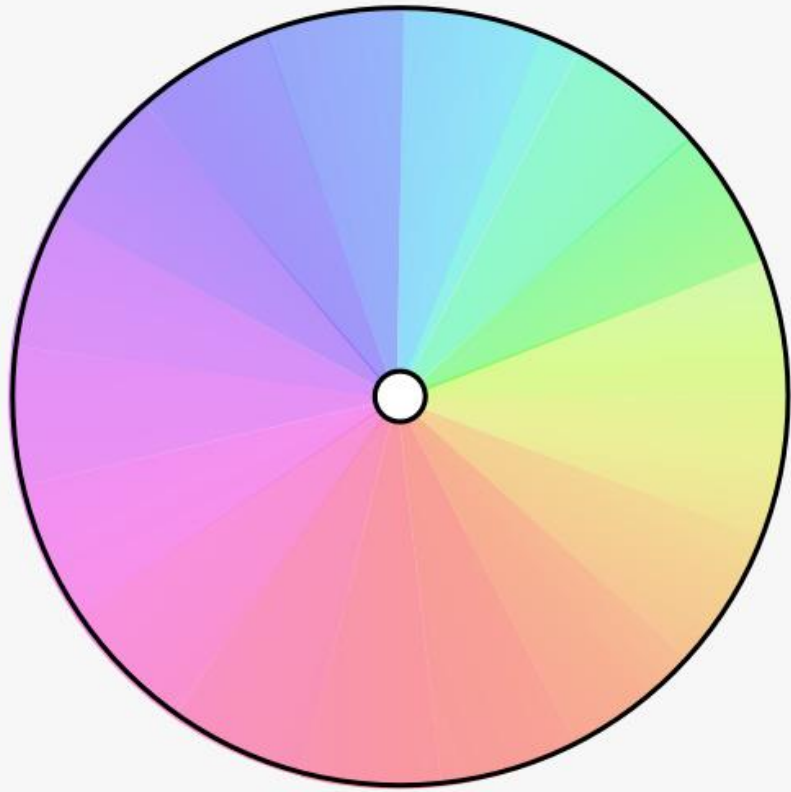
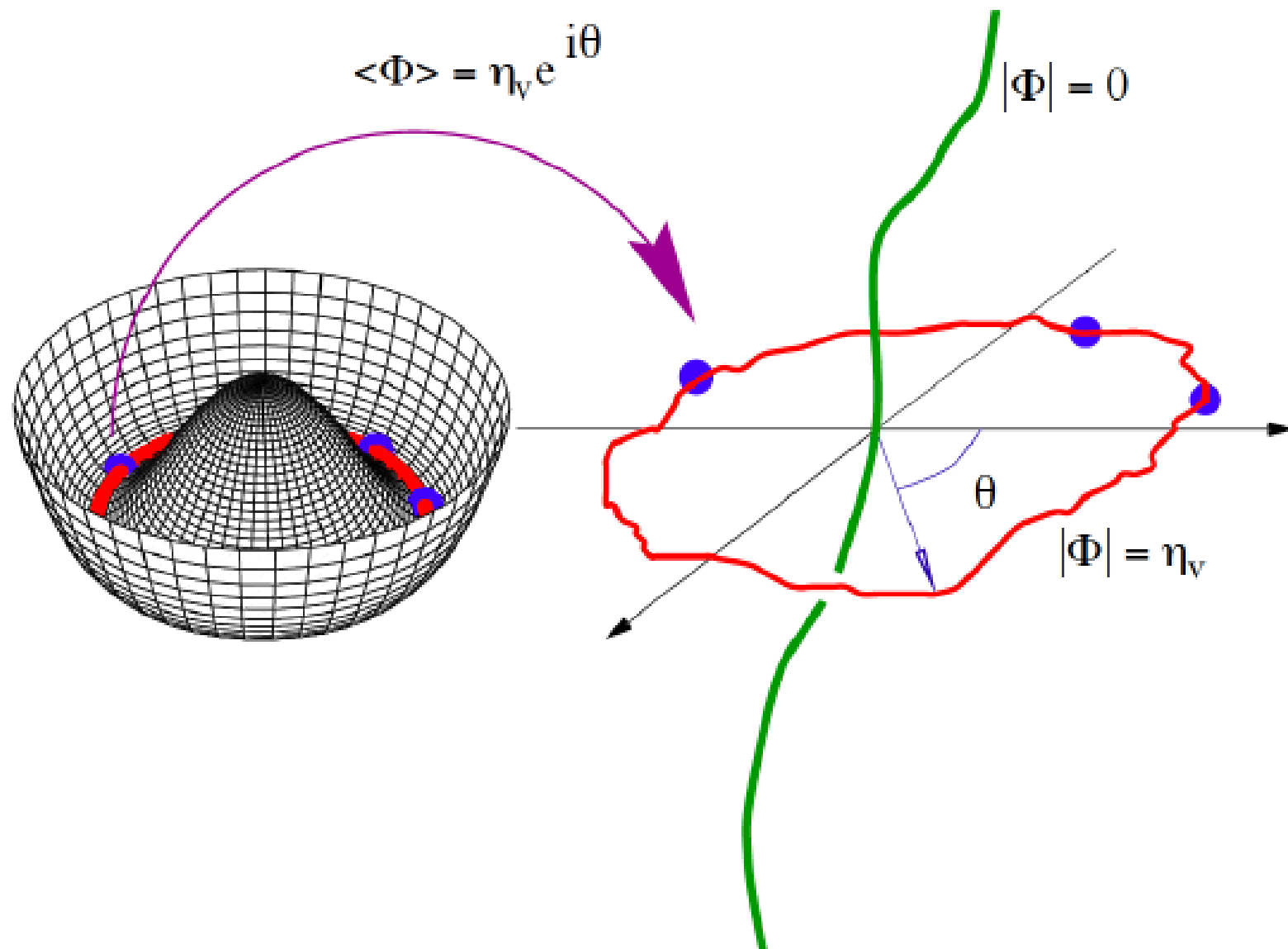


Figure credit: Anna Kormu (Uni of Helsinki)



a brief history of cosmic strings:

we know structures form - but  
how?

Galaxies, stars,  
Norway, etc.

Structure formation



What planted this?



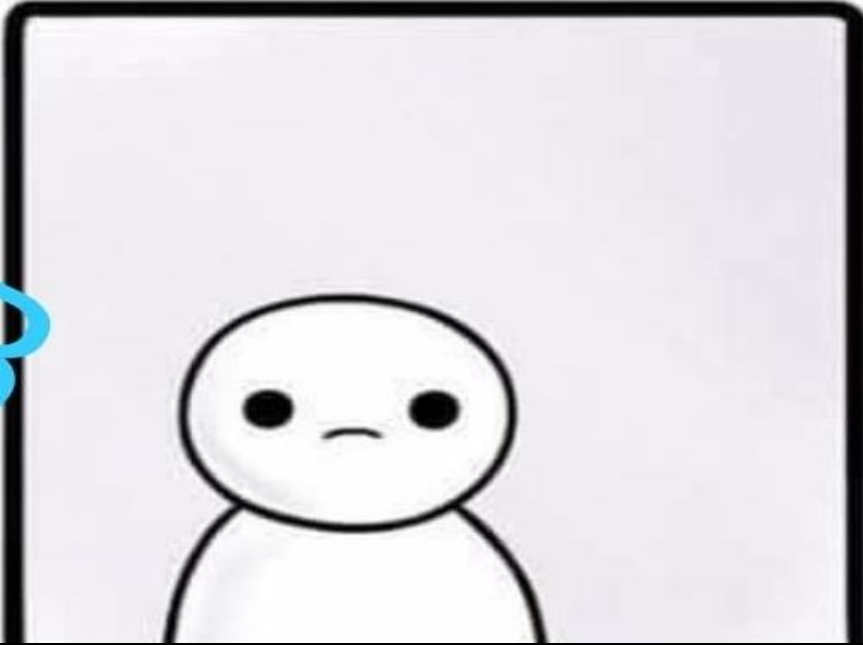
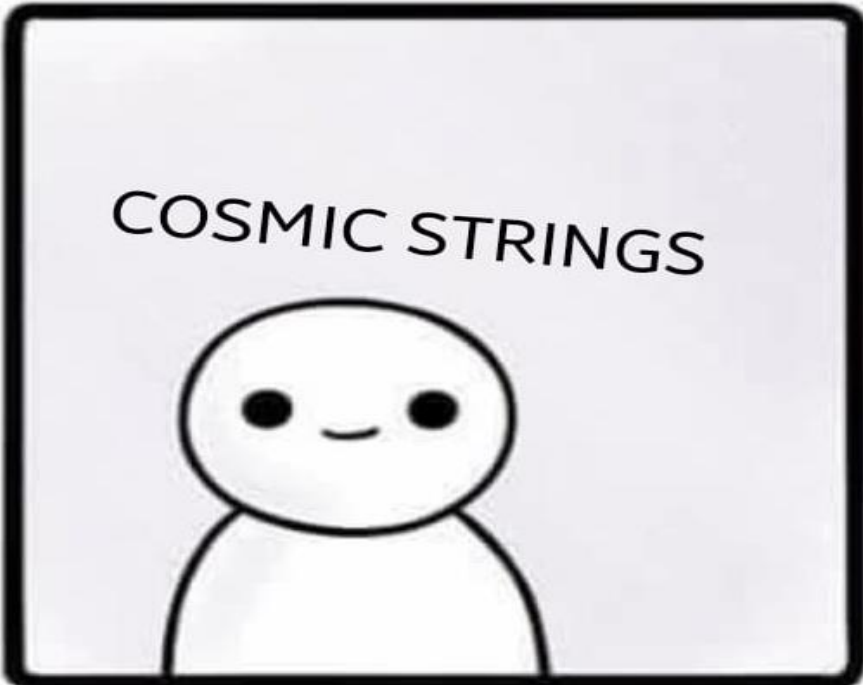
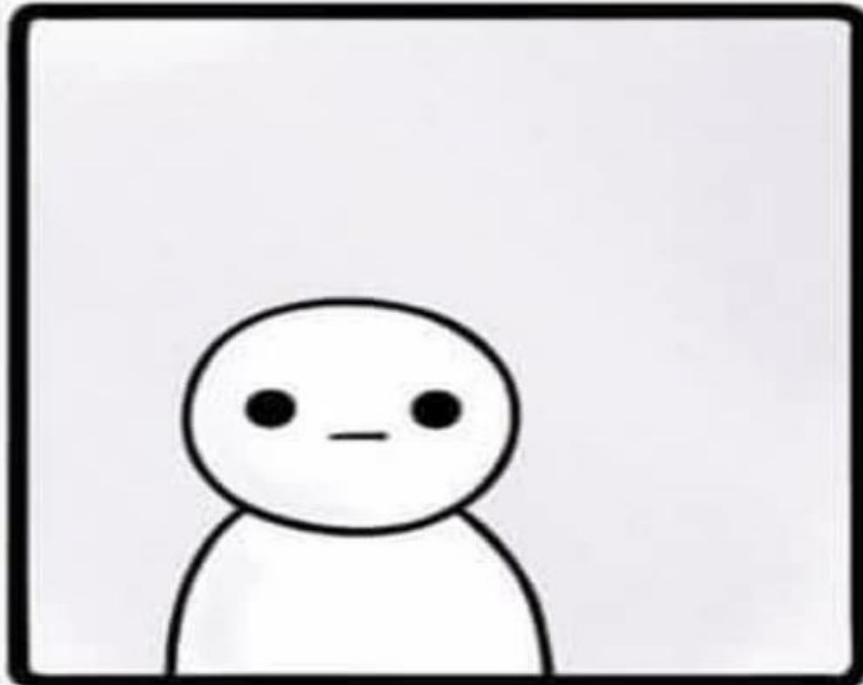
one idea: cosmic strings.

strings have energy (and  
therefore gravitate!)

provide the impetus for the gas  
to coalesce into larger stuff

in the late 80s, early 90s, cosmic strings were an alternative to inflation to seed structure

in the 90s, COBE measured the temperature fluctuations in the CMB



COSMIC STRINGS

\*SPOILERS\*

cosmic strings aren't a  
major player in galaxy  
formation

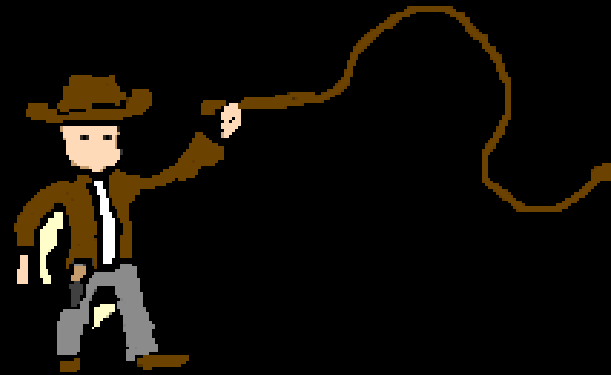
RIP cosmic strings ☹️



late 2000, early 2010s,  
two main ideas emerged  
to give new observational  
possibilities: GWs, and  
EM-related things

# cusp decay

\*crack\*





Based on the work done in --  
<https://arxiv.org/abs/1807.01976> &  
<https://arxiv.org/abs/1810.05836>

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photo by Janik Alheit

we care: about EM radiation in the radio  
regime

because: fast radio bursts (FRBs)

one possibility: cosmic string cusp decay!

not-RIP cosmic strings 😊

BUT - cosmic string dynamics fail to account for two important things:

1. the cusp region is relativistic
2. taking the string to be of zero thickness is not an appropriate approximation

in <https://arxiv.org/abs/1807.01976> :

what happens if we calculate the length contraction of the cusp region, and examine the radio burst parameters?

we found that cosmic strings are severely constrained as an FRB candidate.

what if we take into account the small-scale structure and calculate cusp decay then?

⇒ wiggly cosmic strings

we showed these are unable to produce cusps. the wiggles prevent the regions from reaching sufficient velocities.

what now?

strings aren't definitively ruled out by:

CMB

Or a lack of:

- gamma ray backgrounds
- neutrino fluxes from extragalactic sources
- "necklace" lensing
- GW background emission
- the theoretical limit on generic GW/EM radiation



why care?

a way of testing string theory

f-strings  $\rightarrow$  c-strings and could remain stable.

last real testing arena: GWs pre-epoch of reionisation.

The writing does seem on the wall



OR DOES IT?

thank you 😊