Seeing the Landscape on Earth and in the Sky

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- Detection prospects

Why a landscape?

String Theory   Phenomenology

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- Are other features of our universe selection effects?

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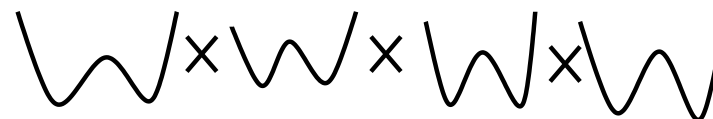Anthropic predictions provide indirect evidence for a landscape

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Is there tangible evidence in our vacuum?

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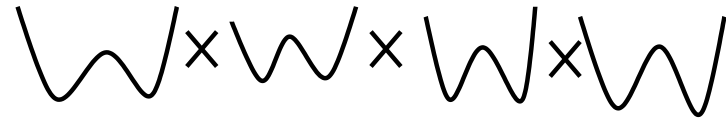
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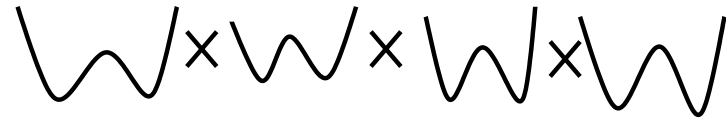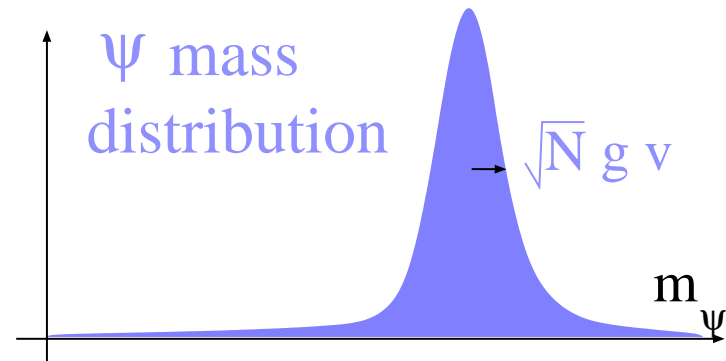
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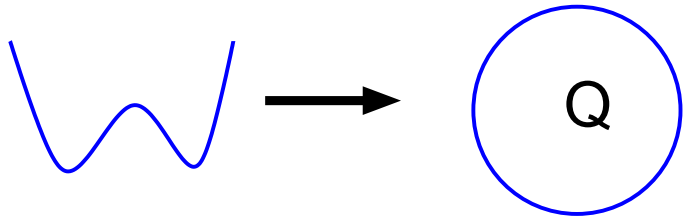
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- Stable charged ψ with mass scanned

Ψ mass distribution

$\sqrt{N}\, g\, v$

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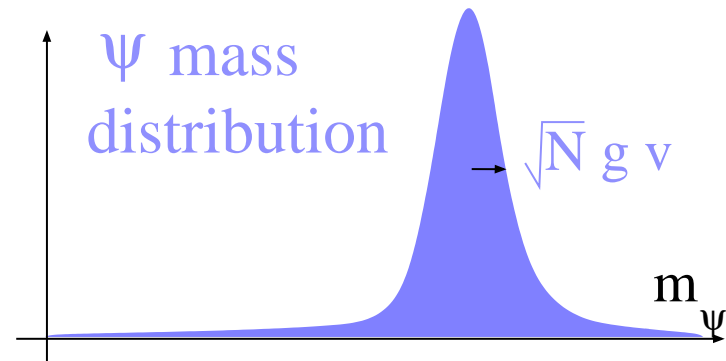
$$V = \sum_i \frac{\lambda_i^2}{8}(\phi_i^2 - v_i^2)^2 + (m + \sum_i g_i(\phi_i - v_i))^2 |\psi|^2.$$
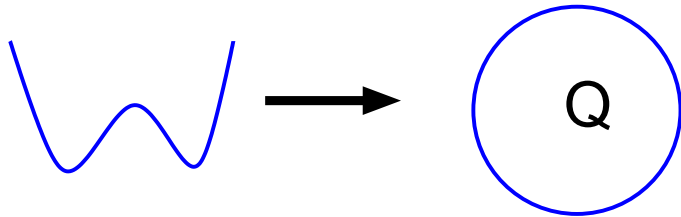
Vacuum Bubbles of one Field

If ψ is lighter in the other vacuum,

- Domain wall binds ψ

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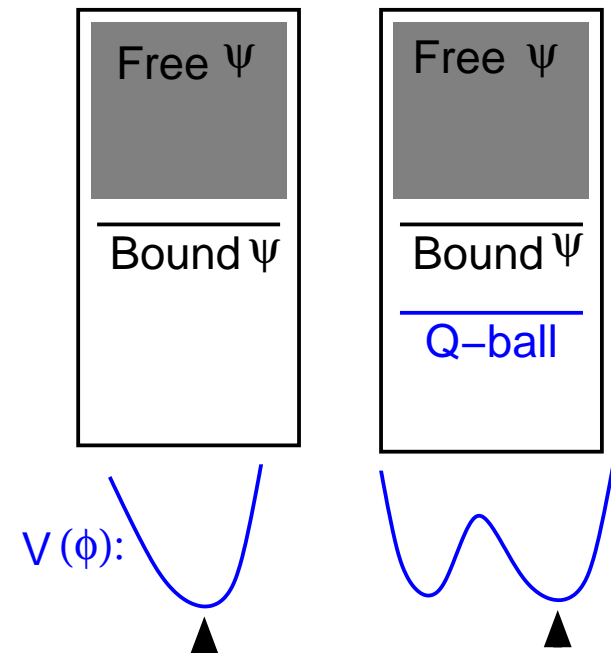

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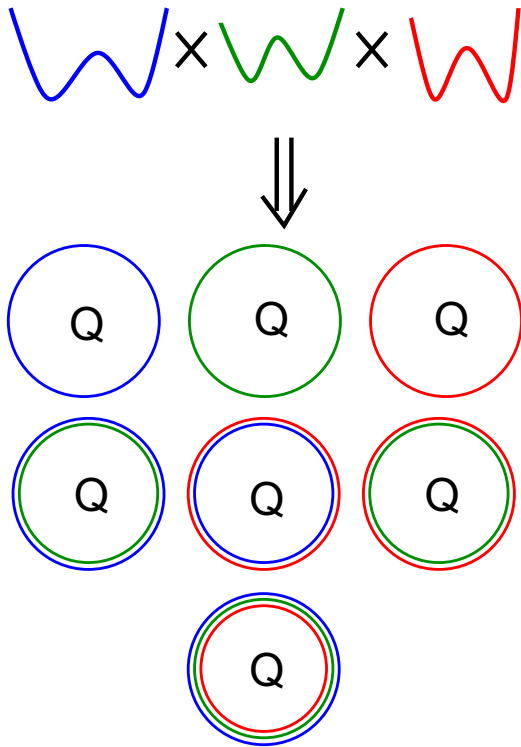This is the NTS of Friedberg, Lee, Sirlin. We call it a Q-ball.

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The spectrum sees the other vacuum!
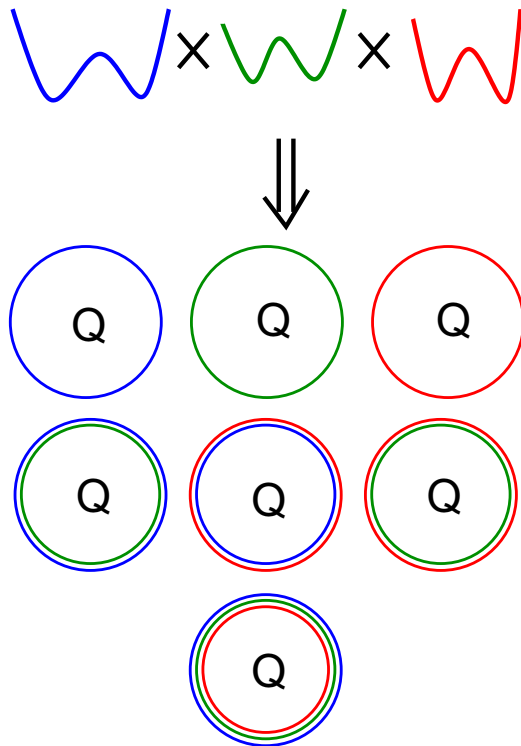
Spectra with Charge Q

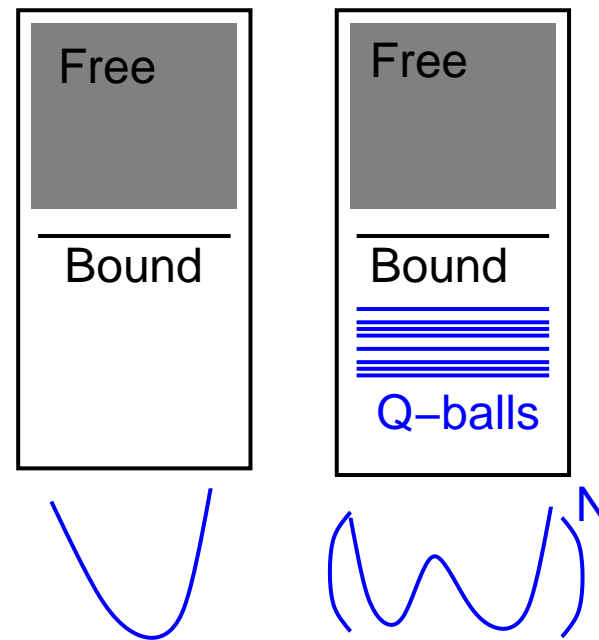# Landscape Vacuum Bubbles

Exponentially many bubble species can be cosmologically long-lived.

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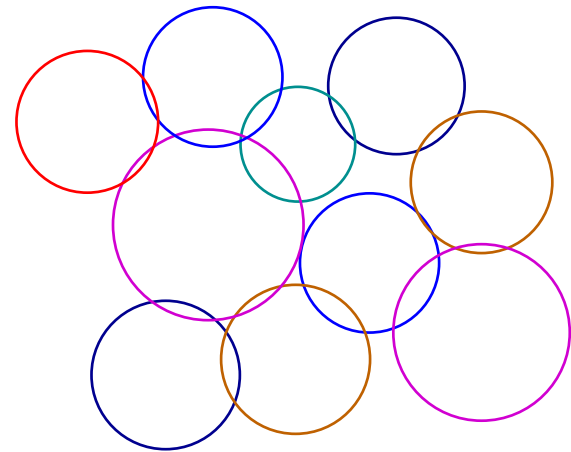

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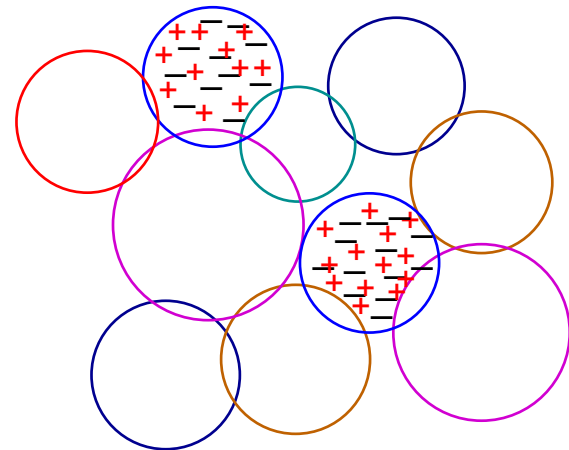- Reheat above phase transitions
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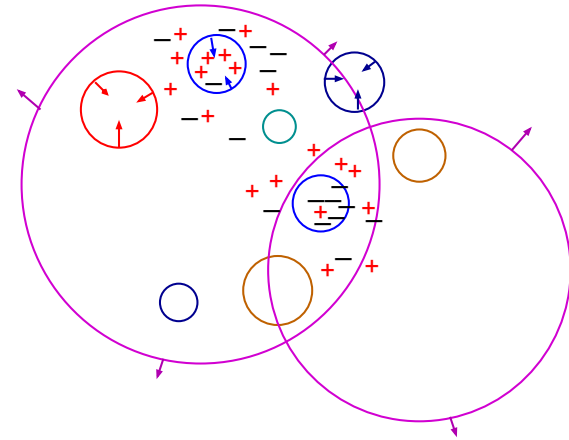
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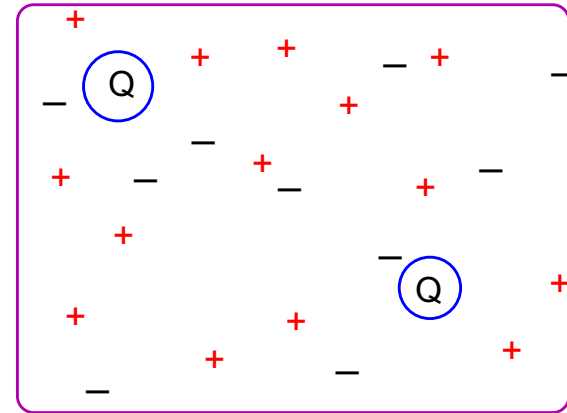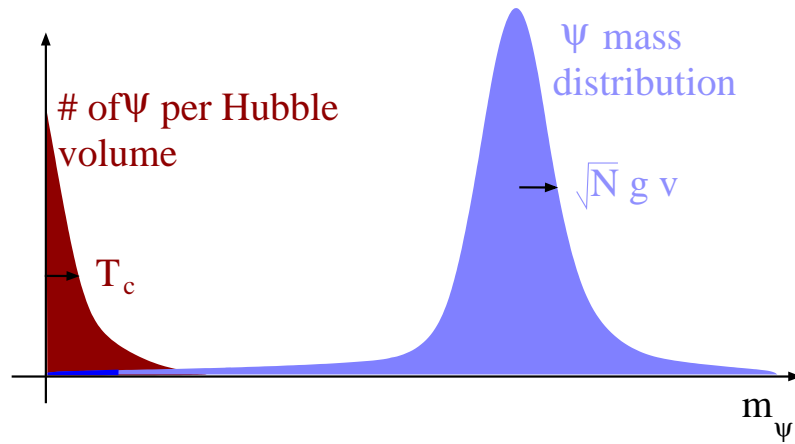- Walls collapse, ψ evaporate

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- Trapped charge asymmetry $\rightarrow$ Q-balls

Abundance of Q-Balls

Power-law tails in mass distribution $\Rightarrow$ both ψ and Q-ball production dominated by ψ-friendly vacua on tail where $m'_\psi \sim T_c$.
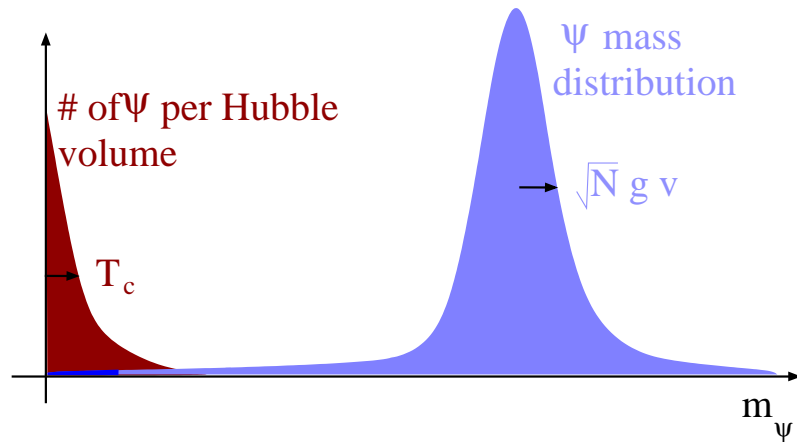
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Ω_ψ controlled by fraction of vacua that are ψ-friendly.

$\frac{n_{\text{Q ball}}}{n_\psi} \lesssim 1/Q^2_{min}$ determined by evaporation.

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- May need to collect Q-balls in order to verify multiplicity.

Q-Ball Detection

CHAMP Flux limits from IMP 8, MACRO:

(figure from M. Perl et al hep-ex/0102033)
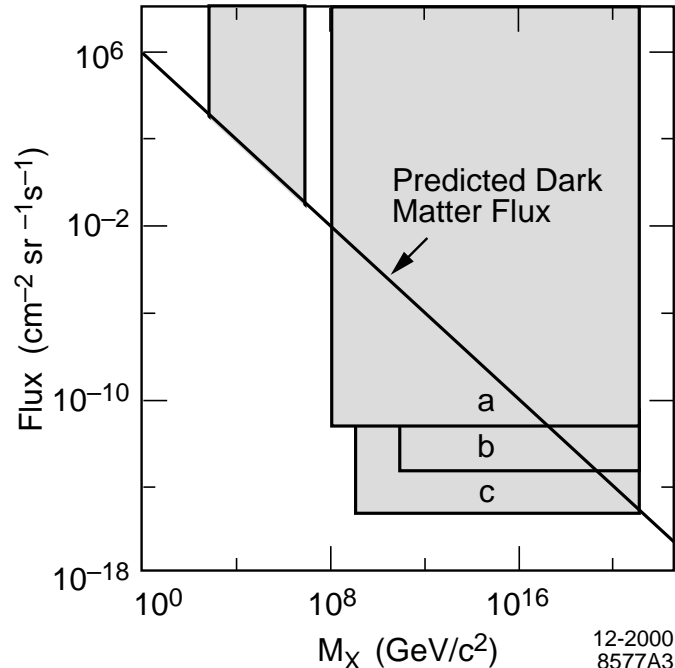
A flux of $\dfrac{10^{-13}}{cm^2 \cdot sr \cdot s}$ stopping in Earth $\rightarrow$ one ψ per ton of matter in the Earth, probably tens of Q-balls per kton.

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- Given current limits, collecting and studying Q-balls could be very challenging.