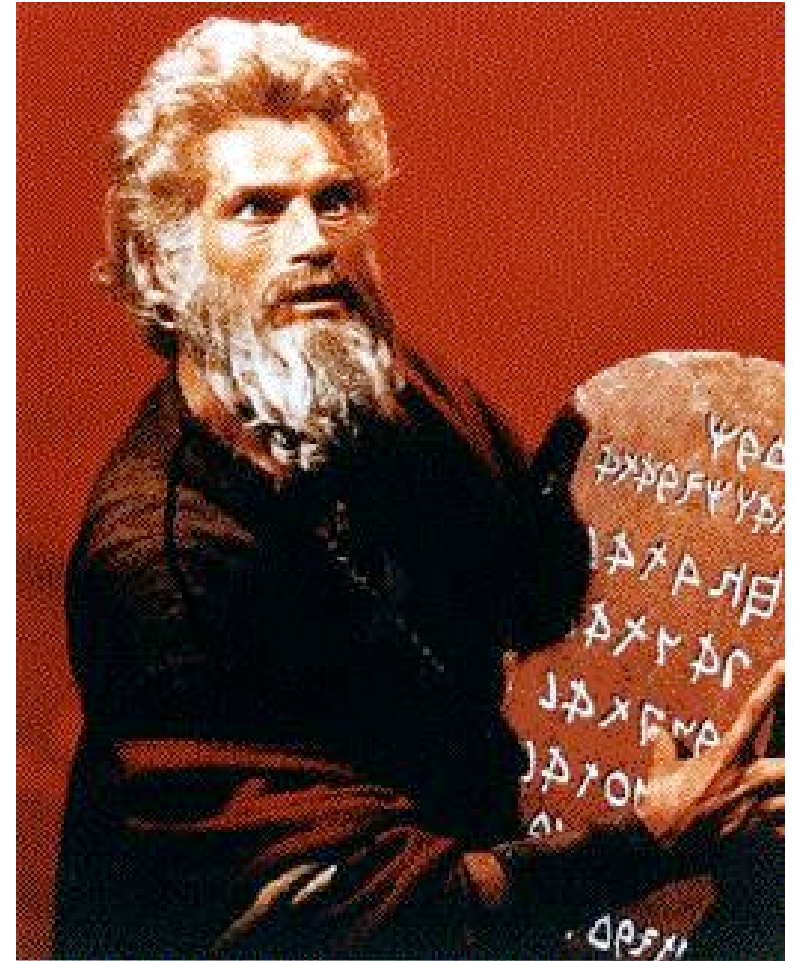


Was the Universe Created?

Vic Stenger

Where do the laws of physics come from?

- ✓ Not handed down **from above**.
- ✓ **Not restrictions** on the behavior of matter.
- ✓ Restrictions on the way **physicists may formulate** their mathematical statements about observations.
- ✓ Physics models must possess **point-of-view invariance**.



Noether's Theorem

For every continuous **symmetry** of the laws of physics there exists a **conservation law** and vice versa.

That is, the most important "laws" of physics:

Conservation of

- Energy
- Linear momentum
- Angular momentum

Follow from **point-of-view invariance**.

The laws of physics are just what they would be expected to be if they came from nothing.



-Emmy Noether (1915)

Gauge symmetry
generalizes
Noether's theorem

The Kalam Cosmological Argument

William Lane Craig

- Everything that **begins** has a **cause**.
- The universe had a **beginning** (big bang).
- Therefore the universe had a **cause**.

Related claim:

Hawking and Penrose (1979):

Universe began as a **singularity**.

Craig and other theologians:

Therefore time and space began with the big bang and there was **no "before."**

Only a **"supernatural"** origin is possible.

Refutation

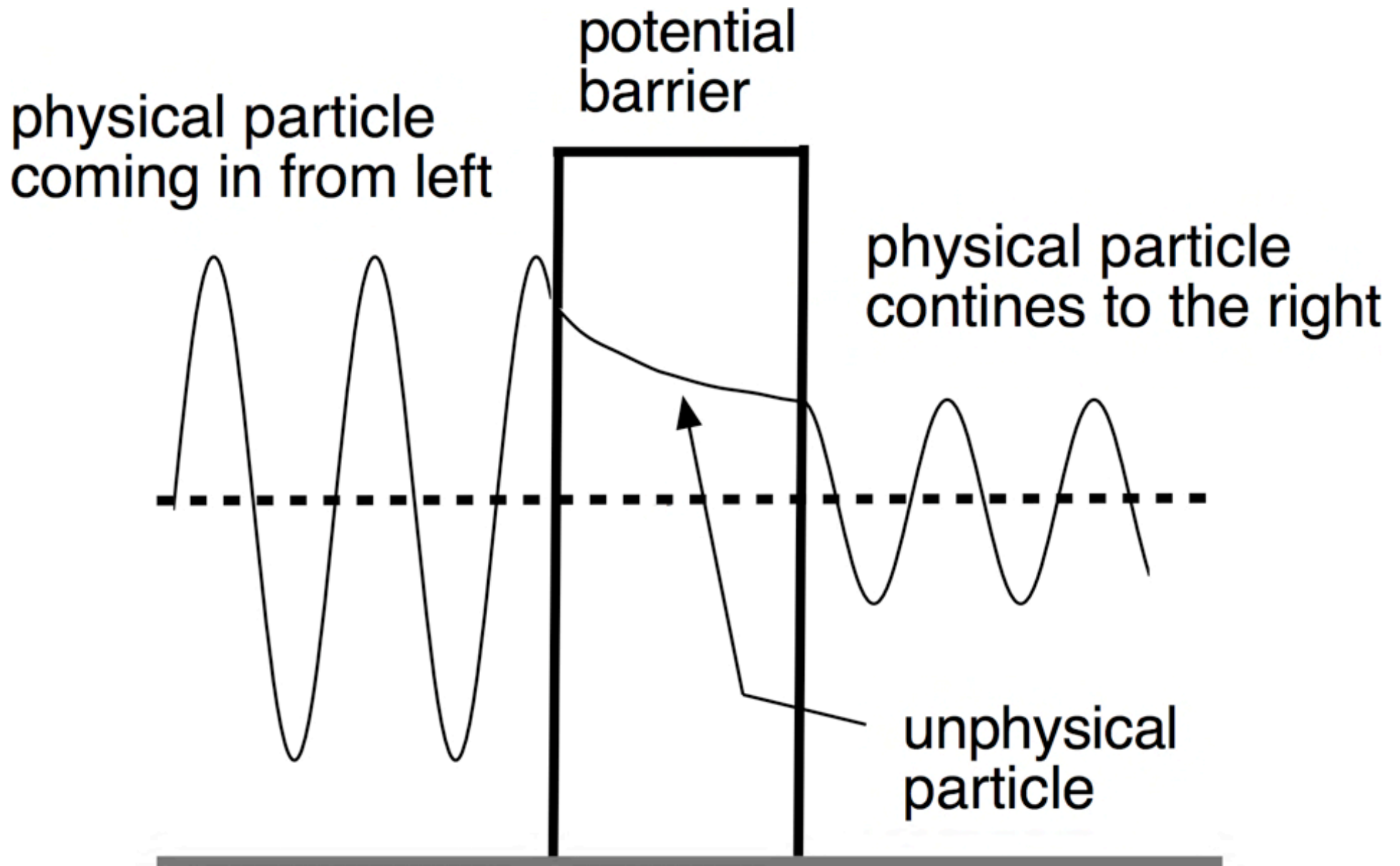
- Not** everything that begins has a cause. **Quantum transitions.**
- The universe did **not** begin with a singularity. **Quantum mechanics. (Hawking 1988)**
- Therefore the universe **need not** have had a beginning or a cause. **No creator needed.**

A Natural Scenario for the Origin of Our Universe

References:

- Hartle, J.B. and S.W. Hawking, "Wave Function of the Universe," *Physical Review D* 28 (1983): 2960-75.
- Atkatz, David. "Quantum cosmology for pedestrians," *American Journal of Physics* 62 (1994): 619-27.

Quantum tunneling



Cosmological
Friedmann equation

$$\left(\frac{da}{dt}\right)^2 - \frac{8\pi\rho G}{3}a^2 = -k$$

Let $a_o^2 = \frac{3}{8\pi\rho G}$

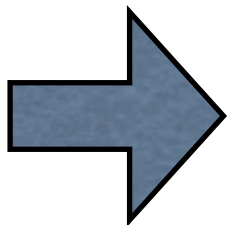
Let $k = 1$ closed
universe

Assume empty
universe

$$\rho = \frac{\Lambda}{8\pi G}$$

$$a_o^2 = \frac{3}{\Lambda}$$

cosmological
constant



$$a(t) = a_o \cosh\left(\frac{t}{a_o}\right)$$

Inflation

Note that t can be negative

Quantizing we get

Wheeler-DeWitt equation

$$\left[\frac{d^2}{da^2} - \left(\frac{3\pi}{2G} \right)^2 a^2 \left(1 - \frac{a^2}{a_o^2} \right) \right] \psi = 0$$

“Wave function of the universe” 

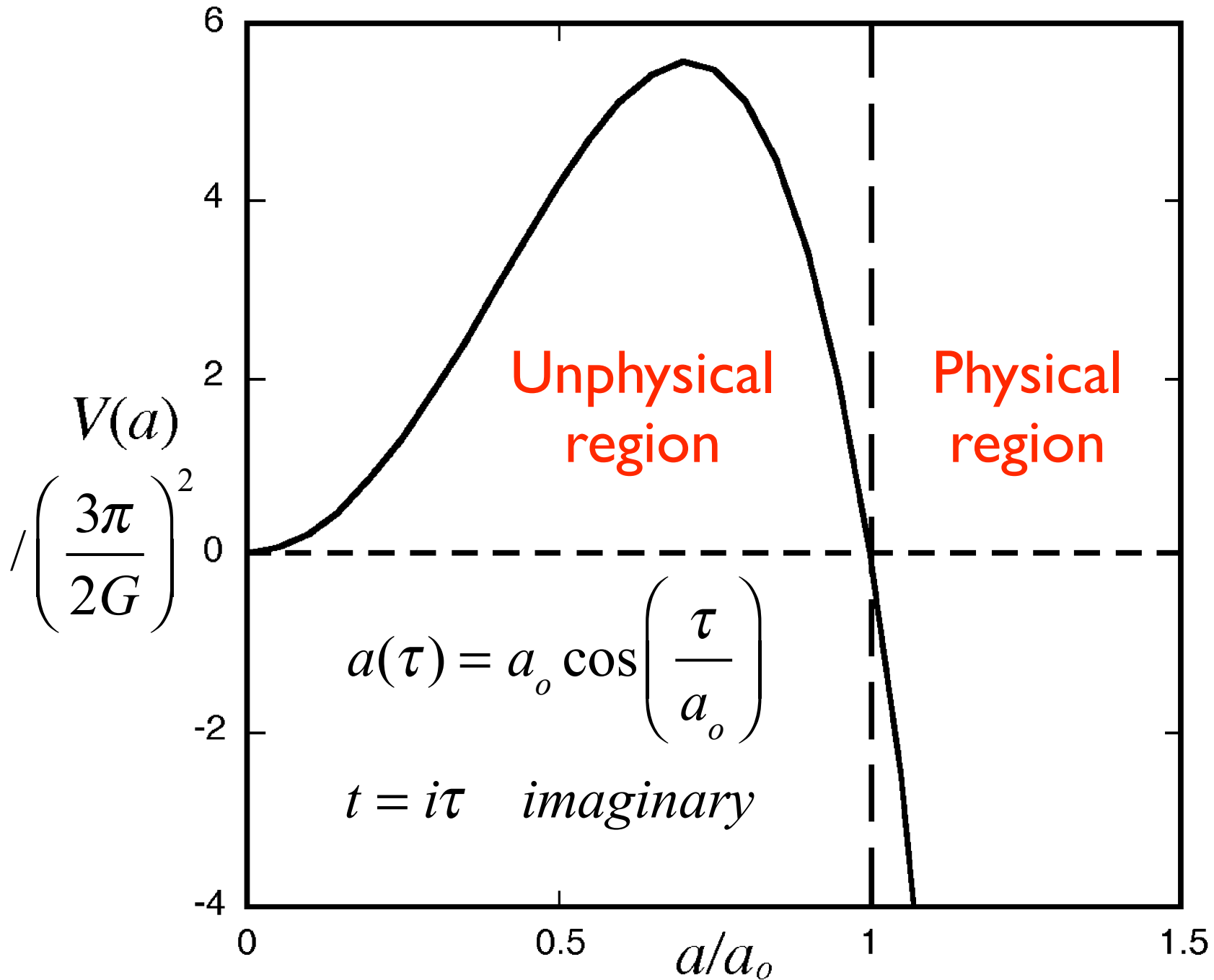
Schrödinger equation for particle with $m = 1/2, E = 0$

$$\hbar = c = 1$$

Potential energy

$$V(a) = \left(\frac{3\pi}{2G} \right)^2 a^2 \left(1 - \frac{a^2}{a_o^2} \right)$$

Potential energy



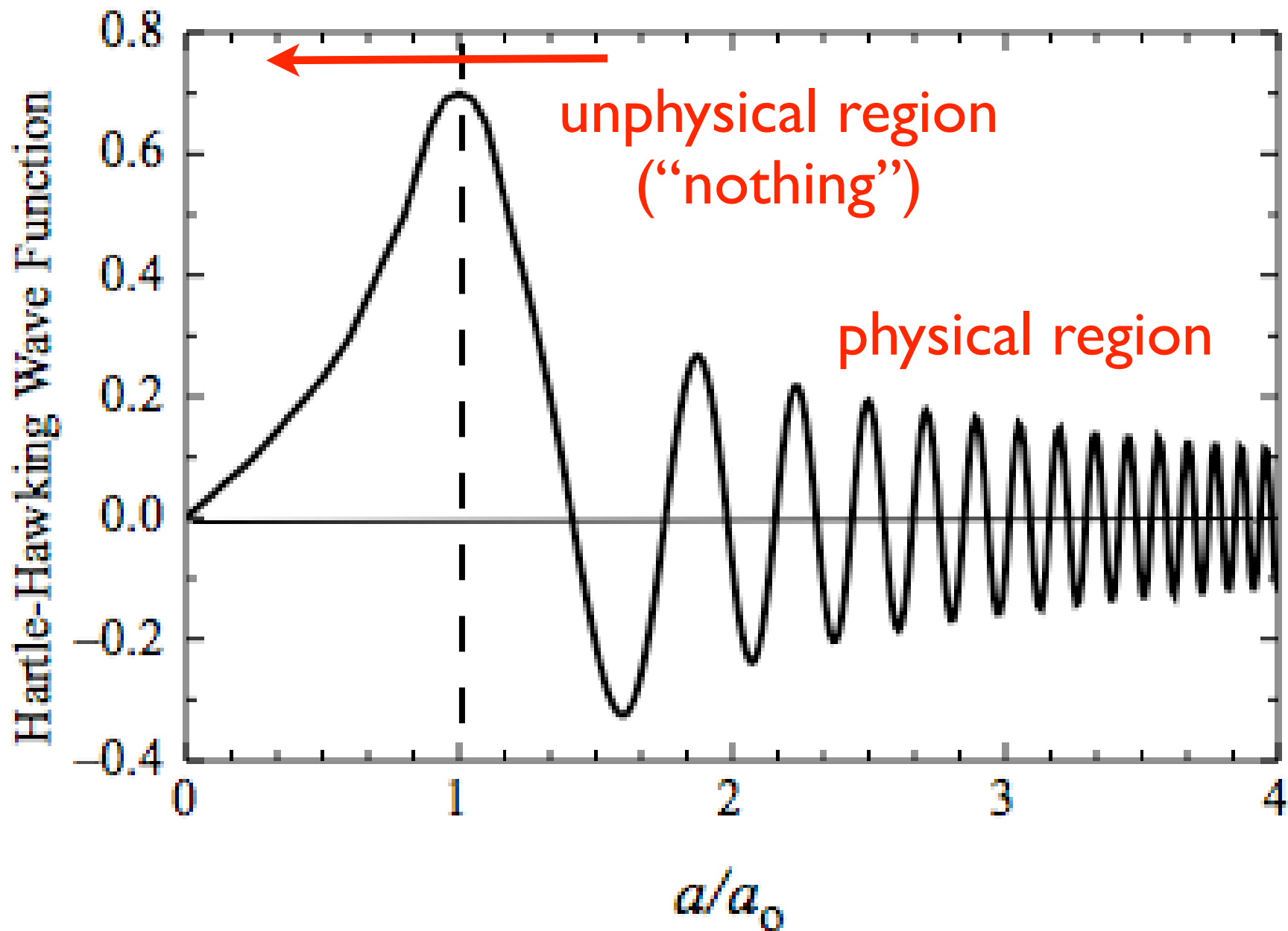
“No boundary” solution of Hartle and Hawking:
Equal amounts of incoming and outgoing waves

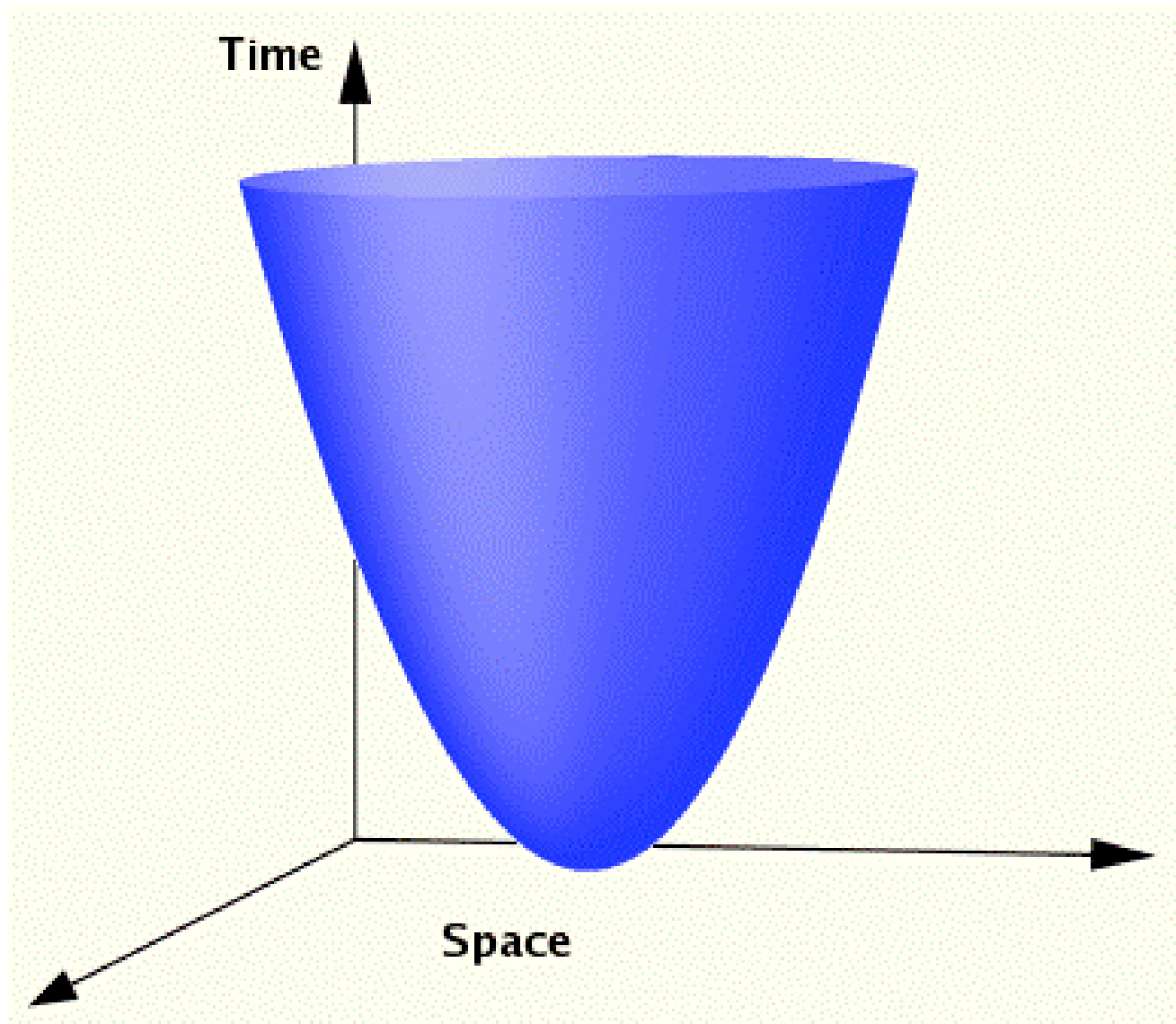
$$\psi_{HH}(a > a_o) = K(a)^{-1/2} \cos \left[\frac{\pi}{2} a_o^2 \left(\frac{a^2}{a_o^2} - 1 \right)^{3/2} \right]$$

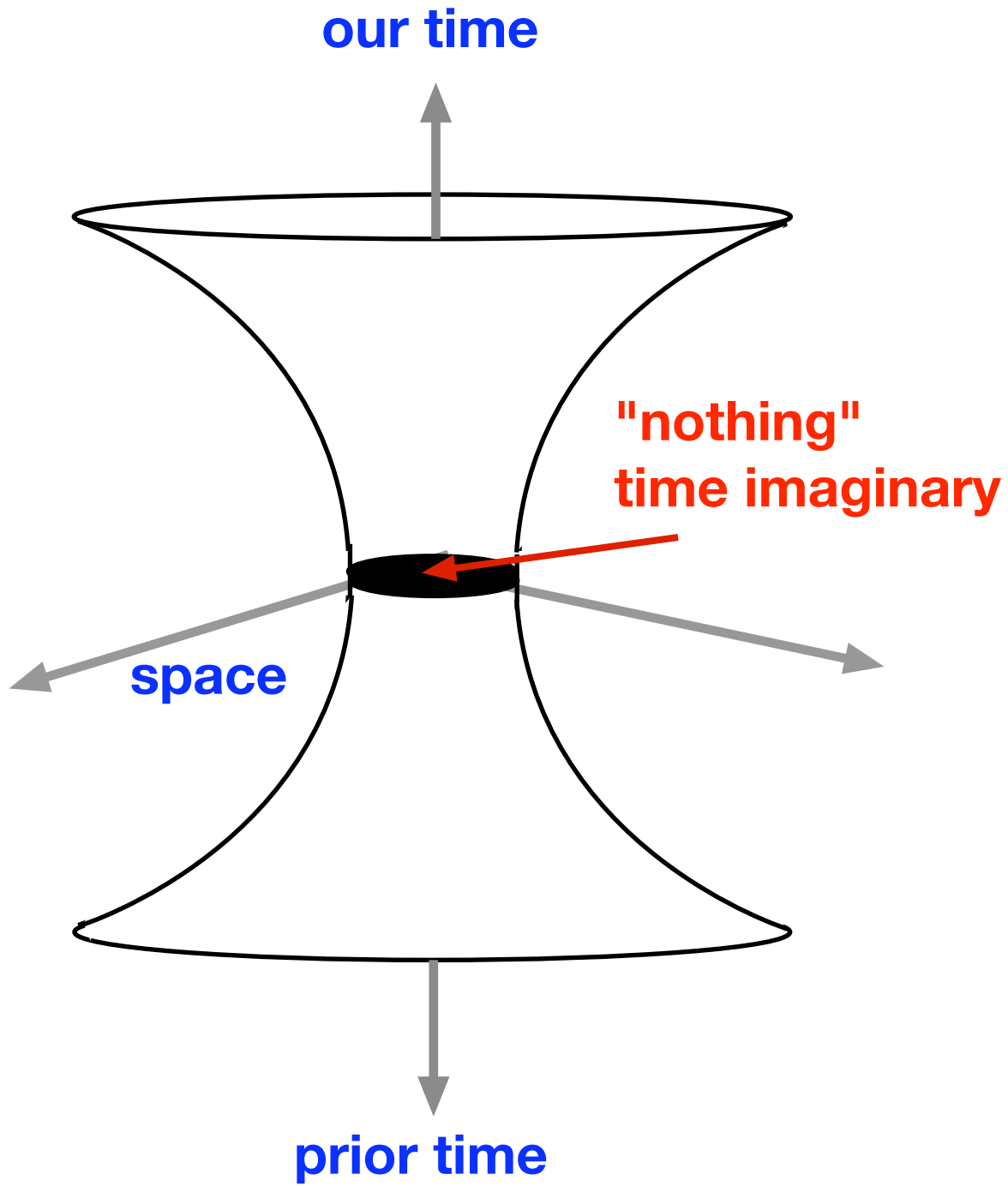
$$K(a) = \left(\frac{3\pi}{2G} \right)^2 a \left(\frac{a^2}{a_o^2} - 1 \right)^{1/2}$$

$$\psi_{HH}(0 < a < a_o) = K(a)^{-1/2} \exp \left[\frac{\pi}{2} a_o^2 \left(\frac{a^2}{a_o^2} - 1 \right)^{3/2} \right]$$

Wave function of the universe







$$P \approx \exp\left(-2 \int_a^b dx 2m |V(x) - E|^{1/2}\right)$$

$$2m = 1 \quad E = 0 \quad a = 0 \quad b = a_o$$

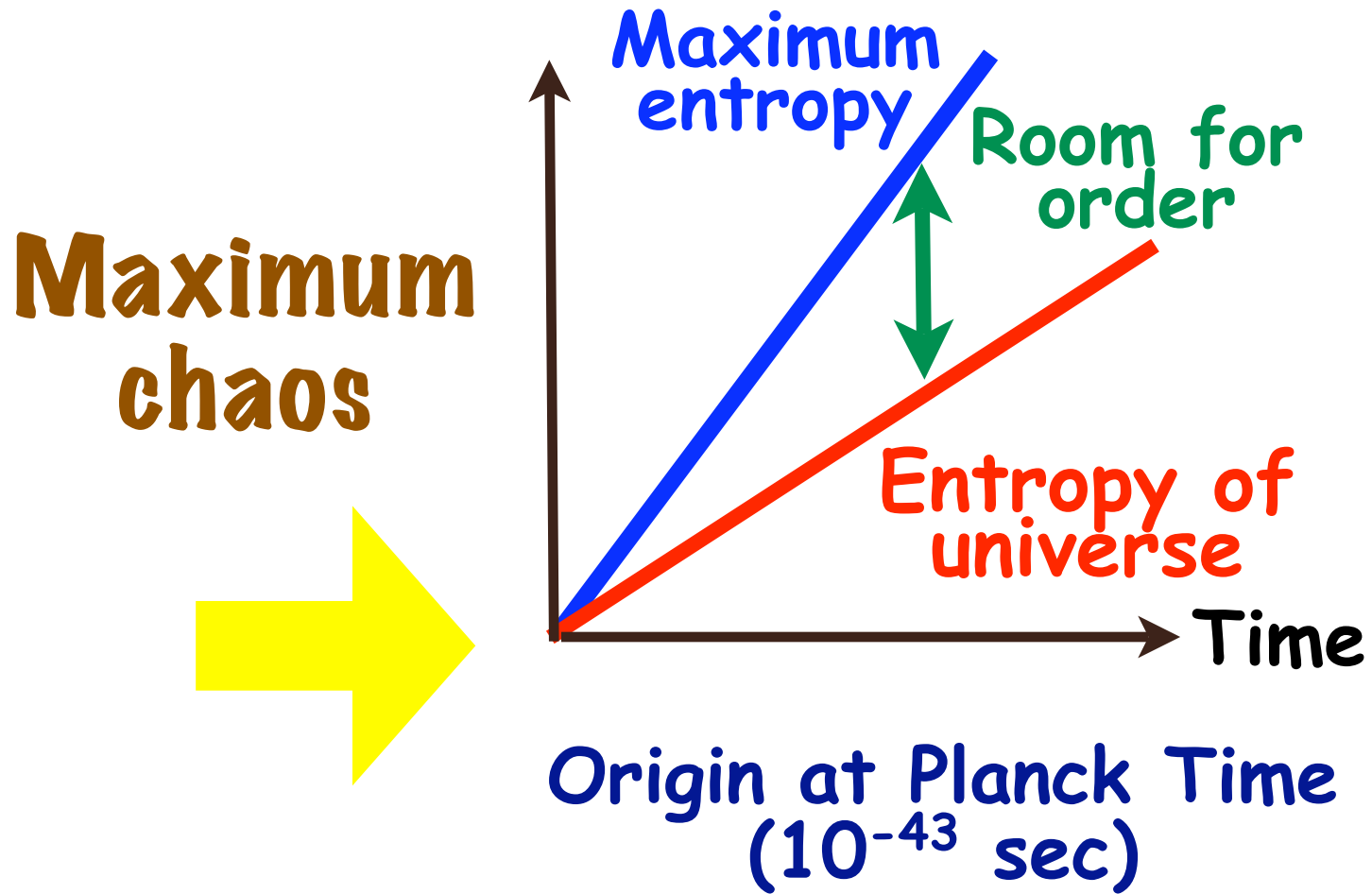
Tunneling
probability

$$P \approx \exp\left(-\frac{3}{8G^2\rho}\right)$$

$$\rho \approx G^{-2} \quad \rightarrow \quad P = \exp\left(-\frac{3}{8}\right) = 0.687$$

“something” 2x as likely as “nothing”

The universe contains no memory of a creator



**The only possible
creator**



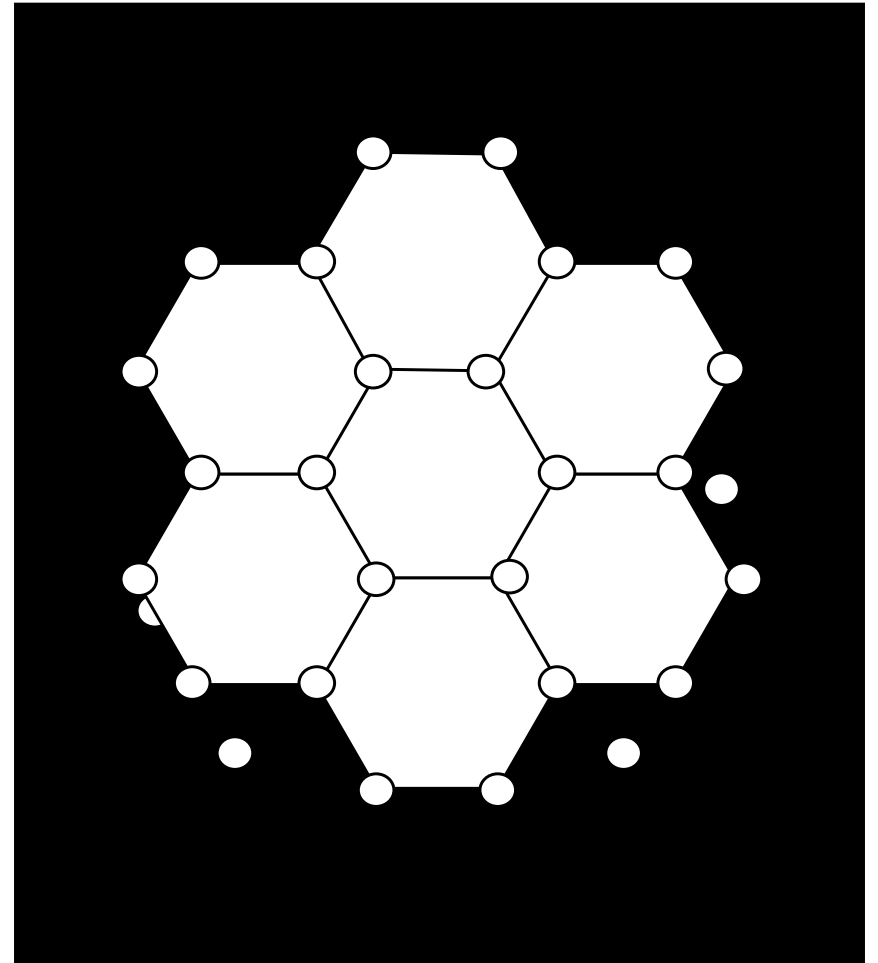
**Why is there something
rather than nothing?**

Why should "nothing" be
more natural than
"something"?

Symmetry and Stability

Symmetric systems tend to spontaneously undergo **phase transitions** to less symmetric systems in absence of energy.

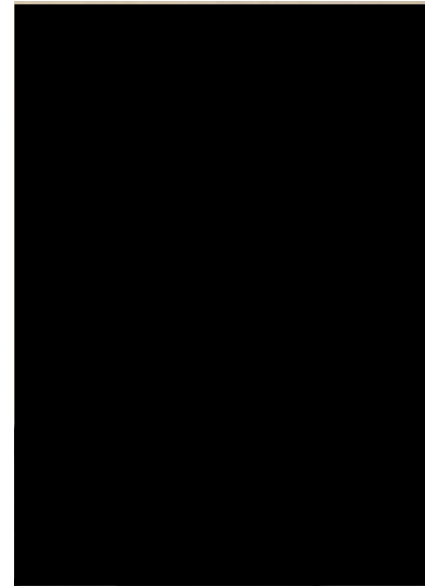
Nothing is more symmetric than **"nothing."**



"Nothing is unstable."

-Frank Wilczek

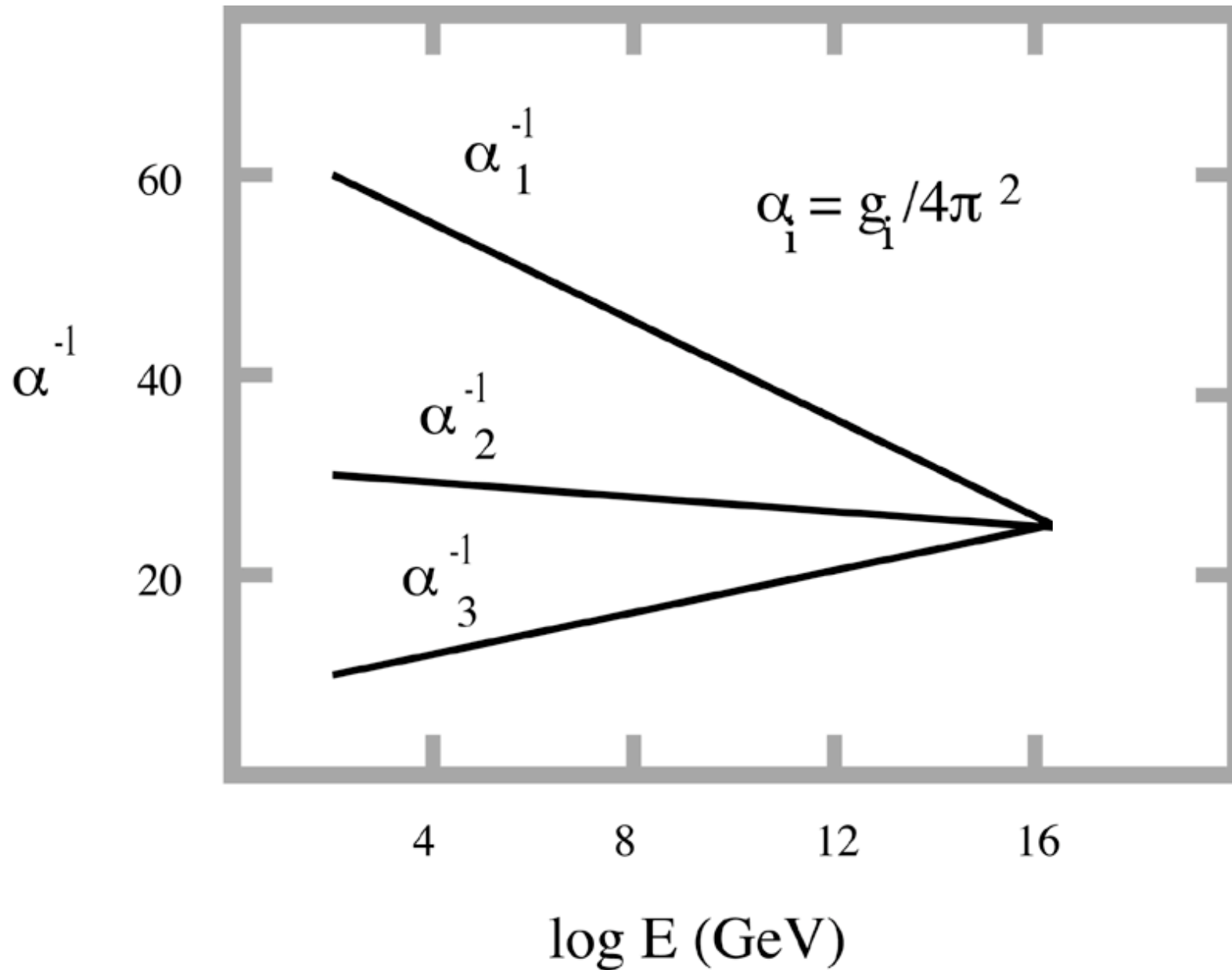
SciAm 1980



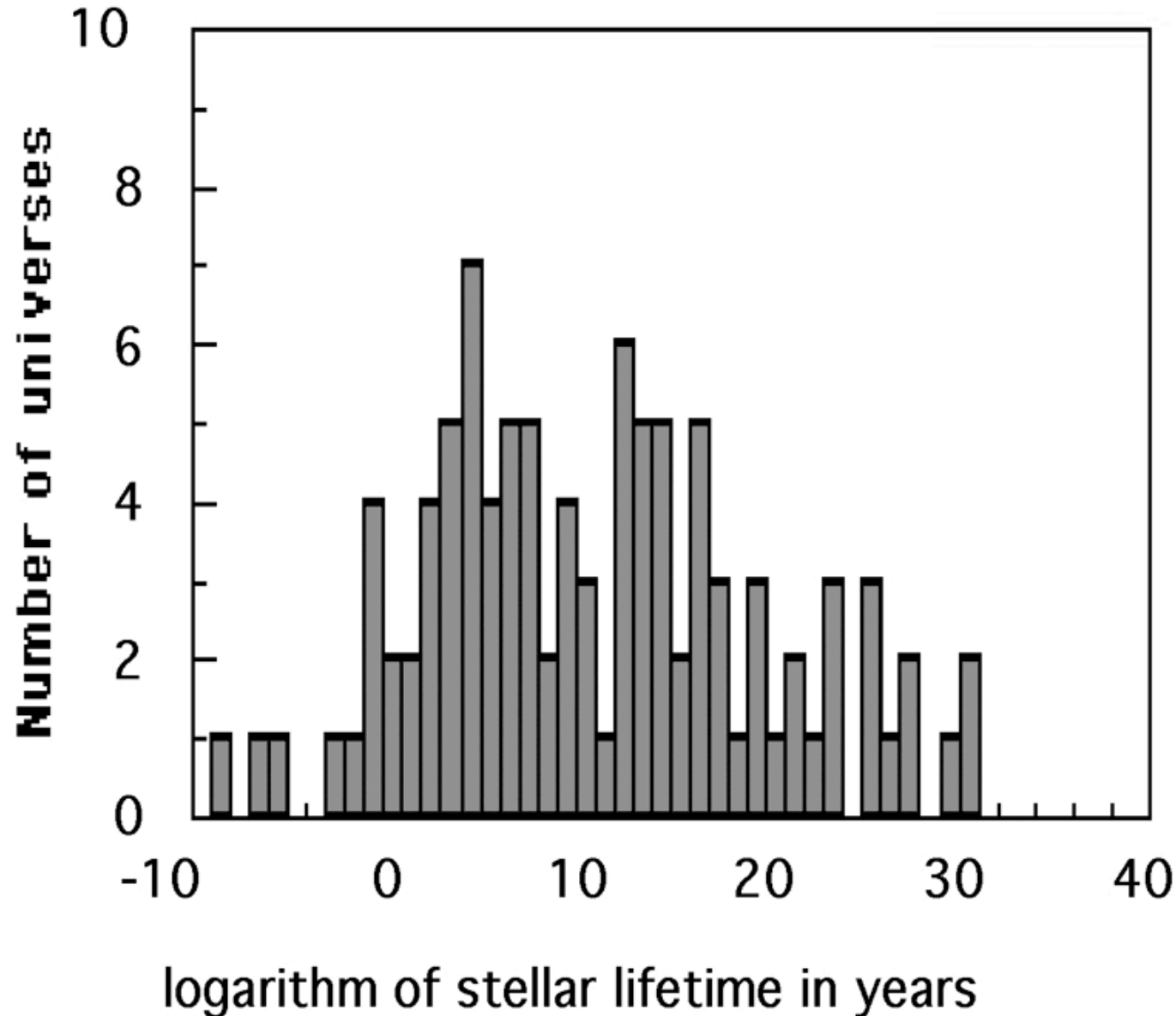
Fine-tuning?

- Other forms of life?
- Multiple universes?
- How estimate probabilities?
- Not all "constants" are constant.
- Not all that fine-tuned

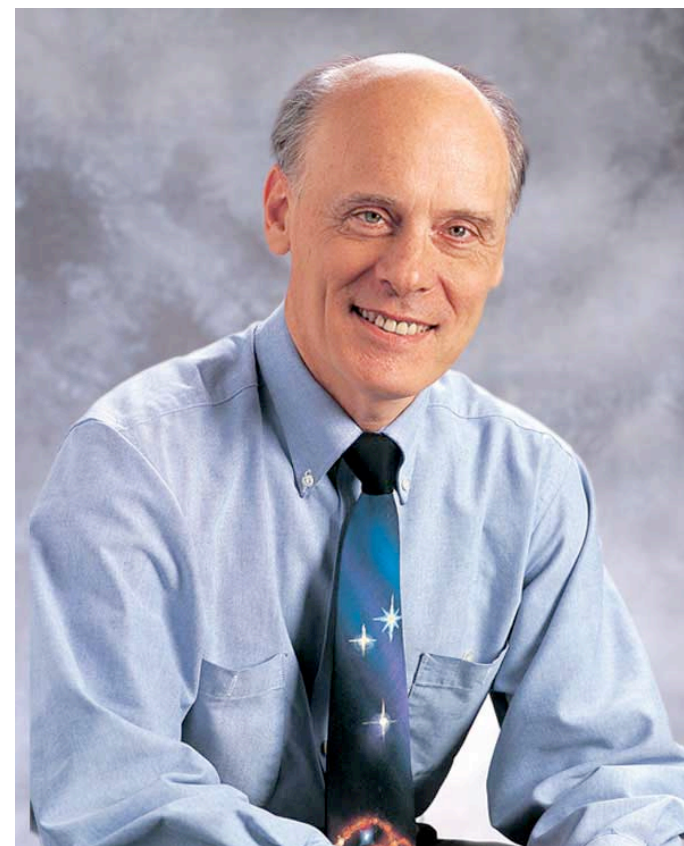
Variation of force strengths with energy (SUSYSM)



Vary α, m_e, m_p randomly over
10 orders of magnitude



For God so loved the human race that He went to the expense of building a hundred billion trillion stars and carefully shaped and crafted them for [fourteen] billion years so that at this brief moment in time we could all have a nice place to live.



--Hugh Ross

We no longer have any
need of a god to explain
what is no longer
mysterious.



--Christopher
Hitchens

Was the Universe Created?

NO