Origin of the Universe

The first puzzle

James Sinclair
REASONS TO BELIEVE

"In the beginning God created the Heavens and the Earth."

God, *Genesis 1:1*

"The cosmos is all that is, or was, or ever will be."

Sagan, *Cosmos 1:1*

Who is right?

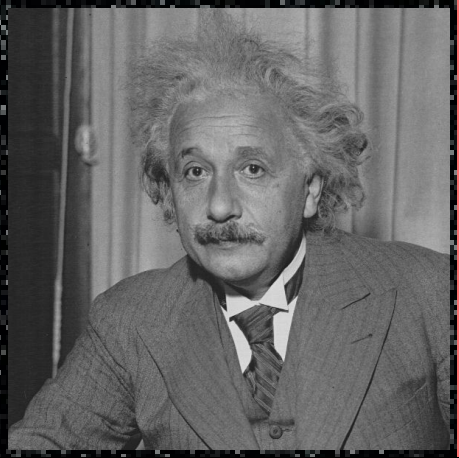
The Kalam Argument

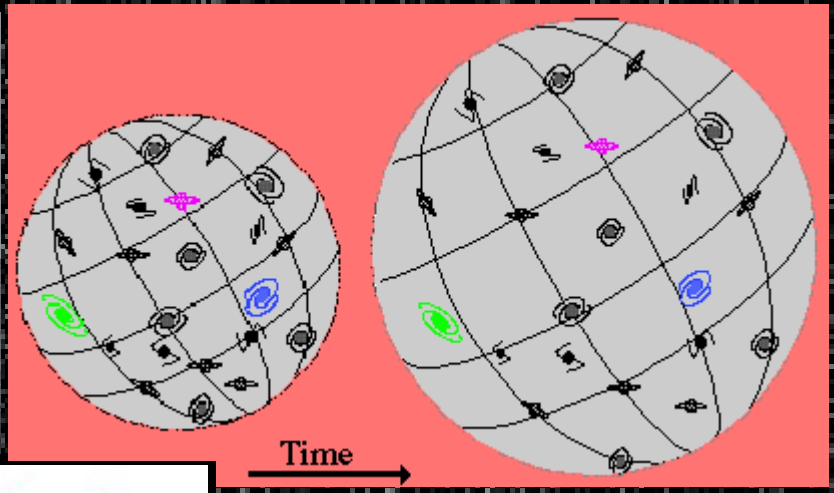
A. That Which Begins to Exist Has a Cause

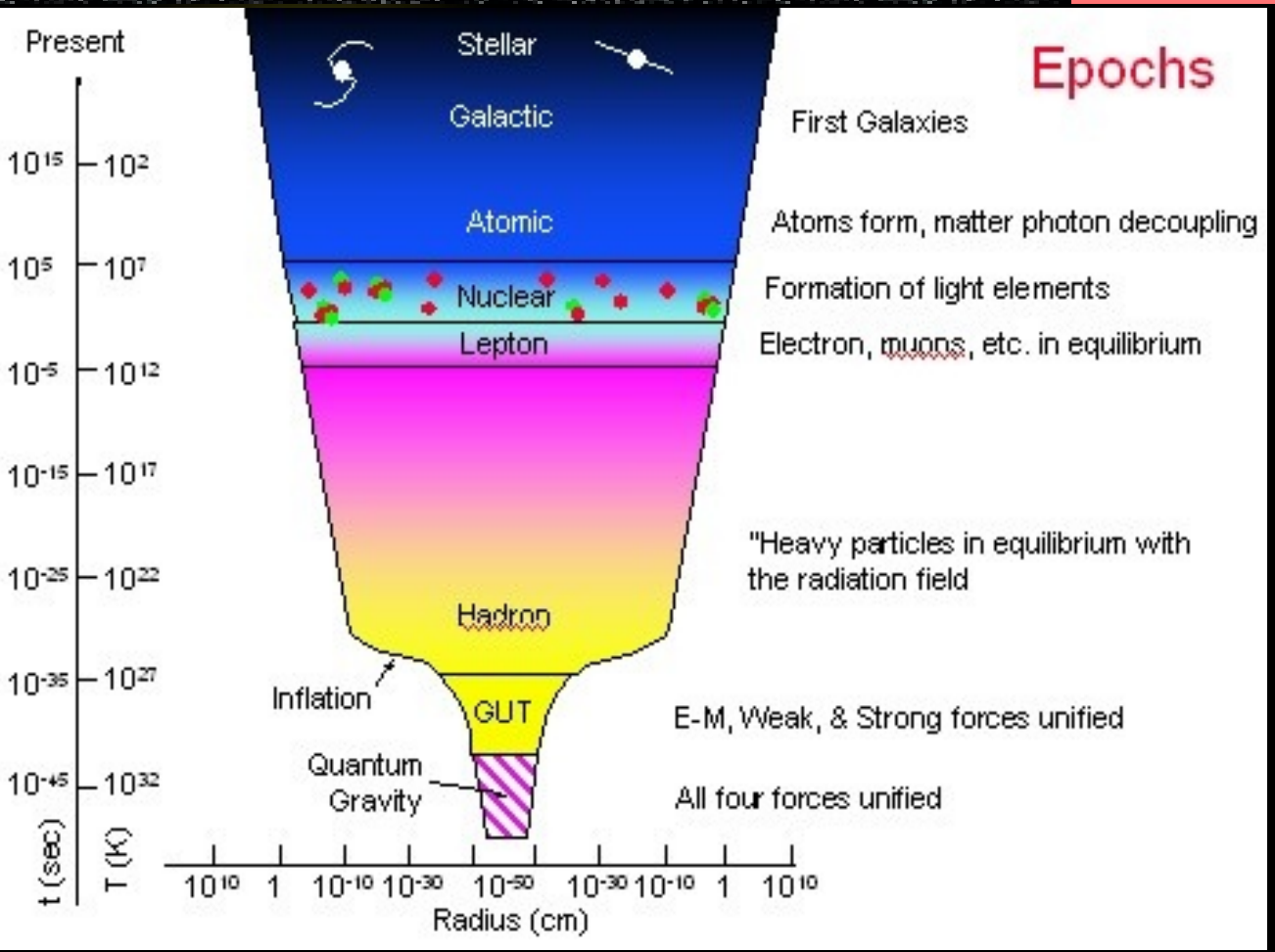
B. The Universe Began to Exist

C. Therefore, The Universe Has a Cause

Big Bang







A controlled and purposeful explosion that started the universe.

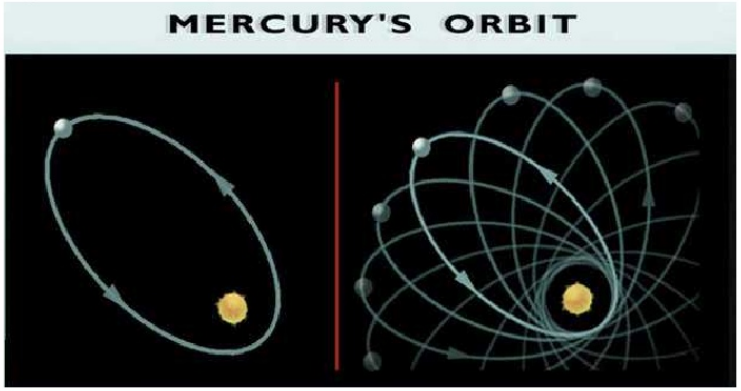
The universe expands everywhere, like dots painted on a balloon as it is being inflated.

Scientists now think the universe literally "inflated" early in its history, then settled down into a "leisurely" expansion.

Some Observational Tests

MERCURY's PRECESSION

The theory of General relativity was able to precisely account for the observed precession of Mercury's orbit.



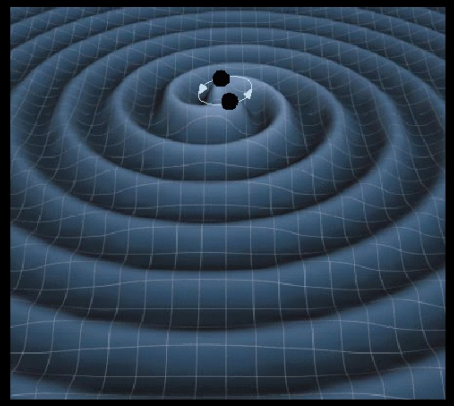
Newtonian gravity

General relativistic gravity

(amount of precession not on scale - artist's view of Mercury's precession)

[Image from www.gravitywarpdrive.com]

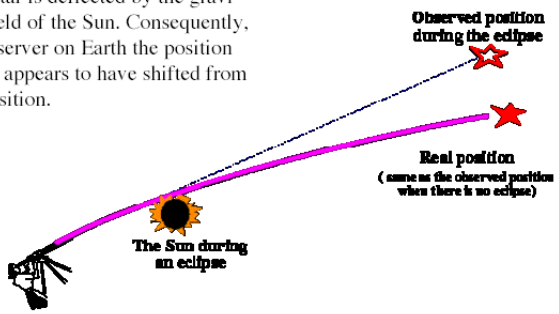
GRAVITATIONAL WAVES



[Image credit: K. Thorne & T. Carnahan]

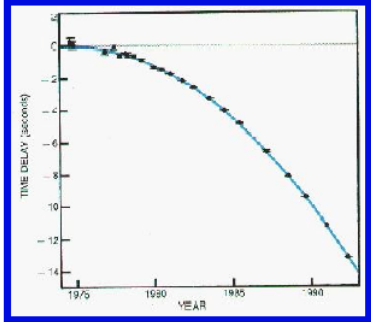
GRAVITATIONAL DEFLECTION OF LIGHT

During the eclipses, the beam of light from the star is deflected by the gravitational field of the Sun. Consequently, for the observer on Earth the position of the star appears to have shifted from its true position.



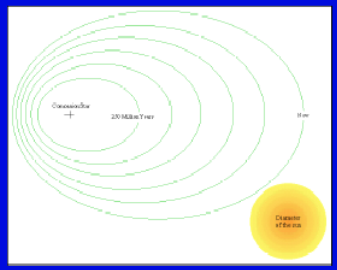
First observational test of the prediction of General Relativity

Hulse-Taylor binary pulsar: experimental confirmation of gravitational waves (it is an indirect detection)



The binary pulsar consists of two neutron stars revolving around each other. With high-precision pulse timing Hulse & Taylor were able to conclude that:

the orbit is shrinking



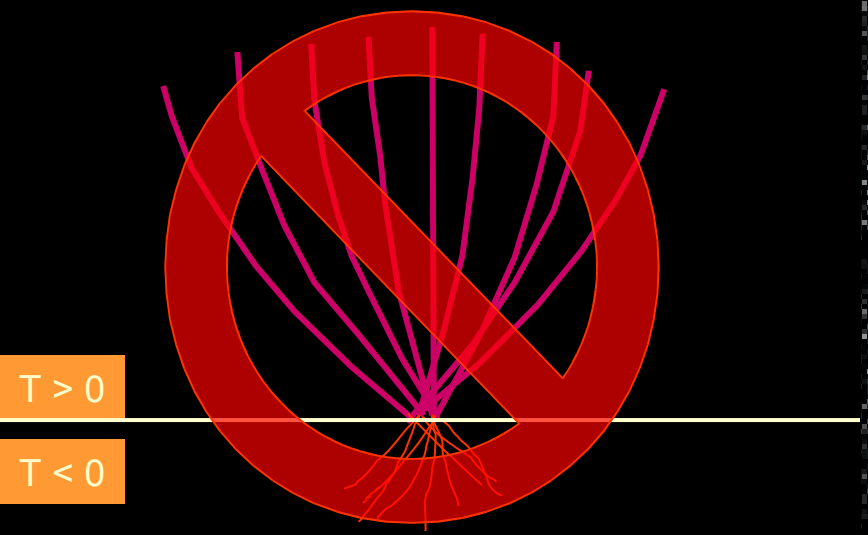
[from Weisberg, Taylor & Fowler 1981]

Shrinking → energy loss

Rate of energy loss found to be in precise agreement with predictions of General Relativity for energy loss due to gravitational wave emission

Singularity Theorems

Singularity Theorems show that the lifetime of components of the universe (like mass & light) cannot be extended into the infinite past. *Therefore the universe had a beginning.*



Ruled out by Hawking-Penrose Theorem if:

2) General Relativity is fundamental
3) Gravity is always attractive
4) No closed time loops

Ruled out by Borde-Vilenkin-Guth Theorem if:

Average expansion of universe greater than zero

Hawking-Penrose (1970)

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Printed in Great Britain

The singularities of gravitational collapse and cosmology

BY S. W. HAWKING
Institute of Theoretical Astronomy, University of Cambridge

AND R. PENROSE
Department of Mathematics, Birkbeck College, London

(*Communicated by H. Bondi, F.R.S.—Received* 30 *April* 1969)

A new theorem on space-time singularities is presented which largely incorporates and generalizes the previously known results. The theorem implies that space-time singularities are to be expected if *either* the universe is spatially closed *or* there is an 'object' undergoing relativistic gravitational collapse (existence of a trapped surface) *or* there is a point p whose past null cone encounters sufficient matter that the divergence of the null rays through p changes sign somewhere to the past of p (i.e. there is a minimum apparent solid angle, as viewed from p for small objects of given size). The theorem applies if the following four physical assumptions are made: (i) Einstein's equations hold (with zero or negative cosmological constant), (ii) the energy density is nowhere less than minus each principal pressure nor less than minus the sum of the three principal pressures (the 'energy condition'), (iii) there are no closed timelike curves, (iv) every timelike or null geodesic enters a region where the curvature is not specially aligned with the geodesic. (This last condition would hold in any sufficiently general physically realistic model.) In common with earlier results, timelike or null geodesic incompleteness is used here as the indication of the presence of space-time singularities. No assumption concerning existence of a global Cauchy hypersurface is required for the present theorem.

Borde-Guth-Vilenkin (2003)

MIT-CTP-3

Inflationary spacetimes are not past-complete

Arvind Borde,[1,2] Alan H. Guth,[1,3] and Alexander Vilenkin[1]
[1]*Institute of Cosmology, Department of Physics and Astronomy Tufts University, Medford, MA 02155, USA.*
[2]*Natural Sciences Division, Southampton College, NY 11968, USA.*
[3]*Center for Theoretical Physics, Laboratory for Nuclear Science and Department of Physics, Massachusetts Institute of Technology, Cambridge, MA 02139, USA.*
(Dated: January 11, 2003)

Many inflating spacetimes are likely to violate the weak energy condition, a key assumption of singularity theorems. Here we offer a simple kinematical argument, requiring no energy condition, that a cosmological model which is inflating – or just expanding sufficiently fast – must be incomplete in null and timelike past directions. Specifically, we obtain a bound on the integral of the Hubble parameter over a past-directed timelike or null geodesic. Thus inflationary models require physics other than inflation to describe the past boundary of the inflating region of spacetime.

PACS numbers: 98.80.Cq, 04.20.Dw

Summary

- The 'Kalam Argument' shows that if the universe began-to-exist, then it has an external cause (i.e. super-to-nature)
- The Christian truth claim suggests just such a *creation-ex-nihilo*, or "creation from nothing"
- Observational evidence suggests that our universe had just such a beginning
- Theoretical calculations suggest that the universe had just such a beginning

- Hence, the answer to the origin puzzle could well be that God created the universe