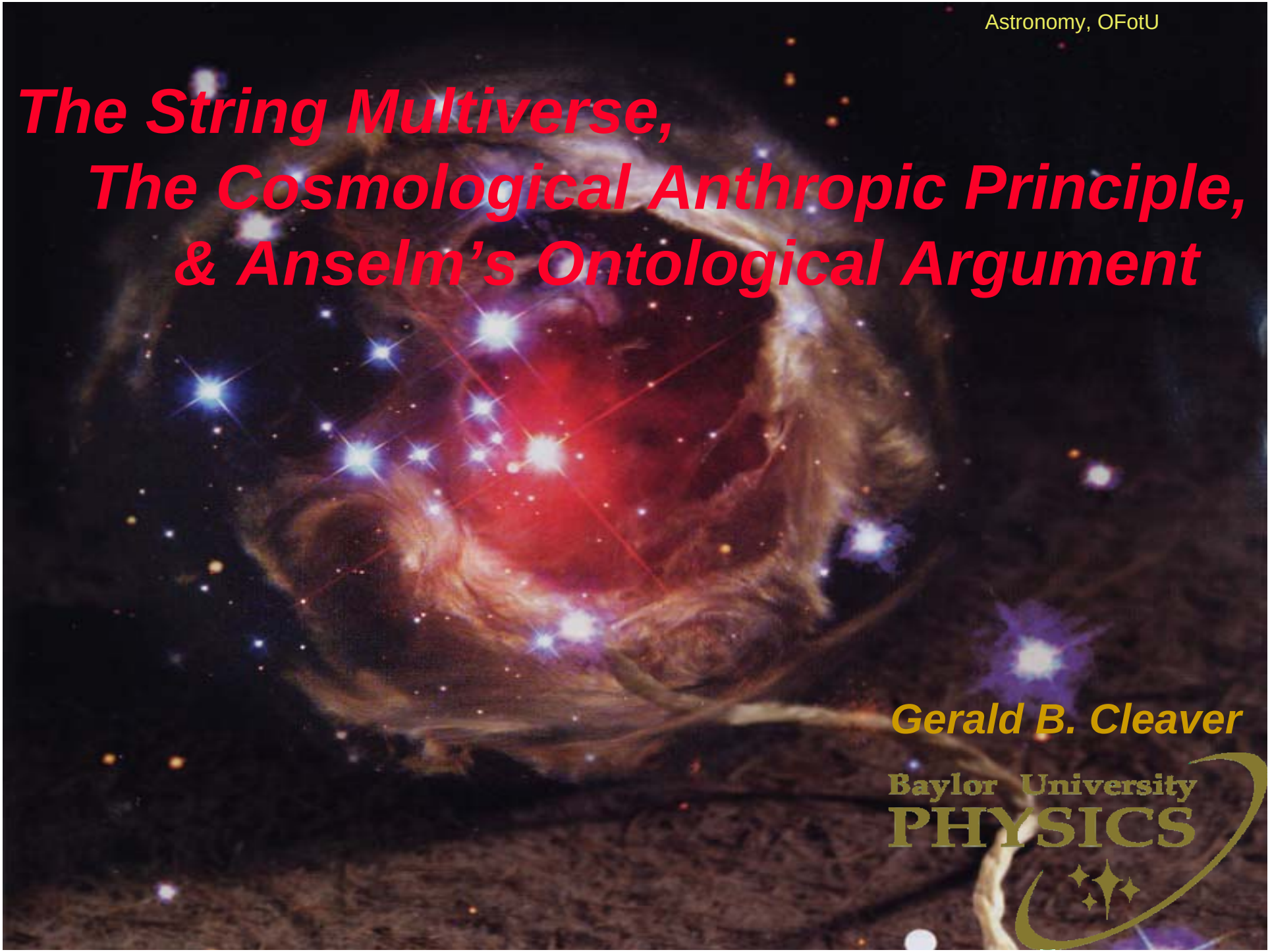

The String Multiverse, The Cosmological Anthropic Principle, & Anselm's Ontological Argument

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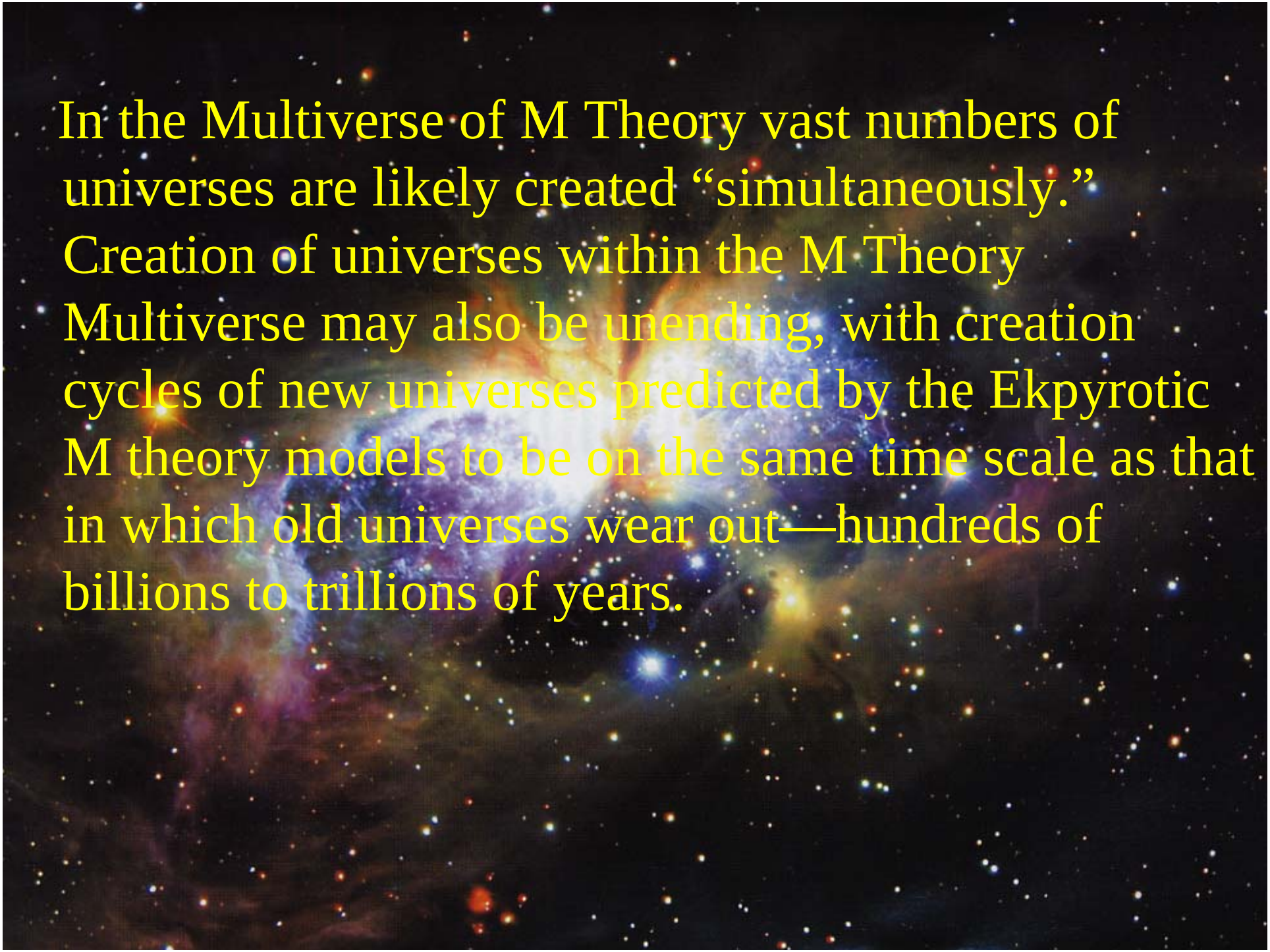
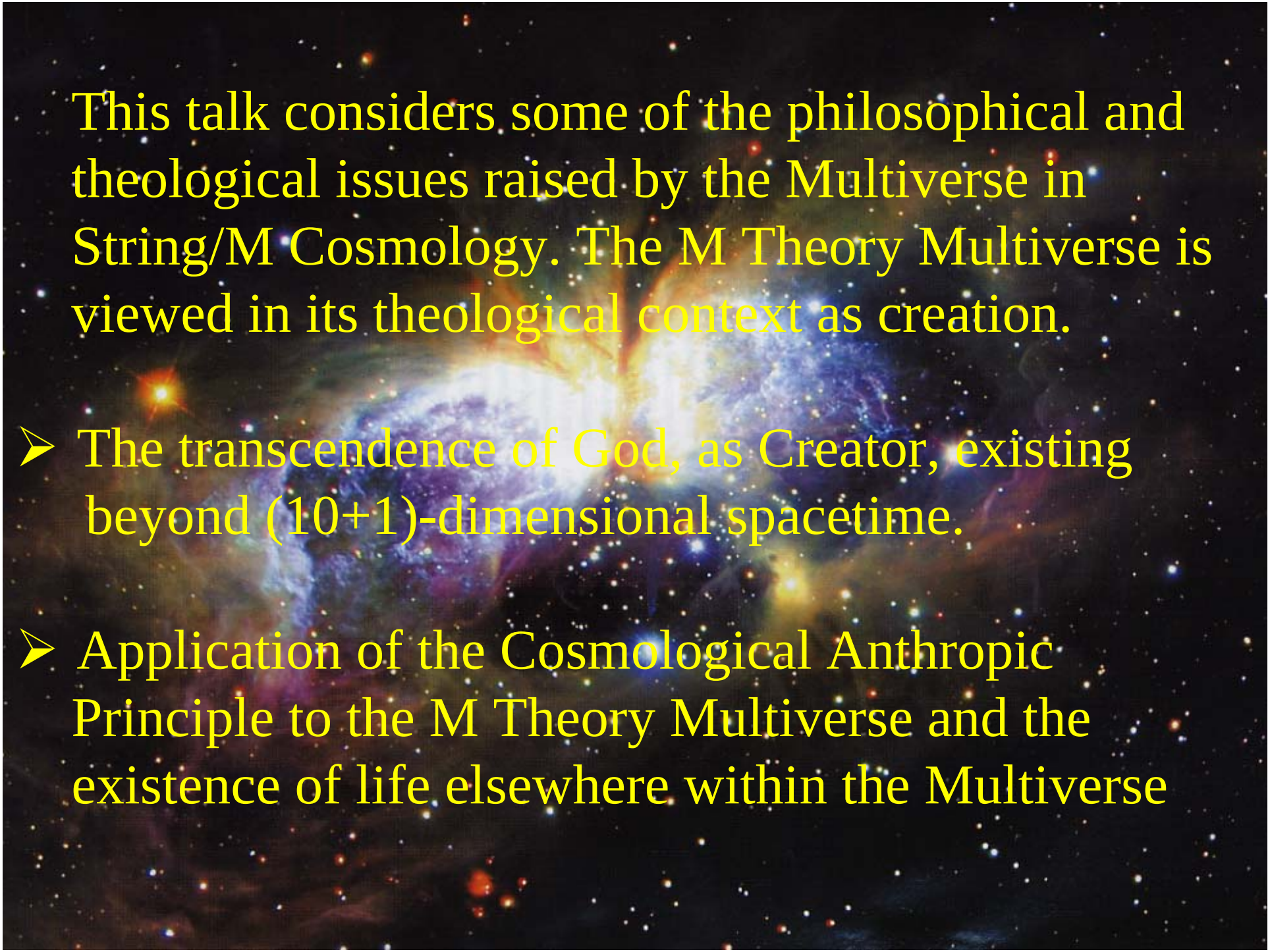
The transformation from a 9+1 dimensional reality of String Theory into a 10+1 dimensional reality of M-Theory has far more profound implications than did even the transformation from a 3+1 dimensional reality into a 9+1 dimensional reality of String Theory.

For while String Theory was consistent with the Univercentric paradigm, M Theory implies our universe is part of a reality far more vast, far more complex, far more beautiful. M Theory suggests a paradigm transformation to humankind's understanding of reality beyond anything conceived prior, a paradigm shift unparalleled.

M Theory implies the existence of a Multiverse that contains at least 10^{100} to 10^{1000} (often "averaged" in discussions to 10^{500}) universes within. Each universe is brought about by its own Big Bang/Inflation process and may contain vastly differing physical laws. The near-countless possibilities for universes is known as the string/M landscape. A significant percent of these universes may well provide for something similar to carbon-based life forms; others may provide for vastly different life forms.


In the Multiverse of M Theory vast numbers of universes are likely created “simultaneously.” Creation of universes within the M Theory Multiverse may also be unending, with creation cycles of new universes predicted by the Ekpyrotic M theory models to be on the same time scale as that in which old universes wear out—hundreds of billions to trillions of years.



This talk considers some of the philosophical and theological issues raised by the Multiverse in String/M Cosmology. The M Theory Multiverse is viewed in its theological context as creation.

- The transcendence of God, as Creator, existing beyond (10+1)-dimensional spacetime.
- Application of the Cosmological Anthropic Principle to the M Theory Multiverse and the existence of life elsewhere within the Multiverse

- The bulk universe is compared to St. Augustine's concept of the block universe and the related implications for our understanding of the transcendence and imminence of God. Connected to this, issues that the M Theory Multiverse raises for process theology are examined.

- Application of Anselm's Ontological Argument will be applied to the understanding of God as Creator from the Multiverse paradigm and the Multiverse paradigm as something we should expect of a God of infinitudes

String Landscape

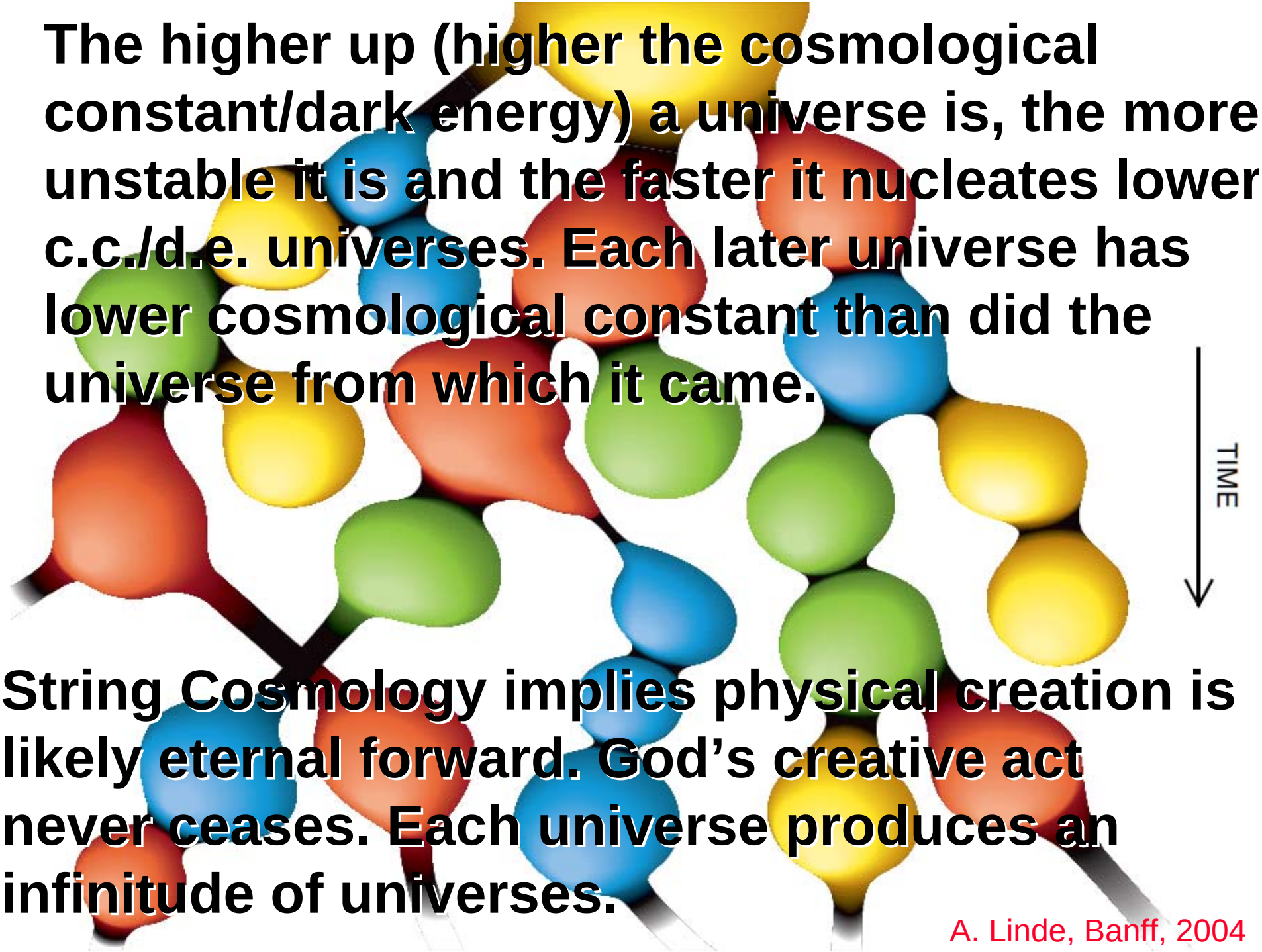
~ 10^{12} x $10^{100\ \text{to}\ 1000}$ Models in M-Theory

String Landscape

Anthropic Principle of String Theory

10^{-119} is upper bound on dark energy/cosmological constant (cc) if galaxies are to form (Weinberg, 1987)

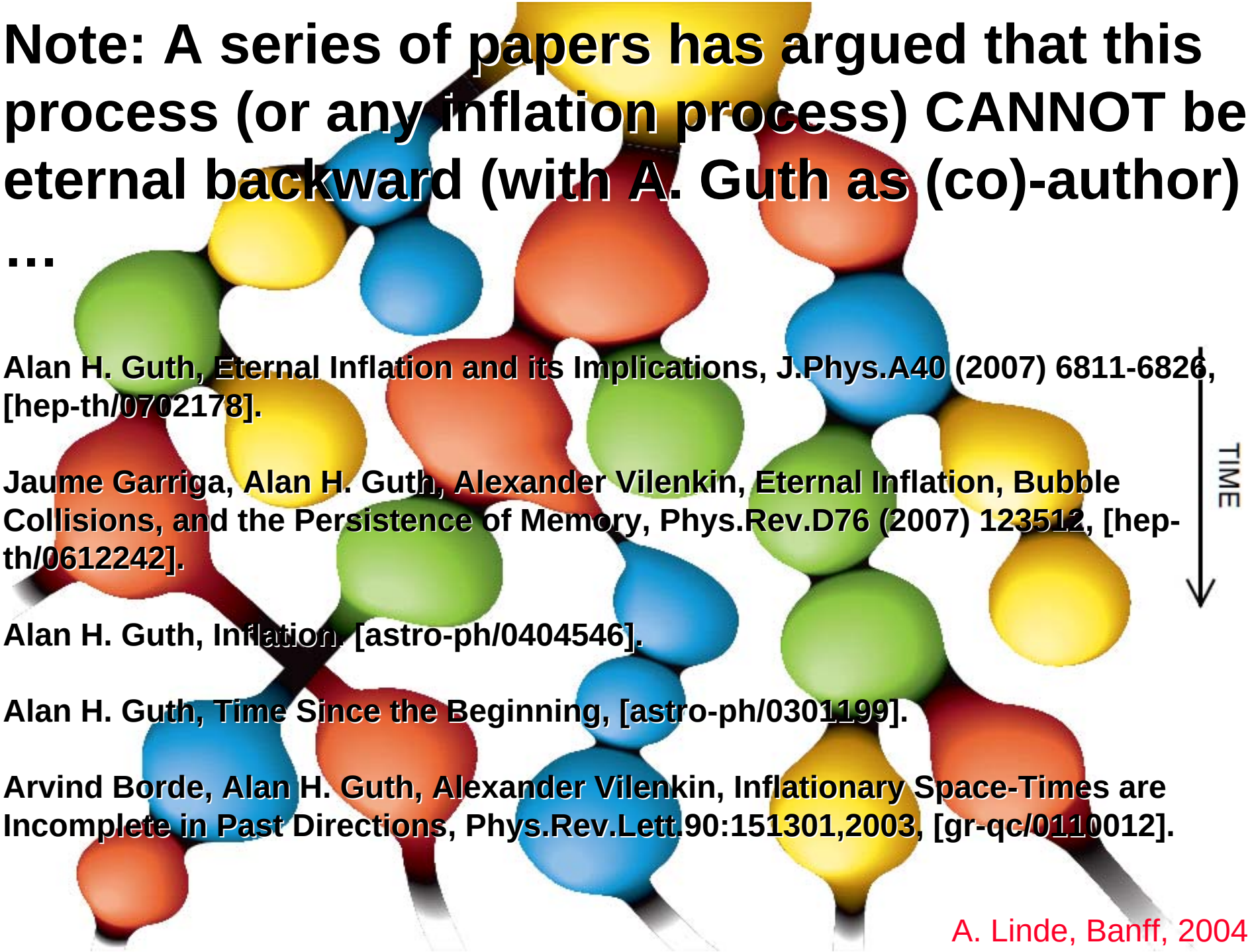
The higher up (higher the cosmological constant/dark energy) a universe is, the more unstable it is and the faster it nucleates lower c.c./d.e. universes. Each later universe has lower cosmological constant than did the universe from which it came.



String Cosmology implies physical creation is likely eternal forward. God's creative act never ceases. Each universe produces an infinitude of universes.

A. Linde, Banff, 2004

Note: A series of papers has argued that this process (or any inflation process) CANNOT be eternal backward (with A. Guth as (co)-author) …



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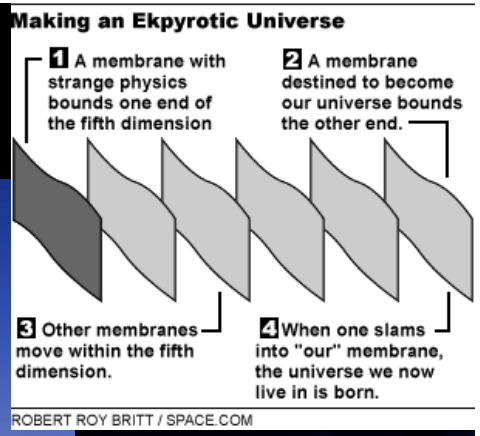
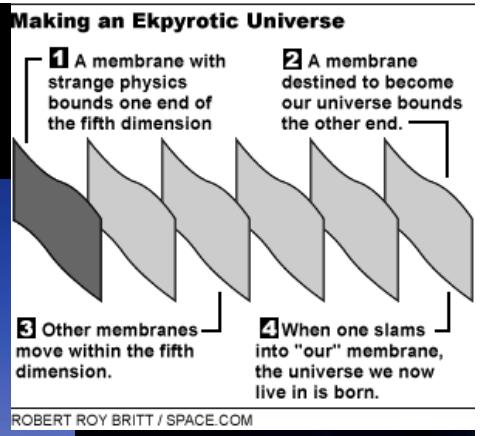
A. Linde, Banff, 2004

Multiverse

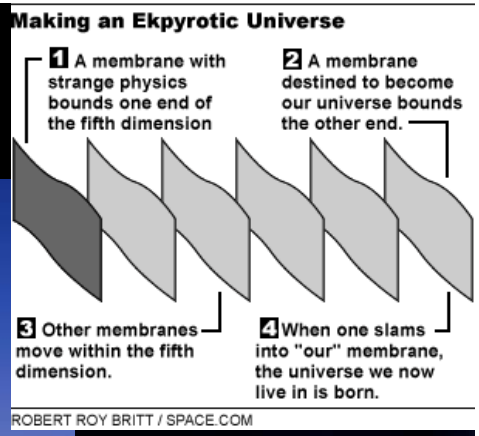

Making an Ekpyrotic Universe
1 A membrane with strange physics bounds one end of the fifth dimension
2 A membrane destined to become our universe bounds the other end.
3 Other membranes move within the fifth dimension.
4 When one slams into "our" membrane, the universe we now live in is born.
ROBERT ROY BRITT / SPACE.COM

Multiverse



Within the multiverse, the independence of times in the respective universes pose problems for process theology

Multiverse

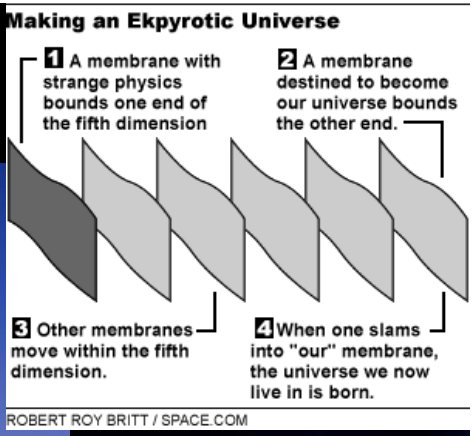


Necessitates Augustine's Block Universe view:

God beyond all creation-beyond of all spacetimes.

Histories of all spacetimes appear as a moment in the frame of the Creator

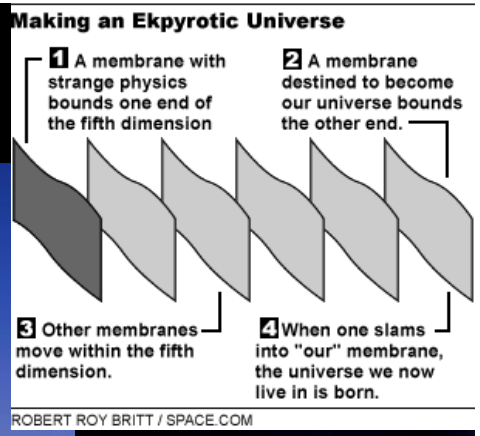
Multiverse



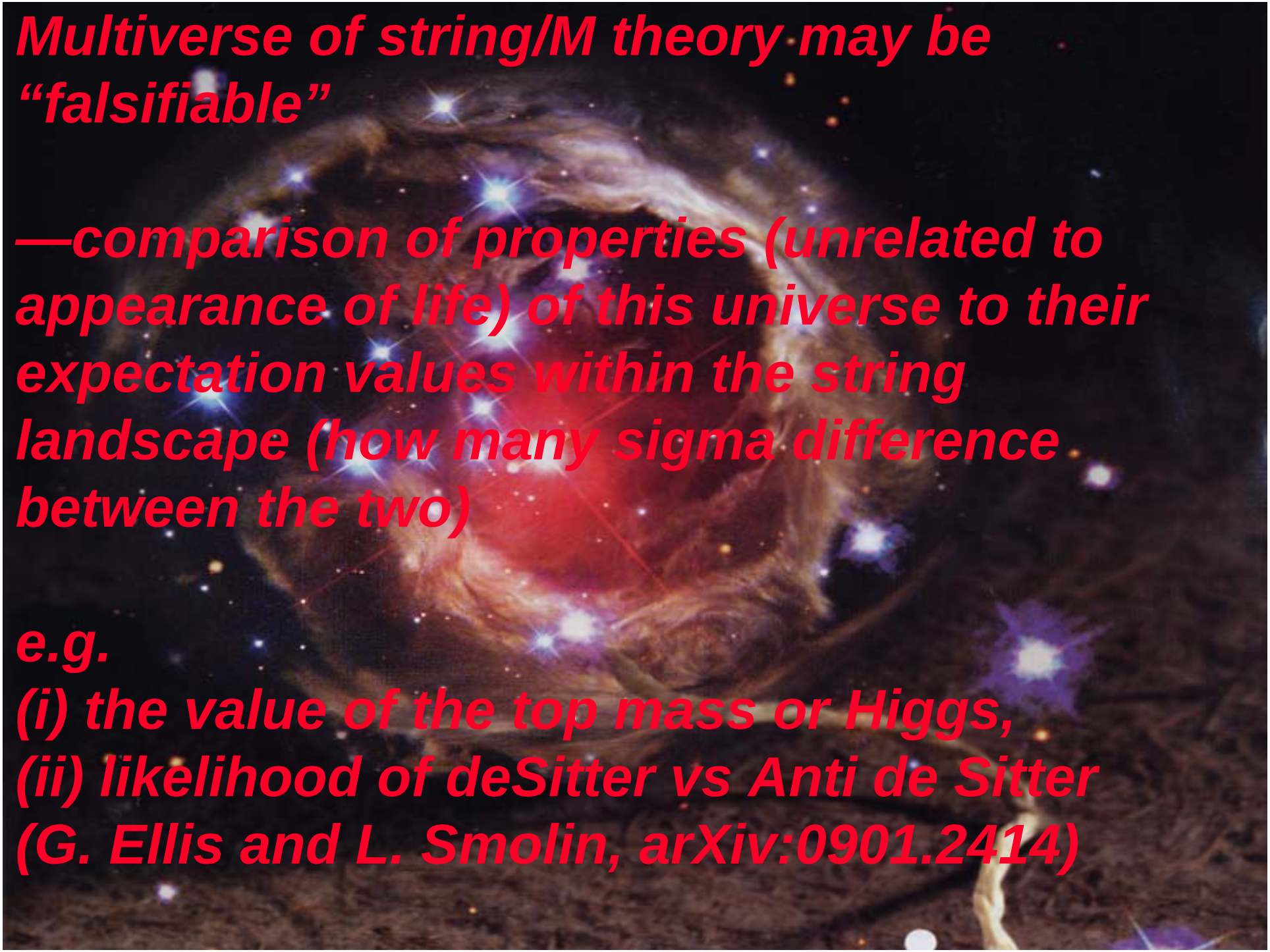
Anselm's Ontological Argument:

God is that than which nothing greater can be conceived. (*Proslogion*, Chap. 2, c. ~ 1100 A.D.)

Multiverse



If we can imagine God creating on this scale, Anselm's Ontological Argument would suggest God's creative act is at least this grand, if it is of the nature of God to create



Multiverse of string/M theory may be "falsifiable"

—comparison of properties (unrelated to appearance of life) of this universe to their expectation values within the string landscape (how many sigma difference between the two)

e.g.
(i) the value of the top mass or Higgs,
(ii) likelihood of deSitter vs Anti de Sitter
(G. Ellis and L. Smolin, arXiv:0901.2414)

Examination of the State of the Universe from Anthropic Principle and Fine Tuning

Weak Anthropic Principle (WAP): *"The observed values of all physical and cosmological quantities are not equally probable but they take on values restricted by the requirement that there exist sites where carbon-based life can evolve and by the requirements that the Universe be old enough for it to have already done so."* (Barrow and Tipler 1986: 16).

> The Merriam-Webster dictionary defines WAP as *conditions that are observed in the universe must allow the observer to exist.*

Strong Anthropic Principle (SAP): "The Universe must have those properties which allow life to develop within it at some stage in its history."
(Barrow and Tipler 1986).

Barrow and Tipler then proposed three (overlapping) elaborations of the SAP:

(i) "*There exists one possible Universe* 'designed' *with the goal of generating and sustaining* 'observers.' "

This implies that the purpose of the universe is to give rise to intelligent life, with the laws of nature and their fundamental constants set to ensure that life as we know it will emerge and evolve. Fine tuning of constants in nature result as necessities for life.

(ii) "*Observers are necessary to bring the Universe into being*."

Barrow and Tipler believe that this can be validly inferred from quantum mechanics.

(iii) "*An ensemble of other different universes is necessary for the existence of our Universe*."

This interpretation sympathizes with the many worlds interpretation of quantum mechanics. We will see a possible reemergence of this in string/M theory

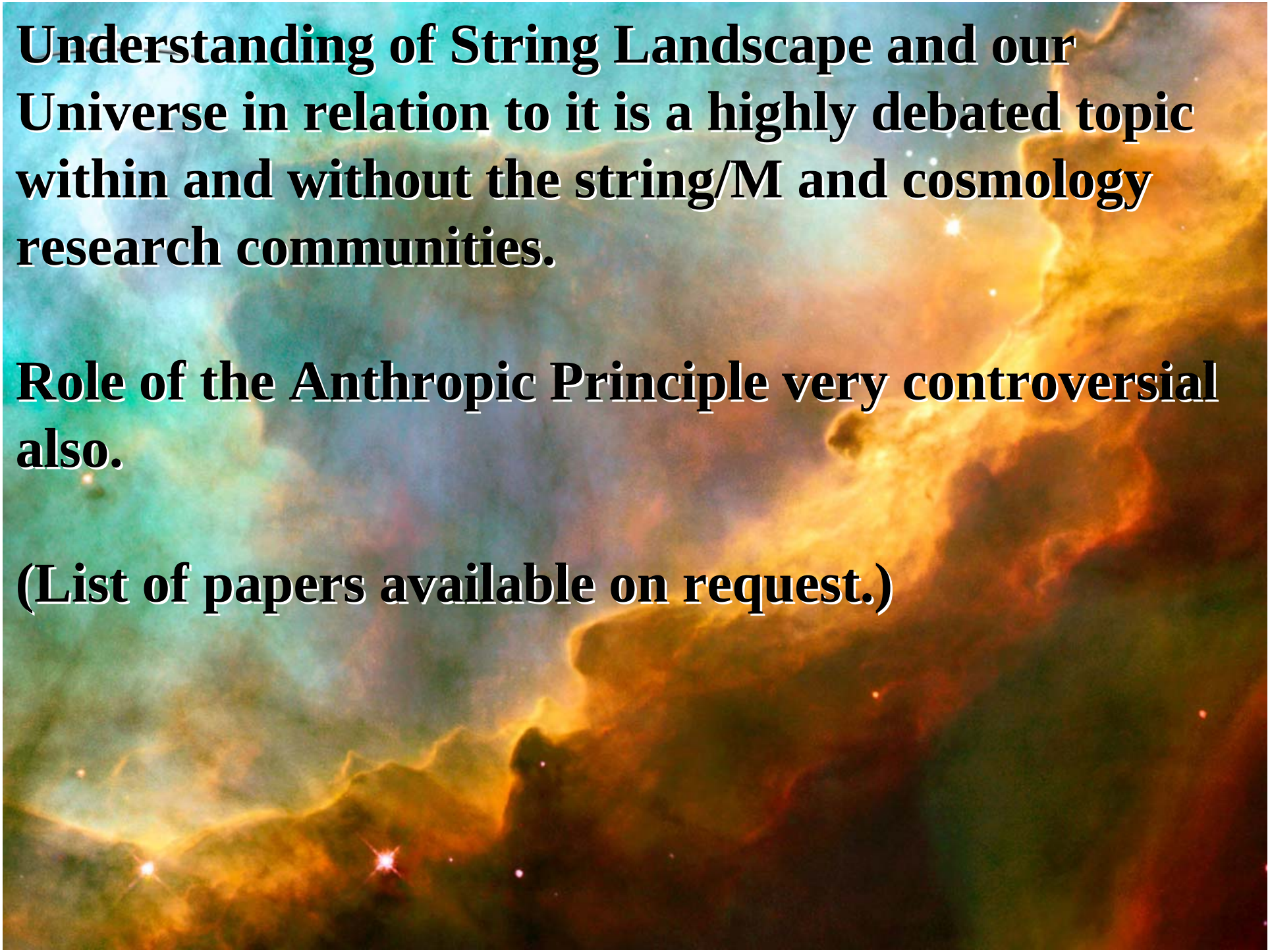
Fine-Tuning: The premise of the fine-tuned universe assertion is that any small change in the twenty or so physical constants would make the universe radically different and therefore, unsuitable for life:

If, for example, the electron's charge were slightly different, or if the strong nuclear force were only 2% stronger, di-protons would be stable and hydrogen would fuse too easily, making stars as we know them impossible and prevent the universe from developing life as we know it.

Or, if the cosmological constant had been greater than it is by a factor of 10, the universe would have expanded too fast for galaxies to ever form.

(allowed range is -10^{-119} to $+ 10^{-119} M_{PL}{}^{4}$)

But fine-tuning may only be a local issue—local with regard to a specific class of life Vastly differing life forms (consider angels) may exist under vastly differing physical laws and/or physics constants.



Understanding of String Landscape and our Universe in relation to it is a highly debated topic within and without the string/M and cosmology research communities.

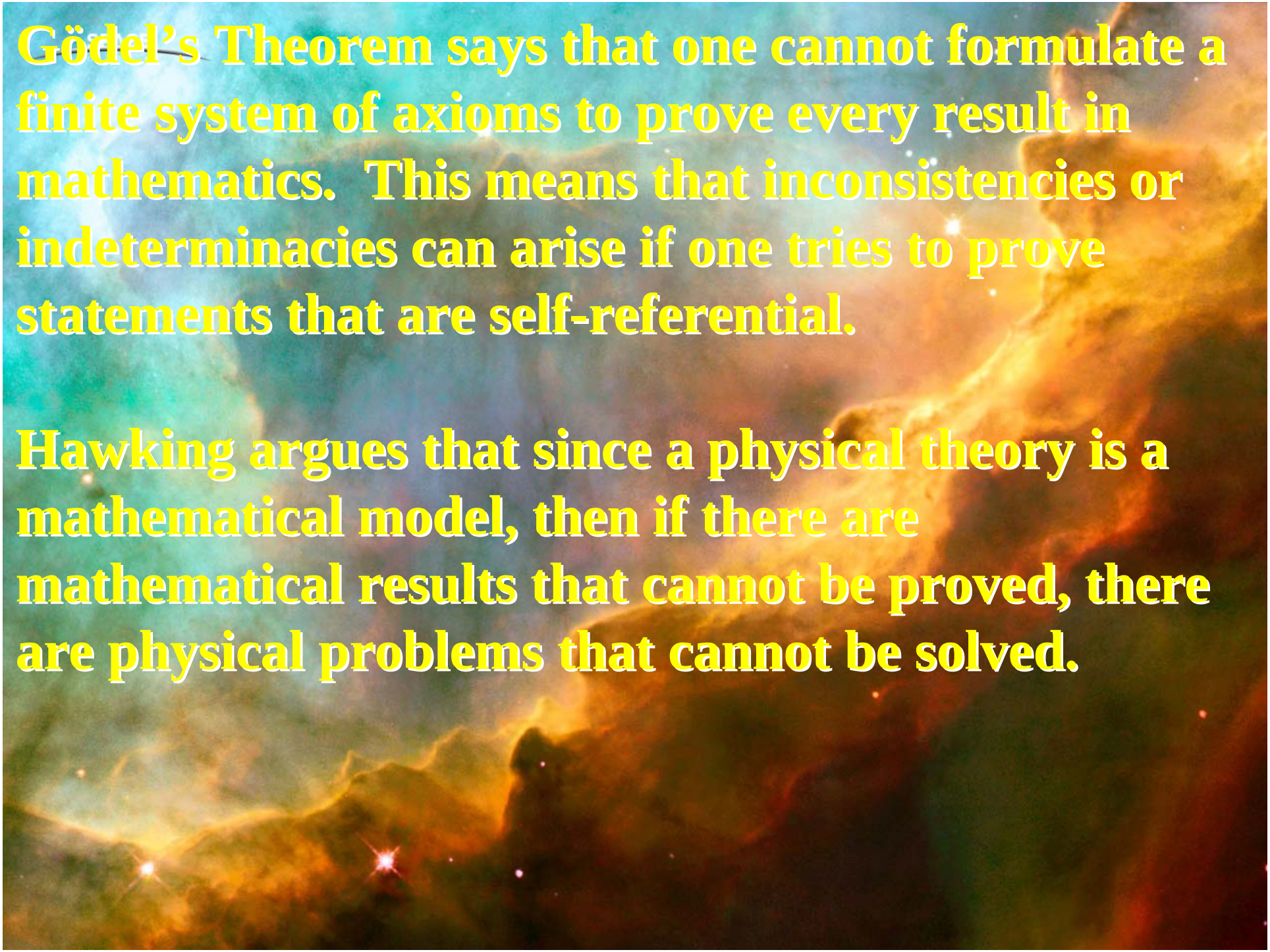
Role of the Anthropic Principle very controversial also.

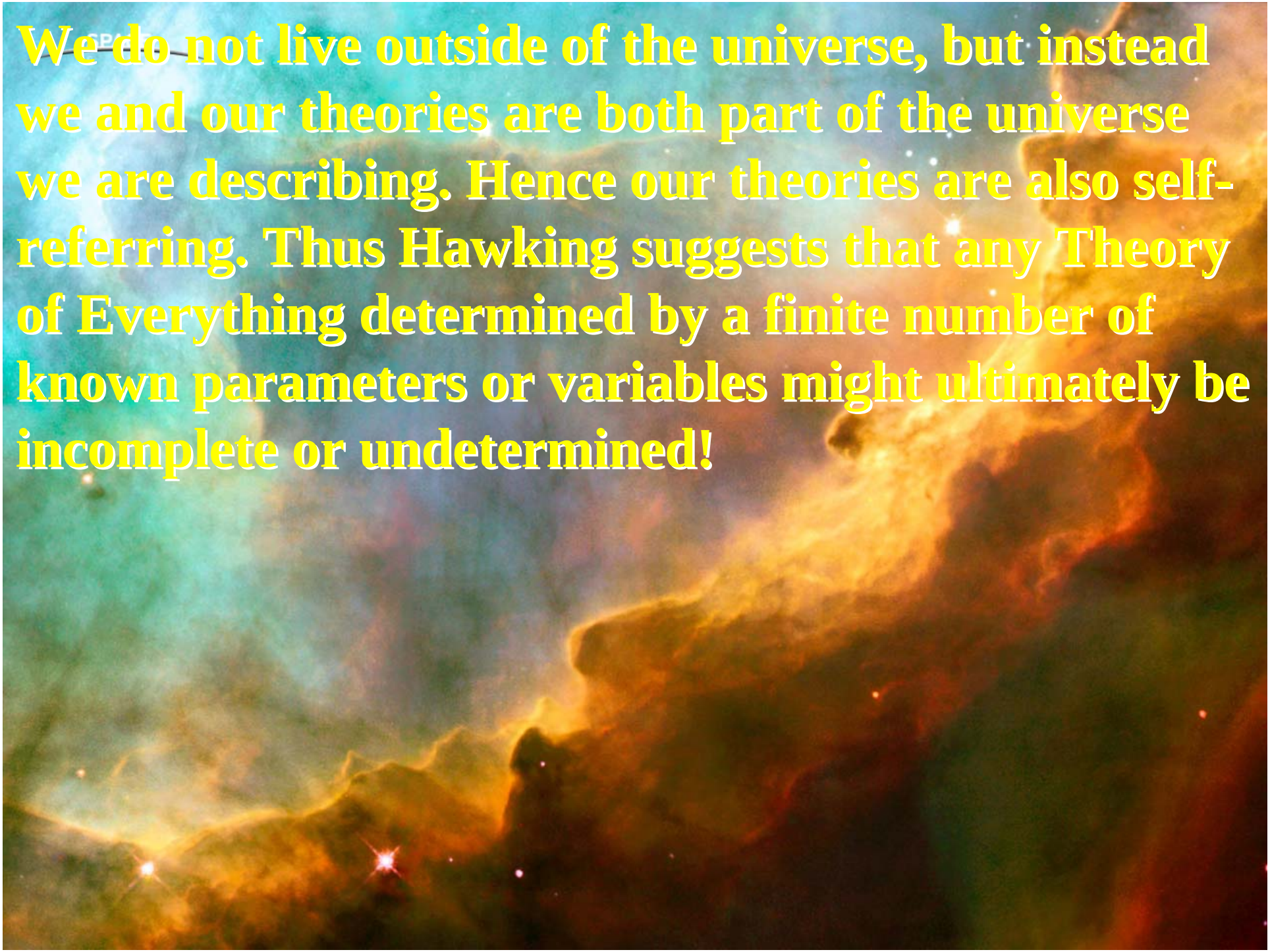
(List of papers available on request.)

Intriguing thought to leave you all with:

String/M-Theory as presently understood has a large parameter space of variables defining the geometry and topology of the compact directions and "fluxes". Given string/M theory is correct, can we ever determine the exact location of our universe on the string landscape?

Many believe "yes", but some scientists (e.g. Stephen Hawking) are suspicious that determination of a particular choice of ALL of the M-Theory parameters might not be totally determinable, based on Gödel's Theorem.


Gödel's Theorem says that one cannot formulate a finite system of axioms to prove every result in mathematics. This means that inconsistencies or indeterminacies can arise if one tries to prove statements that are self-referential.
Hawking argues that since a physical theory is a mathematical model, then if there are mathematical results that cannot be proved, there are physical problems that cannot be solved.


We do not live outside of the universe, but instead we and our theories are both part of the universe we are describing. Hence our theories are also self-referring. Thus Hawking suggests that any Theory of Everything determined by a finite number of known parameters or variables might ultimately be incomplete or undetermined!

Multiverse of String Cosmology

- Next step in our perception of reality? Now undergoing this Paradigm shift.
- Provides much deeper understanding of the whole story of creation, with a simplicity, order, and beauty and complexity to creation never before imagined.
- Has implications for theological views of God regarding meaning of transcendence & imminence
  - Poses problems to process theology concept of God evolving with and within a universe.
  - Suggests expanded view of Augustine's block universe.

Max Tegmark's Taxonomy of Universes:

Level 1: Beyond our cosmological horizon
Same physical laws and physical constants,
But differing initial conditions

Level II: Universes with different physical constants (or laws) resulting from symmetry breaking
From Chaotic Inflation,
(From M-theory Multiverse Brane Collisions)

Level III: Many worlds interpretation of QM (different histories)
Everett's many-world's interpretation of QM

Level IV Ultimate Ensemble: All Mathematical Structures

Max Tegmark's Taxonomy of Universes:

Level IV: Ultimate Ensemble (corresponding to any consistent mathematical structure)
This level considers equally real all universe that can be defined by mathematical structures. This class truly forms multiverse of everything.

QM & QM-String/M Theory based universes just two examples.

Lower levels embedded in this level. Any meaning to this level?