Cosmological Physics Ground Rules and How to Evaluate Cosmology Ideas

Abstract

This paper is a simple reminder for cosmology enthusiasts of the bright line separating the laws of physics from science fiction. It provides some tools: rules, guidelines and a definition of space useful for examining cosmology science claims and concepts. It explains the stringent thresholds for an idea before it can accurately be called a scientific theory or hypothesis; and who bears the burden of proof for a theory.

These simple tools provide solid ground so you may more easily examine cosmology claims to help make up your own mind which side of the science / science fiction line a specific claim belongs on.

Introduction

"I think we can safely say that nobody understands quantum mechanics." – Richard Feynman[1]

We do not fully understand our breathtaking universe. The "standard models" in use admittedly do not correctly explain dynamics for the largest phenomena: filaments, voids, bubbles, and Lyman alpha blobs, or the tiniest: quark sized particles[2]. Yet there are some perfectly nice, serious and brilliant cosmologists who react with alarm or pity when anyone suggests the leading cosmology model may have even the most trivial problems.

Such confidence, however, is not shared by Big Bang's most cited proponent, Princeton's P. J. Peebles, who writes "***It is sensible and prudent that people should continue to think about alternatives to the standard model* [Big Bang], *because the evidence is not all that abundant*."** [3]

Science or Science Fiction?

Unlike in politics, we cannot repeal or bend laws of physics for our own benefit. It is not reasonable to abandon centuries of painstakingly won knowledge of process and facts to embrace a forum where science fiction claims a grasp on reality as well as careful, rigorous science observations; where astrology is just as valid as astronomy. We have and use the scientific method because so many vital decisions for our species' cultures demand reliability to understanding our natural world.

So, when someone needs to "adjust" or "fine tune" a law of physics to support an interesting idea *without solid evidence* that's fine. But they need to clearly concede they have left the field of science.

It does not matter whether a claim comes from your local psychic or Newton, when one departs from unambiguously defined, measurable and repeatable science, they have entered the field of science fiction where any "theory" is valid including perpetual motion, wormholes, warp drive, or time travel.

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[1] Richard Feynman won the Physics Nobel Prize for Quantum Chromodynamics

[2] The Character of Physical Law, 1965

[3] Principles of Physical Cosmology, 1993, pg. 226. Note Peebles does not refer to Big Bang as a "theory."

Cosmological Physics Ground Rules

When I watch someone forcing a jigsaw puzzle piece where it does not fit, I feel cognitive discord. I experience the same discomfort when the term "theory" is applied to a concept which conflicts with the scientific method or basic physics. To help start from solid ground I have assembled a subset, or ground rules, of the scientific method and laws of physics which I find most useful for cosmology.

1) Science confines itself to claims which are fully defined[4], unambiguous, testable, measurable and repeatable.
2) Extraordinary Claims require Extraordinary Proof. (T. Jefferson, C. Sagan)[5]
3) All four fundamental forces, including gravity, have always existed and do not vary over time. (Then why do I seem to get heavier?)
4) Laws of conservation of mass and energy hold. Mass or energy may be converted but none is created, no matter (no pun intended) what miniscule uncertainty may exist.
5) All physics laws, including gravity, conservation of mass and energy, Newton's laws of motion[6], and thermodynamics must be assumed to operate the same in all places, at all distances, at all scales and at all times.
6) All events have causes. No causality violations like time travel are allowed.
7) There is no evidence of any more than one time and three spatial dimensions.
8) Neither light nor matter can travel faster than the speed of radiation in a vacuum. Matter cannot travel as fast as the speed of radiation.
9) There is no Anthropic principle; that we are at the center of the universe. It is too much of a coincidence that we would exist at a special location or time in the physical Universe.
10) Only one measurement is valid for a specific phenomena at a given time.

Cosmological Physics Critera

Does it have any ambiguous claims?

In everyday life anyone can call any idea a "theory," but in science, particularly physics, the use of that term is strictly limited. Before we can claim an idea is a scientific "theory" or merely a "hypothesis" we must make sure it has no, or nearly zero, ambiguity. Any word, term or phrase that can be construed in more than one way is ambiguous.

For example, is this a scientific claim?
"*My car is better than your car*!"

[4] A perpetual motion machine can be defined, is testable and falsifiable (and so far they have failed all tests). However, the assertion "Perpetual Motion machines are bad" is not unambiguously defined, so is not testable or falsifiable denying it the status of a scientific claim - it is merely an opinion.

[5] Not strictly true. All claims require roughly equal proof, but claims without evidence (e.g. dark matter, Higgs bosons, inflation, gravity waves, strings) demand greater scr utiny.

[6] Including amendments for relativity theory and observations.

No, because the word "better" can have a myriad of different and even conflicting meanings.

How about -- *"My car is faster than your car."*

That's better, but no, because there are different kinds of "fast" e.g. top speed, acceleration, and speed around a corner.

One nearly unambiguous claim could be *"My Ferrari 250 GTO can accelerate faster from 20 to 60 mph in a straight line than your Toyota minivan on the dry level pavement at California's "Fremont Dragstrip."*

Burden of Proof on Claimant

When I create a hypothesis to describe a natural phenomena, the burden of proof is on me to fully and unambiguously define my theory and my terms, to present evidence supporting my claim and to accurately describe the strengths and weaknesses of that evidence. I should also be able to describe what evidence would undermine my theory. For extra credit I should clearly explain the problems with my theory and what kinds of evidence might invalidate it.

So, the burden of proof for Big Bang defenders is on them. It is their responsibility to explicitly define their terms, explain and quantify their idea in enough detail to have it tested, and to describe the strengths and weaknesses of their evidence. It is not a skeptic's burden to question moving targets or shadows.

A related serious problem with the "Big Bang" claim is that there is no agreed upon definition or one central repository for its definition. This allows each Big Bang supporter to define the idea, however subtly or dramatically, differently.

It would be a big improvement to Big Bang's credibility to have one official place where its definition is kept, similar to how NIST is used for measurements. [7]

Cosmological Physics Guidelines

Observed or merely Ether?

Whenever a cosmology paper mentions a particle, force or concept you aren't familiar with, ask – "*Has it been detected?*" Surprisingly often the answer is "no," but difficult to confirm.

Please consider this when thinking about claims of dark matter, dark energy, inflation, Higgs bosons, scalar fields, monopoles, gravity waves, strings, tachyons, black holes, and the conjectures which depend upon them. None of these items, all relied upon by Big Bang, have ever been observed. In the case of black holes, by definition - we never will.

Physical Reality vs. Mathematics

"Your mathematics are correct, but your physics are abominable" said Einstein to the father of the Big Bang, the Catholic Priest Georges Lemaitre, upon hearing about universe expansion.

Mathematical correctness does not equate to physical reality. Imaginary and complex numbers (e.g. $\sqrt{-4}$) can be useful tools and even fun constructs, but they cannot create any testable physical existence such as matter or a force. How much hard cash would you pay for $\sqrt{100}$ acres of downtown Manhattan real estate? Now how about $\sqrt{-100}$ acres? or property only existing in theorized 5th through 11th dimensions?

[7] Because of this deficiency, Wikipedia is taking this role away from Big Bang advocates.

Mathematical predictions can tell us where and what to look for, but ***mathematics does not and cannot create physical reality***. Only testable or measurable physical observations are within the boundaries of science.

Reality is that remaining after you stop looking at it through math-colored glasses.

Accuracy Does Not Equal Meaning

"***The great tragedy of science is the slaying of a beautiful theory by an ugly fact.***"**-** Thomas Henry Huxley."

Many are mislead when a theory touts phenomenal accuracy, yet has little or no meaning. I can arrive at my doctor's office within 1/10,000th of a second of my 10 am appointment, but that does not mean I will see him at that precise moment.

When you hear a claim of extreme precision stand back and consider the claim in the context of "*a chain is only as strong as its weakest link.*"

Perhaps one facet of an idea is marvelously accurate. But are there other claims which the idea depends upon, other links in the chain, so painfully weak they fail and wreck the whole idea?

Quantitative or Dimensionless?

It is only reasonable to have quantitative answers to questions in cosmology claims.[8]

Unfortunately, much of cosmology employs dimensionless equations without actual applied quantification or initial conditions. Of the more than 50 major Cosmology books and 500+ papers I've analyzed, I have only found one[9] providing a graph depicting the Big Bang universe size vs. time as it increased in size from an atom to one light year -- which includes *radius quantities*.

It is incomplete and generally meaningless to say merely that a car accelerated at a rate twice the force of gravity. You might reasonably ask "Did acceleration start at zero velocity? Or at 10 meters per second?"

To make a theory or an equation meaningful we need to have meaningful context, and full meaningful astrophysical data which we can examine.

More Graphs or Equations?

"***I couldn't reduce it to the freshman level. That means we really don't understand it***." – Richard Feynman[10]

A guideline of mine is that an explanation is inadequate when there are more equations than graphs. Scientific American is a good example of imparting substantial information with excellent graphs, charts and a minimum of equations or jargon.

Don't Consider the Source

One of the clues that something is wanting with an idea is when more of its credibility is person based ("who says so") than evidence based ("how do they know"). Remember how even the indisputably brilliant Isaac Newton spent many of his waning years hoping to turn ordinary elements into gold?

While it did take 1,000 years to correct Ptolemy's elaborate Earth-centered uni-

[8] Notably, one of the few acknowledged Big Bang quantities, the Cosmological Constant, diverges from its theory by 120 magnitudes; the largest known quantitative difference in physics.

[9] Kai Woehler's "Cosmology" PH4991 course book.

[10] Genius, 1992, James Gleick, pg

verse planet-prediction theory, a more accurate explanation of natural phenomena ultimately prevailed.

A complex science model which is adhered to primarily because of ***who*** advances it is inevitably replaced by a theory with stronger evidence and reasoning.

Definitions

When a hypothesis' definition is so incomplete that it cannot be tested, the idea evaporates into a mere opinion.

Space Defined

Since it is central to the primary mechanism explaining Big Bang[11] and vital for evaluating any cosmology, it is fundamentally incomplete to leave the concept of "space" undefined; space independent of time. If one claims "space" is expanding – one must define space, or at least disclose which definition is used.

Yet, I can find no Big Bang proposition defining the term "space" separate from time. Worse, Big Bang can require space to be used in conflicting manners. Most Big Bang theorists use "space" as physical reality, while a few seem use it as defined here.

So here is one testable definition for space which can be used for cosmology science which does not use or require any untestable components. It employs the Euclidian definition of space sharpened slightly by explaining it first in the negative and then the positive.

What Space Is Not

Space is not matter. It is the antithesis of matter. Space has no inherent shape, edges or physical characteristics of any kind. Space is generally accepted as the absence of matter.

Neither is space energy or force (e.g. radiation or gravity). So space is neither matter, energy or a force. Thus space has no physical existence or reality. It has no testable properties such as size, attraction or color.

What Space Is

Space is an abstract concept like mathematics to help us understand physical phenomena. Space is the abstract concept of volume typically used to geometrically define physical locations and characteristics in up to three physical dimensions. It is used with many coordinate systems, most commonly Cartesian.

Applied Space

A volume of intergalactic space can be relatively empty, with just a few atoms per square meter and nearly undetectable gravity and electromagnetic forces, or filled with matter or forces.

A vacuum is a specific volume and location defined in a coordinate system in Euclidean space containing extremely little or no matter. Although a three dimensional space may contain testable matter[12] and almost always contains forces (e.g. gravity and high energy photons), space itself is unobservable and untestable. Space is not affected by any of the four fundamental forces (i.e. matter or light may bend in a gravitational field, but since space is non-physical it cannot bend).

This definition of Space is consistent with Einstein's special relativity theory in that it does not require an `absolutely sta-

[11] Space expansion is Big Bang's leading premise.

[12] Intergalactic space often contains hydrogen and dust.

tionary space' with special properties, nor does it assign a velocity-vector to a point of the empty space. It departs from the untestable implications of Einstein's theories that space has substance and curvature.[13]

In any case, **if Big Bang space is either matter or force, it has not been observed. If space is neither matter or force it cannot be observed.** Since this space cannot expand or contract there is nothing physical, no matter or force, to measure as expanding or contracting.

Conclusions

A valid cosmological hypothesis fully clearly, unambiguously defines and quantifies its rationale and its terms, makes meaningful, quantifiable testable predictions based entirely on observable phenomena. It will reasonably explain redshift, galaxy surface brightness to distance ratios, millimeter radiation, supernova rise and decay, Olbers paradox, gamma ray burst dilation, and light element abundances.

Perhaps most importantly – it must not conflict with, or need adjustments to, any well established laws of physics, particularly matter and energy conservation.

As of 2009 we have no agreed upon unambiguous, testable definition of Big Bang or Inflation models. The varying claims and descriptions available have such serious conflicts with fundamental science they all still need serious work before they are even ready for critique.

It is worthwhile pondering that if Big Bang is a firm concept - why are so many cosmologists working on Inflation, which makes radical amendments to Big Bang? Compounding that, why is there little agreement on which of the six severely different inflation ideas is best?

Cosmology is a science, but in my opinion, Big Bang is not until it fully and unambiguously defines its fundamental claims and terms. Advocates need to clearly state whether "space" is either a testable matter or force or neither; must get rid of the dependence upon untestable phenomena including negative energy, the continual increase of matter from nothing, and provide comprehensive, quantified failure criteria. Then we will have a Cosmology Theory we can all celebrate.

$$\int c(i)e^{n}C_{e} \geq f(u^{n}) \quad [14]$$

Useful Cosmology References

1) Peebles, P.J.E., 1993, *Principles of Cosmology*, Princeton University
2) Lerner, E., 1992, *The Big Bang Never Happened*, Simon & Schuster
3) Silk, J., 1989,*The Big Bang (Revised and Updated)* , W. H. Freeman (excellent text, charts & graphs)
4) Woehler, Kai, 2001, Cosmology physics course book (P-4491) and class notes, Naval Postgraduate School

For much more, including a comprehensive cosmology glossary, leading edge news and analysis and **the definitive version of this paper by Astronomical Society of the Pacific** - please see my website -

CosmologyScience.com

[13] While he carefully described time and space-time, I cannot find where Einstein clearly defined space independent of time, or whether it is composed of matter or forces or not.

[14] Derived from Betsy Devin & Joel E. Cohen's marvelous equation in "Absolute Zero Gravity" 1992

