

SEVEN PINES, May 14, 2015

•
**Comments on Penrose's "Conformal
Cyclic Cosmology",
(CCC)**

or

How to go Thru the Big Bang Happily.

•
Ted Newman

Dept. of Physics and Astronomy, Univ. of Pittsburgh.

Something Outrageous and Unbelievable.

•
•
{Please no Physical Violence.}

•
•
Not Necessarily True but to be Considered Seriously.

•
•
**I am referring to Roger Penrose's theory of the Big Bang,
CCC, Cyclic Conformal Cosmolgy**

•
•
**Arguments Good - maybe not yet Compelling.
Recent Good Observational Support !!!!!**

•
•
**Alternative Theories of Big Bang more
Outrageous and Unbelievable.**

Some of the alternate theories of the Big Bang.

•
**1. The Ekpyrotic Universe has two 3-dimensional 'Branes' moving in a Higher Dimensional Space - Collide and give rise to the Big Bang.
(Turok & Steinhardt)**

•
2. Analytically continuing the FRW solution around the initial Big Bang singularity.

•
**3. Maybe the Einstein equations allow for periodic solutions -- first expansion, then contraction, a bounce and all is repeated.
Also attempts via adding in Torsion.**

•
4. Loop Quantum Gravity and String Theory Apparently have Explanations.

•
**5. Most Prevalent and Accepted "Explanation" of the Big Bang is that there was nothing there at all - and suddenly the Universe came into being; the Big Bang" .
It requires no explanation -- its just true. In other words, God -- or someone like him or her - did it.**

•

Aside:

Many years ago the American Astronomer Robert Jastrow, director of the NASA Goddard Institute, called & asked me "Didn't I think that the Big Bang was proof of the existence of GOD."

•
#####

In an interview with *Christianity Today*, Jastrow said "Astronomers now find they have painted themselves into a corner because they have proven, by their own methods, that the world began abruptly in an act of creation to which you can trace the seeds of every star, every planet, every living thing in this cosmos and on the earth. And they have found that all this happened as a product of forces they cannot hope to discover. That there are what I or anyone would call supernatural forces at work is now, I think, a scientifically proven fact."

•
#####

•
I ask

**Proponents of Inflationary Cosmology:
Where did they get the initial conditions for their scenario?
A shrug of the shoulders, or a change of the topic,
i.e., who cares, or HE DID IT.**

•
-- but usually stated with more care and diplomacy.

Penrose's proposal certainly stays far closer to conventional physics than most of the others.

•
#####

•
**It's the only one -- to my knowledge (??) --
that heavily relies on and is based on
the 2nd law of thermodynamics.**

•
#####

•
**Penrose posits initial condition at Big Bang,
Very Low Entropy.**

**Entropy of
Gravitational Degrees of Freedom
(expressed as Weyl Tensor)
are not excited --**

•
★ Weyl Tensor vanishes at the Big Bang.

Another Aside
Eddington's Admonition

The law that entropy always increases holds, I think, the supreme position among the laws of Nature. If someone points out to you that your pet theory of the universe is in disagreement with Maxwell's equations --- then so much the worse for Maxwell's equations. If it is found to be contradicted by observation --- well, these experimentalists do bungle things sometimes.

But if your theory is found to be against the second law of thermodynamics I can give you no hope; there is nothing for it but to collapse in deepest humiliation.

Sir Arthur Stanley Eddington,

The Nature of the Physical World

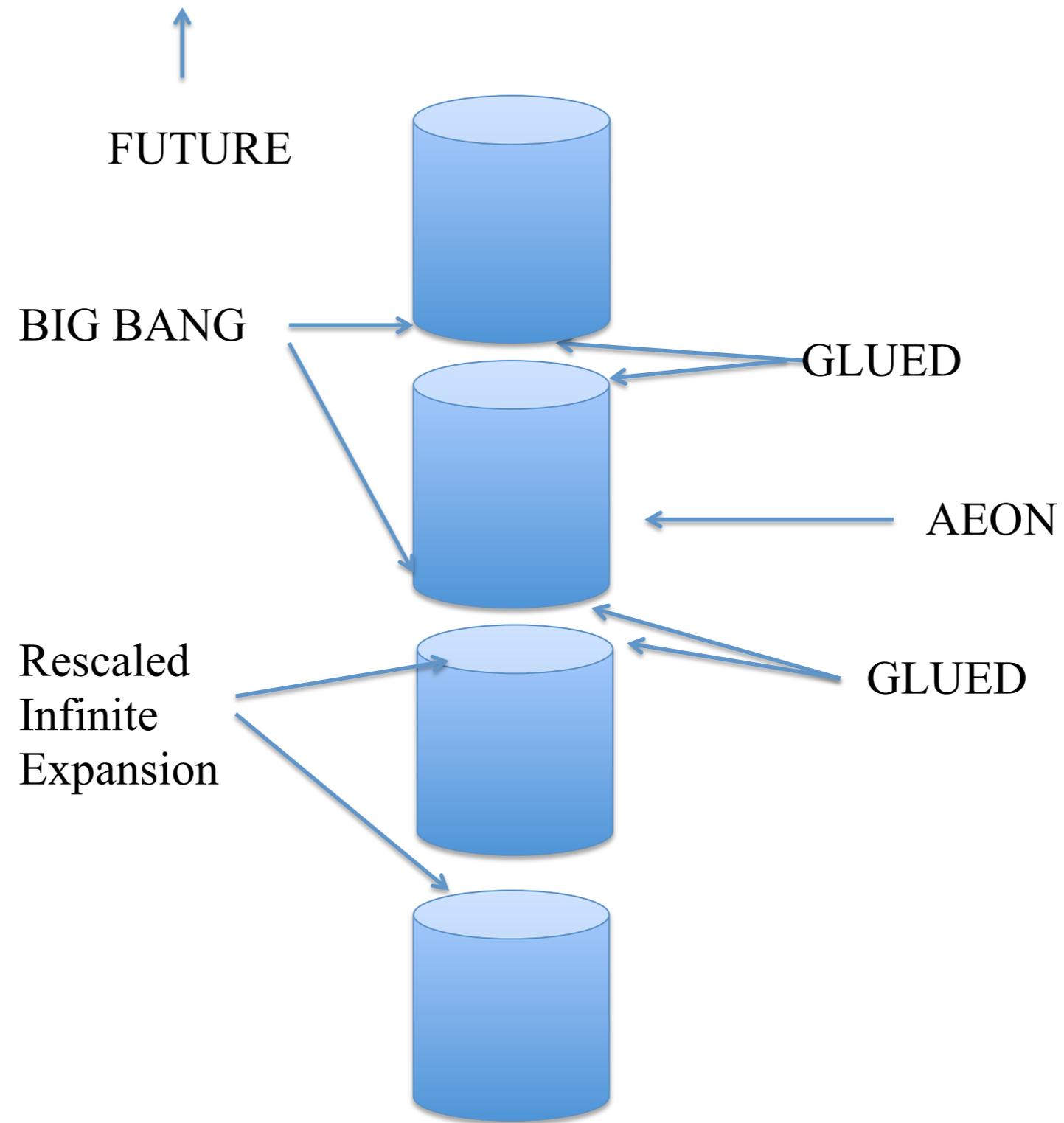
WHAT IS CCC?

**The basic idea of CCC:
A cyclic aspect of cosmology
- one has many `Aeons' -
(a portion of the history of the universe)
that repeats itself indefinitely.**

#

**Each `Aeon' begins with Big Bang
ends with an
Infinite DeSitter-like expansion.**

**Transition from one Aeon to Next
is by
Conformal Rescaling of their Metrics**



Infinite Sequence of Aeons

Major Issue:
how to transition between
end of any aeon- ("previous aeon")
thru Big Bang
to next aeon -- ("present aeon")

...

...

CCC Requires:

Physics at the late stages and early stages of
any aeon becomes conformally invariant.

...

- g_{ab} equivalent to $\Omega^2 g_{ab}$
- Matter fields also conformally invariant.
 - Trace-free Stress-Energy Tensor

Requires:

**All rest-mass has evaporated by
the time of the transition.**

**New rest-mass is generated shortly after
the Big Bang.**

**(weakest point?? - biggest departure from default)
[long time and no Poincare group]**

·
·

**Unique Choice of Conformal Factor relate Metric
Between aeons.**

·
·

**To overcome the Infinity of Metric,
Conformal Factor becomes Infinite at Cross-Over.**

$g^{\wedge}_{ab} \Leftrightarrow$ **Metric of previous**

$g_{ab} \Leftrightarrow$ **Metric of transition region, smooth**

$g^{\vee}_{ab} \Leftrightarrow$ **Metric of present aeon**

Ω , **conformal factor, \rightarrow infinity at crossover**

$$g^{\wedge}_{ab} = \Omega^2 g_{ab}$$

$$g^{\vee}_{ab} = \omega^2 g_{ab}$$

$$\omega = -\Omega^{-1}$$

METRIC RESCALING at Crossover

How to choose the conformal factor.

Ω satisfies the Yamabe equation.

Diff. Eq. for the conformal factor between two conformally related metrics, both with constant Ricci scalar.

-- in CCC case--

**the two Ricci scalars,
the same positive cosmological constant.**

$$\square \Omega + 2 \Omega = 2 \Omega^3$$

Wave operator, \square , from transition metric, g_{ab}

Higgs for fun

Observational confirmation.

Penrose: Violent events in the previous aeon

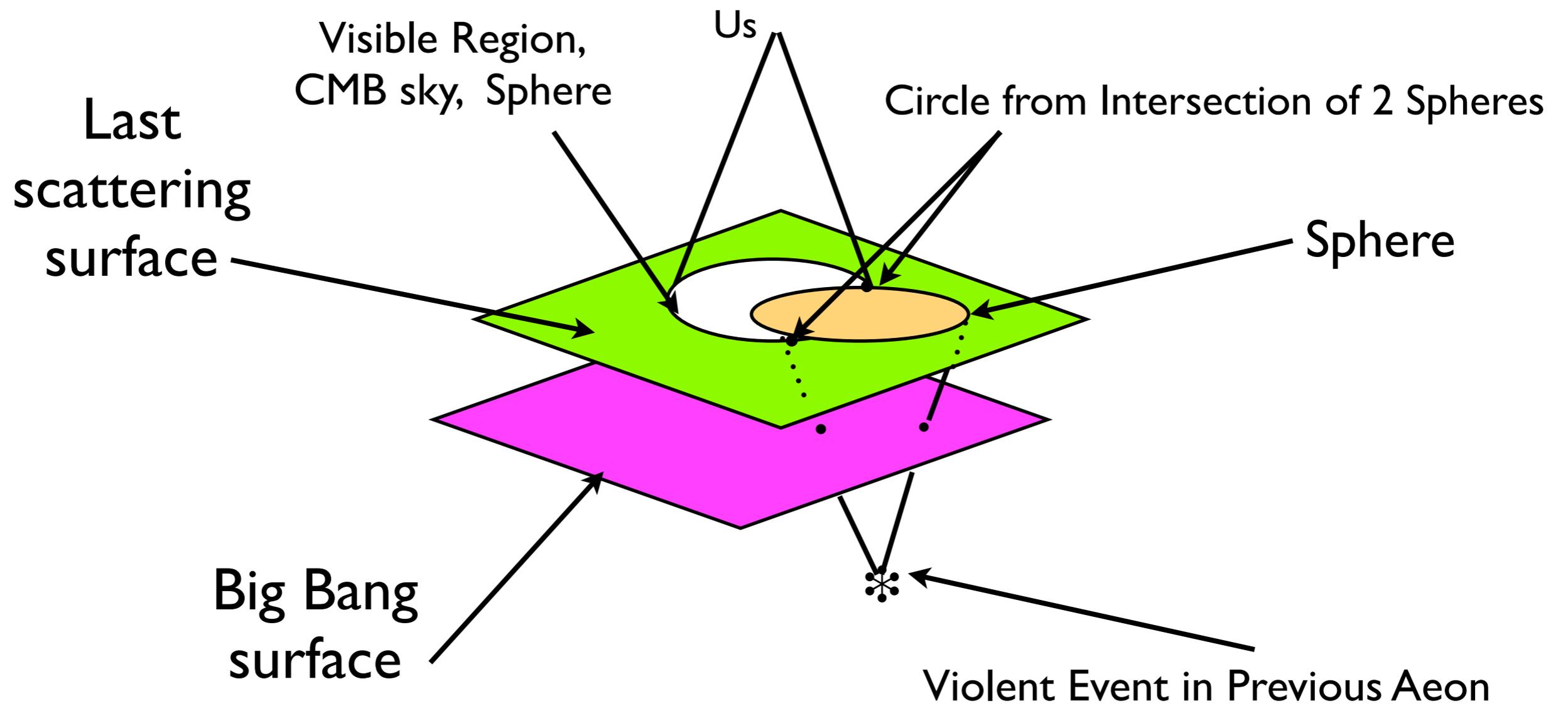
- **Collisions of Galaxies within their Clusters** ✨
- **Emitting huge amounts of Gravitational Energy,
in rescaled Weyl tensor** ✨
- **Go smoothly thru the Transition (BB) Surface.** ✨
- **It Gives Matter (Last Scattering Surface)
an Impulsive Kick** ✨



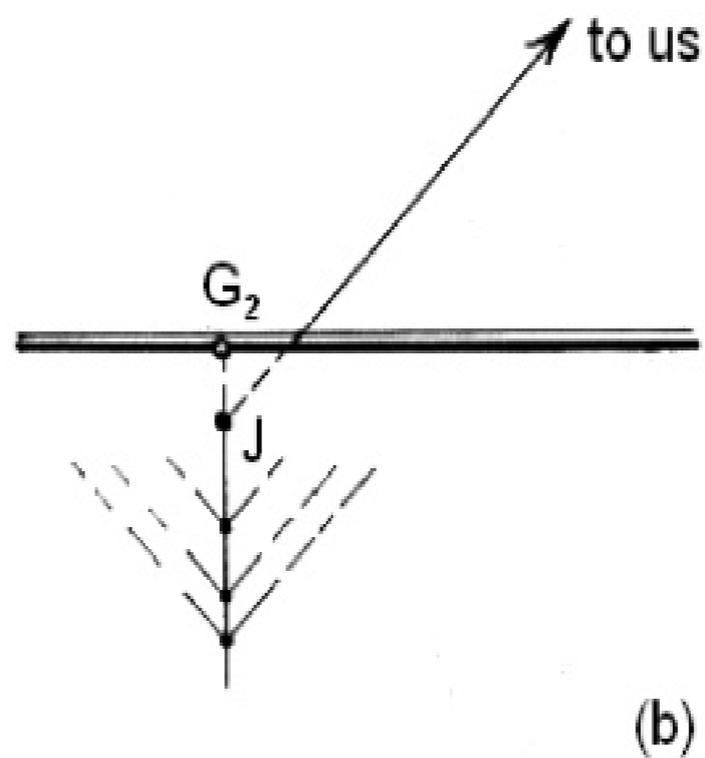
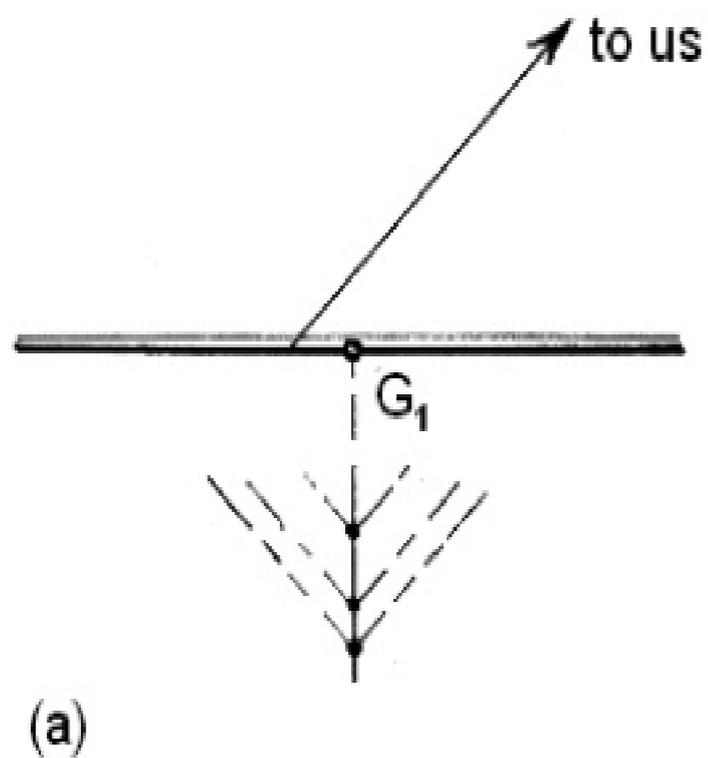
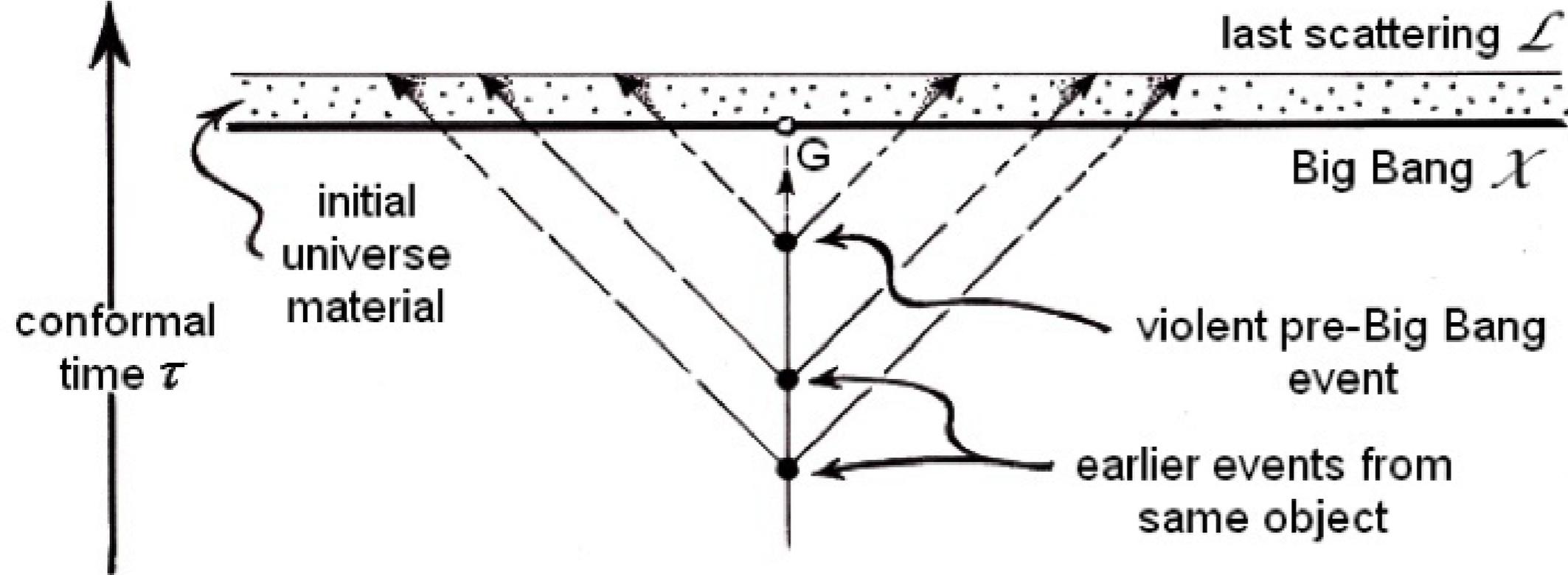
Prediction: On CMB background,
very weak

families, red or blue shifted concentric circles.

seriously proposed but ??????



Past & Future Pointing Light-Cones.
 Circle on CMB Sky



**Gurzadyan, of the Yerevan State University, Armenia,
analyzing the W-Map data
claimed to see many of these families.**

**Greeted by howls of very ugly criticism, “gibberish”,
"stupid", "ignorant", "the circles were purely statistical
artifacts", "Has Penrose entered old age loonihood?".**

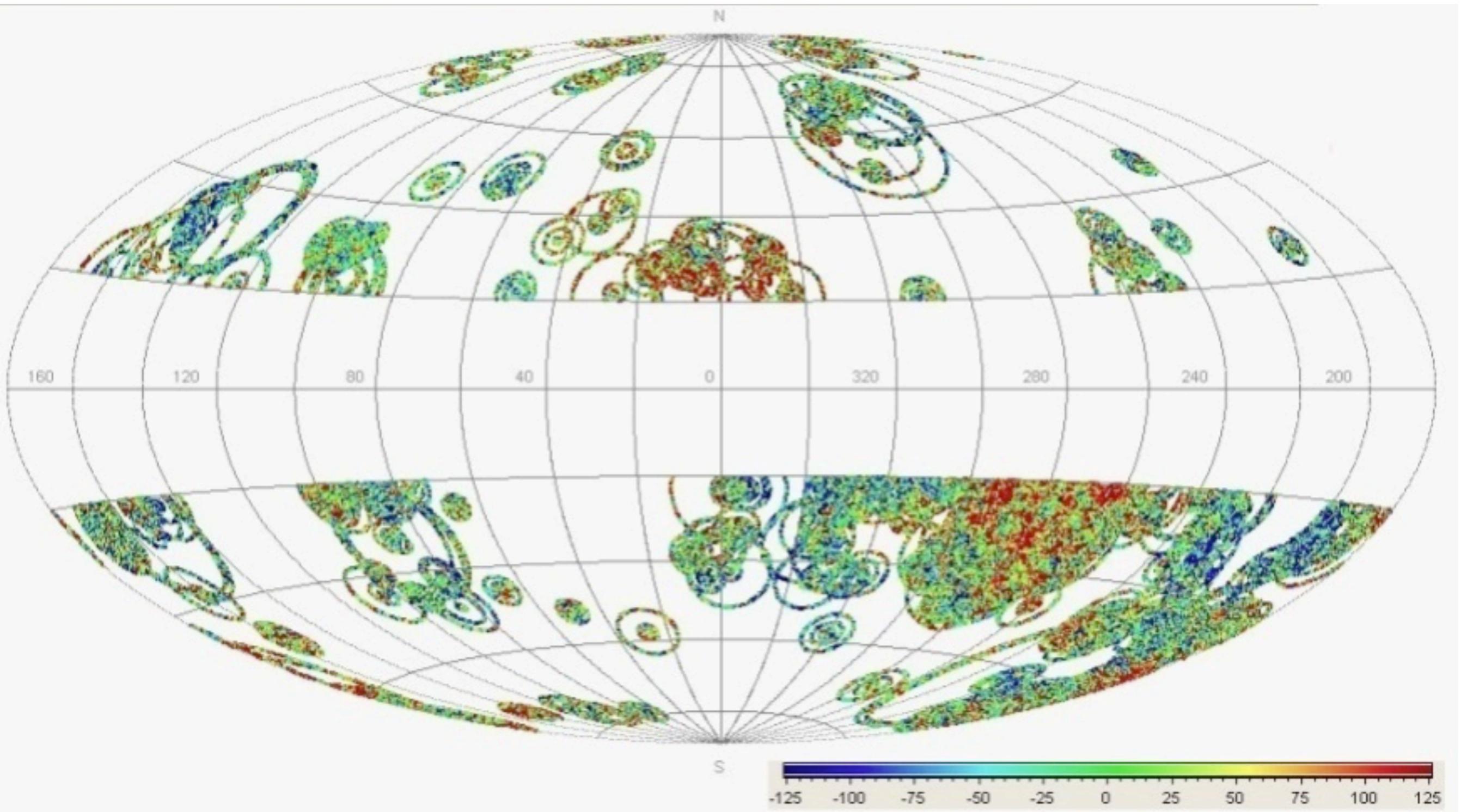
**Penrose and Gurzadyan twisted the CMB sky by the
transformation**

$$\begin{aligned}\theta^* &= \theta, \\ \varphi^* &= \varphi + S \theta\end{aligned}$$

Looked for Circles on twisted CMB sky.

**For Increasing value of S,
Circles began to disappear,
& finally vanished.**

So much for “statistical artifacts” ?



Sky Distribution of Concentric sets 3 or more circles of variance depth 15micro.K (352 sets)

**Independent group -- from Warsaw, Poland--
- analyzed the W-Map and the Planck data.
[to disprove]**

•
•

**With a completely different search algorithm, they
likewise found families of circles in the CMB sky
blue shifted & red shifted.**

•
•

Very recent note .

**Preliminary Analysis of revised Planck data,
Circle families essentially coincided with those of the
Gurzadyan circles.**

•

Much still to be clarified,
e.g., physics of how does mass
evaporate, then reappear,
and
observations still must be
confirmed

but

I think that some form of CCC has
a reasonable chance!!!!

Thank you