Horizon Problem Resolution (2/28/09)

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- *Date*: Sat, 28 Feb 2009 13:15:00 −0800

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\documentclass[12pt]{article}
\usepackage{graphicx}
\usepackage{amsmath}
\usepackage{graphics}

\topmargin=−3.5pc
\oddsidemargin=−1pc
\textheight=55pc
\textwidth=41pc

\author{Copyright \copyright\ 2008−2009 David E. Rutherford \\
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http://www.softcom.net/users/der555/horizon.pdf}

\title{Horizon Problem Resolution}
\date{February 28, 2009}

\begin{document}

\maketitle

\section{The Horizon Problem}
In cosmology, it is believed that regions of space on `opposite' sides of the universe are too far apart to have ever been causally connected. That is, they are outside each other's `particle horizon'. Consequently, it is difficult to explain the apparent similarities in their characteristics as evidenced by COBE results. Inflation theory has been offered as a way to overcome this `Horizon Problem'. However, it is my intention, here, to show that it is not necessary to postulate Inflation in order to insure that \emph{all} regions of spacetime are now, and have always been, causally connected.

\section{A Resolution to the Problem}

Referring to Fig. \ref{1}, let us imagine that the three dimensions of space exist on a circle centered at the origin. The `radius', or scaling factor, of the universe is denoted by $r$. The radius at the present time is $r_0$ and the point $P_0$ represents here and now. The inner circle of radius $r$ represents space at an earlier time. The angle $\theta$ is the angular separation between $r_0$ and $r$.

We will assume that light pulses travel from a source along the expanding circle, at constant speed $c$, toward $P_0$ from opposite directions, represented by the upper and lower ``Light paths''. The points of convergence of the upper and lower light paths, in Fig. \ref{1}, occur at $\theta = n\pi, n = 0,1,2,3 ...$ . We
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also assume, for now, that the expansion rate $\dot{r} = dr/dt$ is constant, so that $\dot{r}/c$ is also constant. The vectors $\vec{c}$ and $\vec{\dot{r}}$ are tangent and normal to the circle, respectively, as shown in Fig. \ref{1}.
\begin{figure}[h]
\begin{center}
\input{light}
\caption{Light paths}\label{1}
\end{center}
\end{figure}

A curve describing the light path, subject to the properties above, is known as a logarithmic spiral, described in this case by\footnote{See http://www.softcom.net/users/der555/logspiral.pdf for the derivation of this equation.}
\begin{equation}\label{path}
r = r_0 e^{−\dot{r}\theta/ c}
\end{equation}
It is important to note that the speed of a light pulse is c relative to its location on the circle, everywhere along the circle. If the speed of the pulse slowed as it progressed along the circle, light from more distant sources would propagate more slowly than light from nearer sources. Experience indicates that this is not the case.

The recession velocity v between two comoving points on the circle is
\begin{equation}\label{v}
v = \dot{r}\theta
\end{equation}
Therefore, inserting (\ref{v}) into (\ref{path}), we get for the scaling factor in terms of the recession velocity,
\begin{equation}\label{r}
r = r_0 e^{−v/c}
\end{equation}

A point on the circle at an angular separation of $\theta = 1$ would have a recession velocity, from (\ref{v}), of $v = \dot{r}$ along the circle. Assuming for the moment, that $\dot{r} = c$ and $r = \dot{r} t = c t$, any comoving light source at a greater angular separation than $\theta = 1$ would have a recession velocity greater than c, but would still be visible. This visibility is due to the fact that the speed of light is equal to c relative to each point in space along its path.

For example, assume that a source in a region of space at an angular separation of, say, $\theta = 1.1$ (which has recession velocity of $1.1 c$, relative to P_0) emits a pulse toward P_0. This pulse would surely reach a region of space at an angular separation of, say, $\theta = 0.9$ (which has recession velocity of $0.9 c$, relative to P_0), since the two regions have recession velocities of $0.2 c$ relative to each other. And since the pulse is traveling at speed c relative to space in this region, it will reach P_0.

Unfortunately, a logarithmic spiral never actually reaches the origin. Consequently, we would never be able to see the origin of the universe. However, we would apparently be able to see our own region of space as it appeared at earlier times ($\theta = 2n\pi, n = 1,2,3 ...$), providing that light maintains its integrity as it passes through the convergence points.

If the expansion rate $\dot{r}$ varies, the light curve no longer fits the definition of a logarithmic spiral. However, since c is nonzero, its form would remain similar to a logarithmic spiral.

Equation (\ref{path}) assures that all regions of space are causally connected at all times. Therefore, there is

```latex
no particle horizon, thus no `Horizon Problem', in this model.

\section{Cosmological Redshift}

The cosmological redshift, $z$, is
\begin{equation}\label{redshift}
z = \frac{\Delta\lambda}{\lambda} = \frac{\lambda_0 − \lambda}{\lambda} = \frac{\lambda_0}{\lambda} − 1
\end{equation}
where $\lambda$ is the wavelength of light at emission and $\lambda_0$ is the wavelength at reception. And since, using (\ref{r}),
\begin{equation}\label{calc1}
\frac{\lambda_0}{\lambda} = \frac{r_0}{r} = \frac{r_0}{r_0 e^{−v/c}} = e^{v/c}
\end{equation}
we can insert (\ref{calc1}) into (\ref{redshift}) to get
\begin{equation}\label{zc}
z = e^{v/c} − 1
\end{equation}

\section{Velocity Redshift and Distance Redshift Relations}

\begin{figure}[h]
\begin{center}
\input{zgraph}
\caption{Recession Velocity vs. Cosmological Redshift}\label{2}
\end{center}
\end{figure}

By rearranging (\ref{zc}), we find the the recession velocity as a function of redshift
\begin{equation}\label{v1}
v = c \ln(1 + z)
\end{equation}
This would not be subject to a relativistic correction since the source is not traveling through space, but is comoving with it. Fig. \ref{2} shows the relationship between redshift and recession velocity.

In order to find the distance $d$ between two comoving points on a circle with radius $r$, measured along the circle, as a function of redshift, we first note that
\begin{equation}\label{d1}
d = r\theta
\end{equation}
Rearranging (\ref{v}) and inserting (\ref{v1}), we have
\begin{equation}\label{a}
\theta = \frac{v}{\dot{r}} = \frac{c \ln(1 + z)}{\dot{r}}
\end{equation}
Plugging (\ref{a}) into (\ref{d1}), we get
\begin{equation}\label{d2}
d = r\,\left(\frac{c \ln(1 + z)}{\dot{r}}\right) = \frac{r}{\dot{r}}\,c \ln(1 + z)
\end{equation}
The present distance $d_0$ between two comoving points on the circle with radius $r_0$, as a function of redshift, is
\begin{equation}\label{d3}
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d_0 = \frac{r_0}{\dot{r}}\,c \ln(1 + z)
\end{equation}
If we take the Hubble constant H_0, for constant $\dot{r}$ and present radius r_0
\begin{equation}\label{H0}
H_0 = \frac{\dot{r}}{r_0}
\end{equation}
and insert (\ref{H0}) into (\ref{d3}), assuming constant $\dot{r}$, we have for the present distance as a function of redshift,
\begin{equation}\label{d0}
d_0 = \frac{c}{H_0}\,\ln(1 + z)
\end{equation}
Combining (\ref{v1}) and (\ref{d0}), we get
\begin{equation}\label{daves}
v = c \ln(1 + z) = H_0 d_0
\end{equation}
Equation (\ref{daves}) is my version of Hubble's Law ($v = c z = H_0 d_0$).

\section{A New Explanation for the CMBR?}

At $\theta = \pi$, if $\dot{r}$ is made to equal c, we get
\begin{equation}
r_{\pi} = r_0 e^{−c\pi/c} = r_0 e^{−\pi}
\end{equation}
This is about 5% of the present radius or 5% of the present age of the universe (about 750 million years, assuming a present age of fifteen billion years).

Radiation emerging from this period shares the property of omnidirectionality with the cosmic microwave background radiation (CMBR). Furthermore, the possibility exists that it may share \emph{all} of the properties of the CMBR. At this time, these properties have not yet been investigated. However, if these properties match those of the CMBR, the tantalizing possibility exists that the light emerging from the convergence point at $\theta = \pi$ could \emph{be} the CMBR.

\section{Elimination of the Dark Ages}

If the light from the convergence point at $\theta = \pi$ is the CMBR, then the era associated with the the CMBR would be much later than commonly believed. This era is interesting in that it approximates that associated with the most distant luminous objects observed to date.

The period referred to as the ``Dark Ages'' in standard cosmology describes the epoch extending from the era of the emission of the CMBR radiation, estimated in standard cosmology to be at about 400 thousand years after the Big Bang, to the era of the currently most distant observed luminous objects, at about 750 million years after the Big Bang. Cosmologists have no reasonable explanation for the length of this `blank spot' in cosmic history, or for what occurred during it.

Since the light emerging from the convergence point at $\theta = \pi$ may be the CMBR, the era associated with the CMBR may be approximately the same as the era associated with the most distant observed luminous objects, thus eliminating the ``Dark Ages'' altogether, along with their mystery.

\section{Do We Need Dark Energy?}
The theory that the universe is expanding at an accelerating rate relies on Hubble's Law to determine the recession velocity and distance of supernovae. If we compare my relation (\ref{daves}), with Hubble's Law,

we see that the recession velocity and distance, for a given redshift, are less for my relation than for Hubble's Law.

The determination that the expansion rate of the universe is accelerating is based on the belief that distant supernovae are receeding at a faster rate and are more distant than projected for a constant or decelerating expansion rate. Using (\ref{daves}), rather than Hubble's Law, to determine recession velocity and distance, since (\ref{daves}) results in lower recession velocities and distances, may lead to the conclusion that there is no acceleration. The concept of dark energy was first postulated to explain the apparent accelerating rate of expansion of the universe. Thus if there is no acceleration, there would no longer be a need to invoke the existence of dark energy.

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Dave Rutherford
"New Transformation Equations and the Electric Field Four−vector"
http://www.softcom.net/users/der555

Applications:
"4/3 Problem Resolution"
"Action−reaction Paradox Resolution"
"Energy Density Correction"
"Proposed Quantum Mechanical Connection"
"Biot−Savart's Companion"
"Horizon Problem Resolution"

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