The Hubble Diagrams Limitations and Surprises

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Abstract

In 1929, Edwin Hubble measured the brightness and redshift of distant stars to calculate their distance and escape velocity. The resulting data, plotted on the now famous Hubble diagram, showed a proportional relationship between distance and redshift. It is important to note, however, that any measurement of a star's brightness (magnitude) also gives its corresponding lookback time.
But is the correlation between redshift and lookback time causal or spurious, or is even the correlation between redshift and distance spurious ?
In other words, does the redshift-brightness plot reflect the spatial or the temporal evolution of the Universe or both, and to what extent?
This article shows that there are many different possible events that could lead to the same redshift-brightness diagram.
For example, the redshift could depend almost entirely on changes in distance, or almost entirely on changes in lookback time.
It turns out that the more redshift depends on changes in distance, the less it depends on changes in lookback time, and vice versa.
However, due to a lack of data, no one knows what really happened.
But many things would be simpler, if one assumed that the redshift depends almost exclusively on the lookback time:
The amazing idea of an expanding space would not be necessary.
The expansion rate of the universe would be steadily decreasing.
Dark energy and the cosmological constant
(Einstein's biggest blunder) would not be necessary.
Until new discoveries are made, it is not possible to determine what conclusions can be drawn from a redshift-brightness diagram.
But these inferences are a key pillar of the ΛCDM model.
If this pillar wobbles, the whole structure could collaps.

1 Introduction

In 1929, Edwin Hubble [1] measured the brightness and redshift of distant stars. Since the absolute brightness of the (then) Cepheids and (now) Type Ia supernovae are known - they are standard candles - the distance of the stars can be calculated by comparing the absolute and the measured brightness.
He plotted the redshift-derived escape velocity and distance on what is now known as the famous Hubble diagram. The result was a straight line from the origin, leading to the conclusion that the redshift-derived escape velocity of distant stars is a function of distance. It is important to note, however, that any measurement of a star's brightness (magnitude) also gives its corresponding lookback time [2].
But is the correlation between redshift and lookback time causal or spurious, or is even the correlation between redshift and distance spurious ?
In other words, does the redshift-brightness plot depend more on changes in redshift over time, or on changes in distance, or on both, and to what extent? What are the implications?

2 Preliminary Considerations

A fundamental property of light is that its speed, c, remains constant regardless of the observer's frame of reference. This has two important consequences:
First, if you know the distance to a distant star, you can precisely determine its lookback time, and vice versa.
Distance and lookback time are thus inseparable, like Siamese twins.
Second, the visibility of stars depends on the precise alignment of distance and look-back time. Light and other electromagnetic waves can only travel at the speed of light - not faster or slower.
As a result, for the vast majority of distant stars in four-dimensional space-time, the look-back time and distance are incompatible, making them effectively invisible.
For clarity and ease of understanding, the following conventions and explanations are used in this paper:
In a redshift-brightness diagram, the redshift is plotted on the y-axis, while the brightness (a physical quantity from which distance or lookback time can be derived) is plotted on the x-axis.

Up to a redshift of 0.1, the result is a straight line from the origin showing a proportional relationship between redshift and both distance and lookback time. If the redshift is proportional to the lookback time, the redshift will steadily decrease because time can only move in one direction.
The points A, B, C, and D on the straight line of the Hubble diagram are arbitrarily chosen for later explanations.

Redshift Brightness Diagram

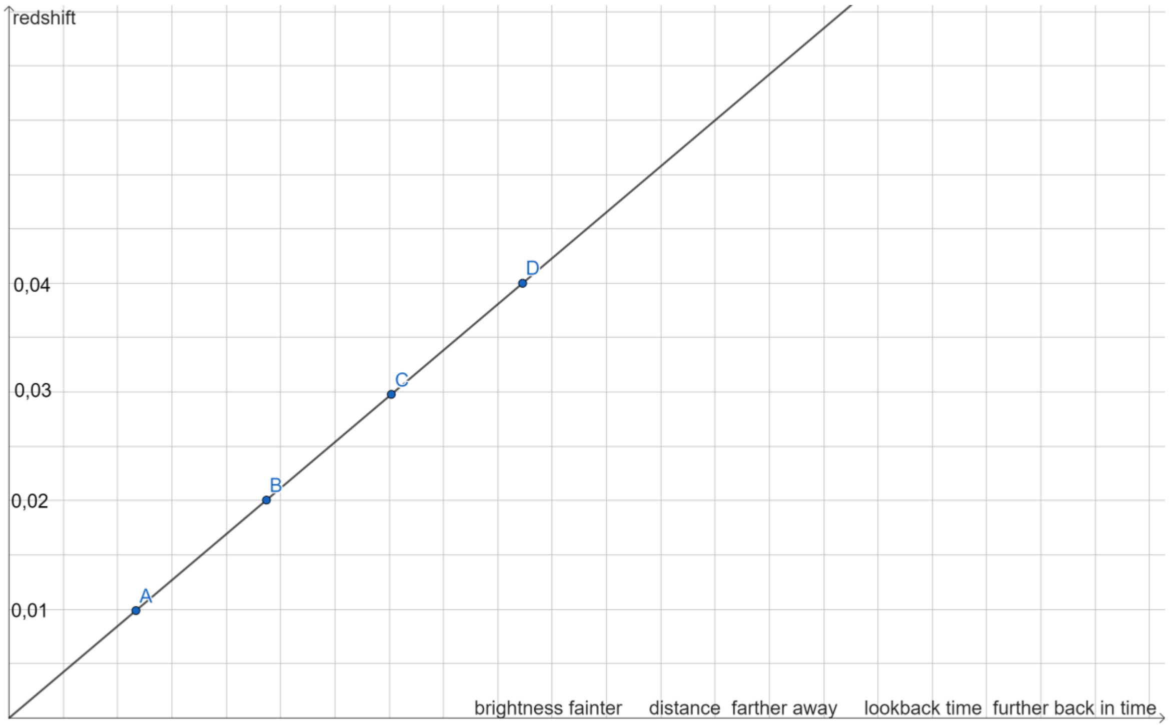


Figure1: Redshift brightness diagram

To help us understand these relationships, four-dimensional space-time is plotted on a two-dimensional graph with the following peculiarities.
Some aspects of other well-known graphs are used, adapted to the subject of this article.
Space is represented by the x-axis, labeled x.
Time is represented by the y-axis, multiplied by the speed of light c, labeled ct [2]. In this framework, coordinates in space-time are positions in space at a given point in time.
A straight line shows many different stars on a line in space-time, each with

different space-time coordinates, not the orbits of objects.
In this particular case, a straight line shows different stars on a (straight) line in space-time at the same redshift.
Since light always comes from the past, all we need is a negative time axis.
Since the universe is isotropic, the backward quadrant would be a mirror image (axis mirroring at the ct-axis) of the forward quadrant. Therefore, in this context, a graph with a negative time axis and a positive space axis is elected.
The unit of time is chosen so that the line of the speed of light lies on the bisector between the x-axis and the ct-axis [2].
This is the only place where distance and lookback time are perfectly aligned, and therefore the only place where you can see the stars.
Since all the stars measured and plotted on a redshift brightness diagram are visible, the data can be transferred and retransferred to the speed of light line in the space-time diagram. Since there is no redshift axis in a space-time diagram, the redshift must be labeled on the speed of light line.
So points A, B, C, and D on the redshift-brightness diagram were arbitrarily chosen and transferred to the speed-of-light line on the space-time diagram with redshifts of 0.01, 0.02, 0.03, and 0.04. But what about the vast invisible regions where distance and lookback time are not perfectly aligned and the stars are invisible?
In the absence of data, there is room for hypothesis, assertion, and conjecture.

3 Hypothesis

There are several possible scenarios (possibilities) that could produce the same Hubble diagram and yield identical observational measurements.
These different scenarios could lead to very different conclusions about the structure of the Universe.

4 Possible Events

Figures 2, 3, 4, 5, 6, and 7 on the following pages illustrate different assumptions about what might have happened beyond the observable universe.
They each show four parallel straight lines intersecting at the same points A, B,

C, and D on the speed of light line in each figure, but the slopes are different in each figure.

Space-Time Diagram

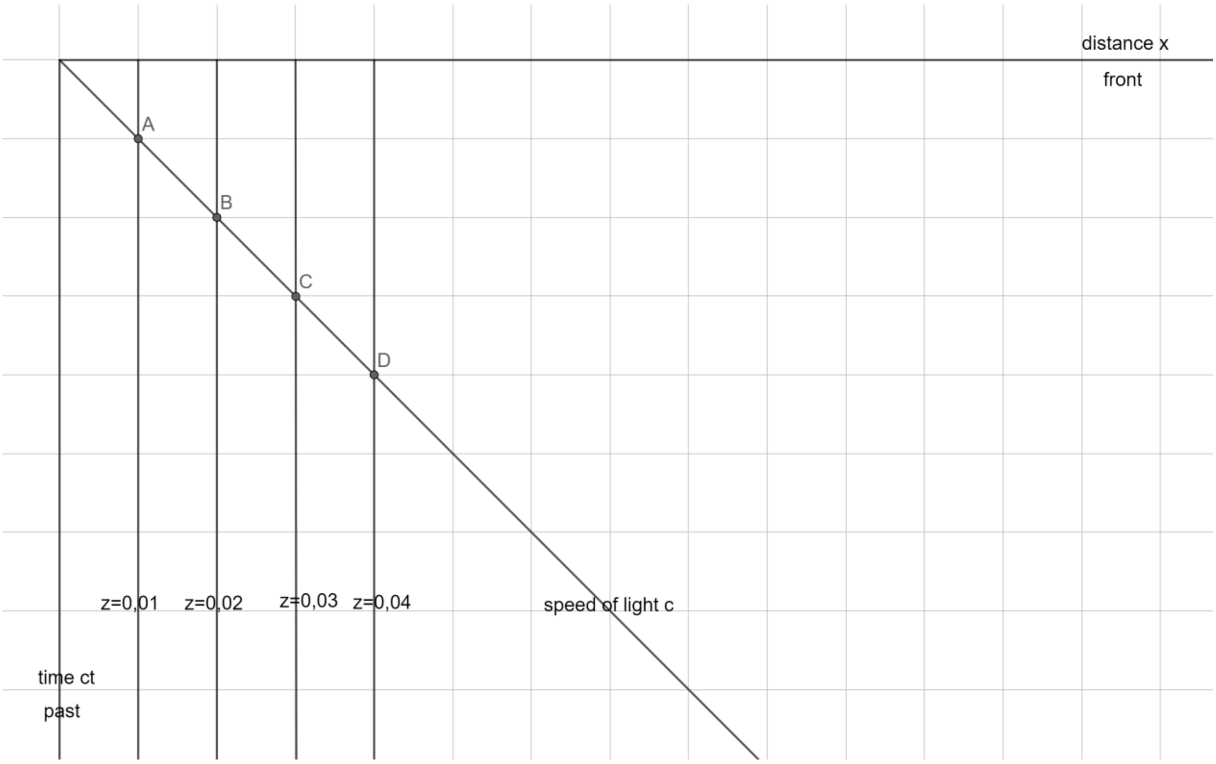


Figure 2: Space-time diagram

In this quadrant of a space-time diagram the redshift is proportional to distance and does not depend on time.
The conclusions drawn from the original Hubble diagram only make sense if we postulate that this is exactly what is happening.

Space-Time Diagram

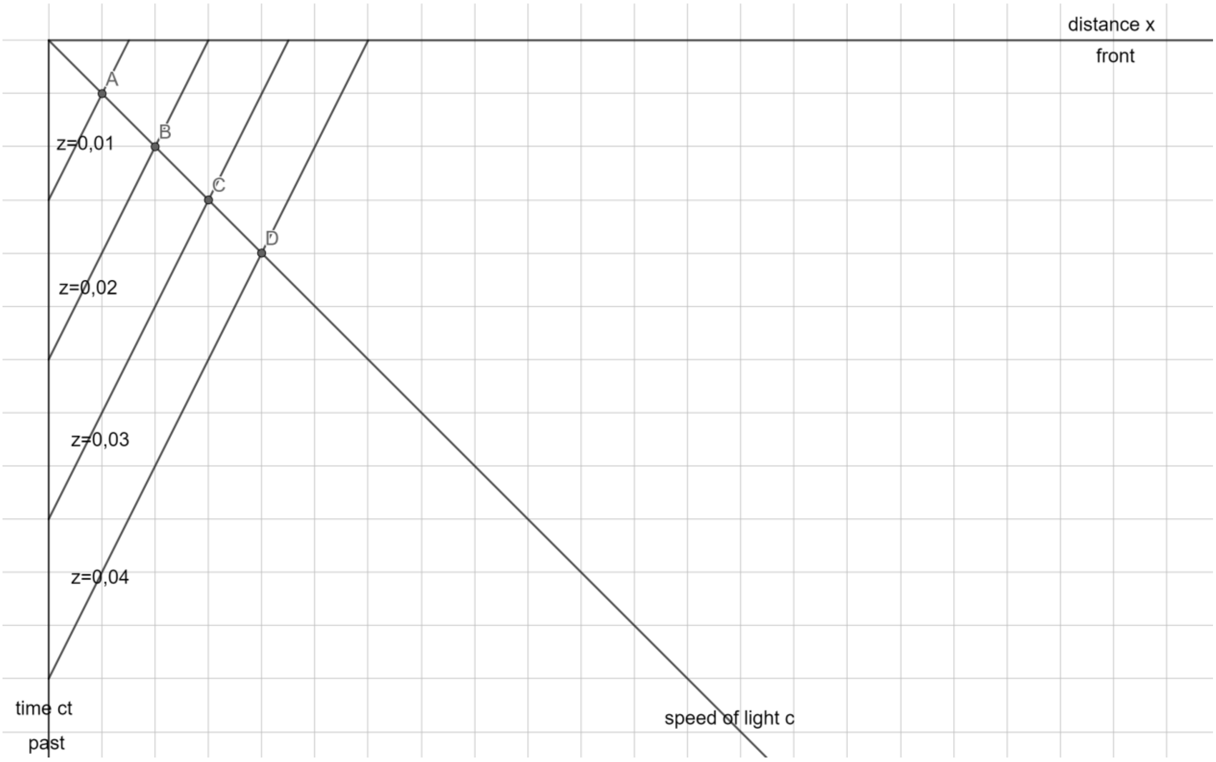


Figure 3: Space-time diagram

In this spacetime diagram, the redshift depends on distance and lookback time, but more on distance and less on time.

Space-Time Diagram

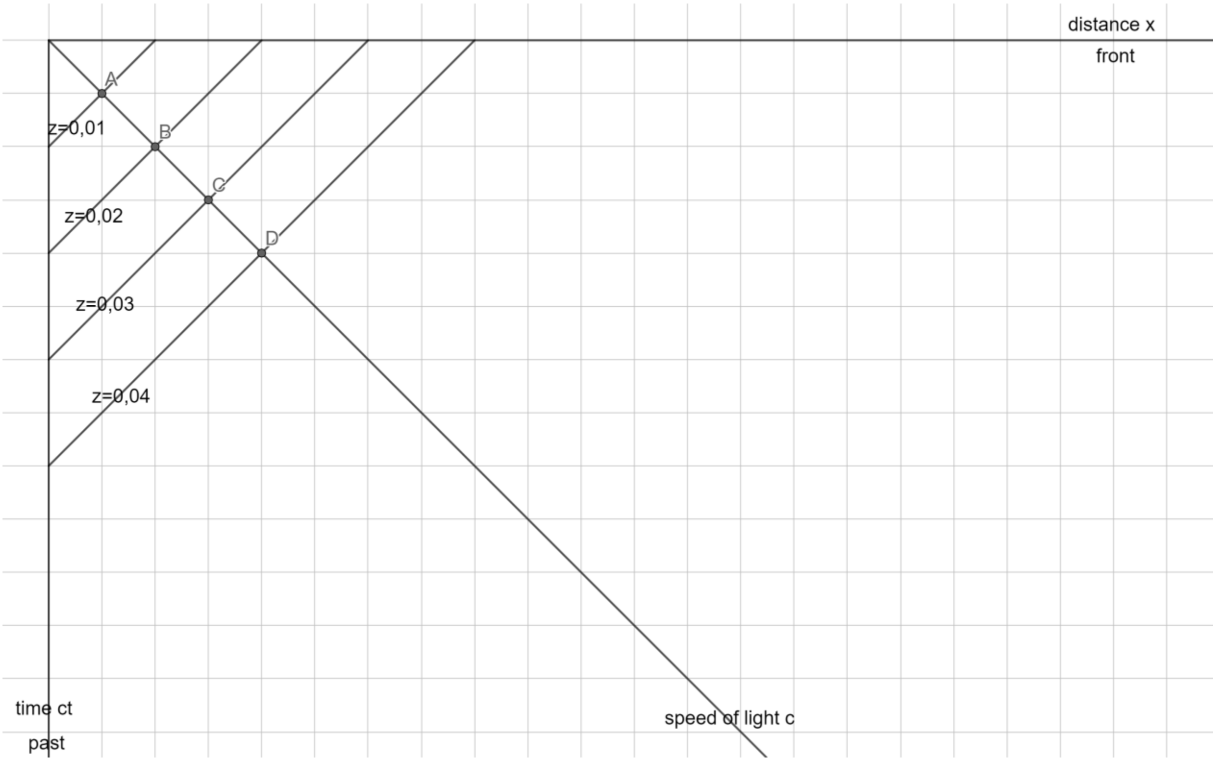
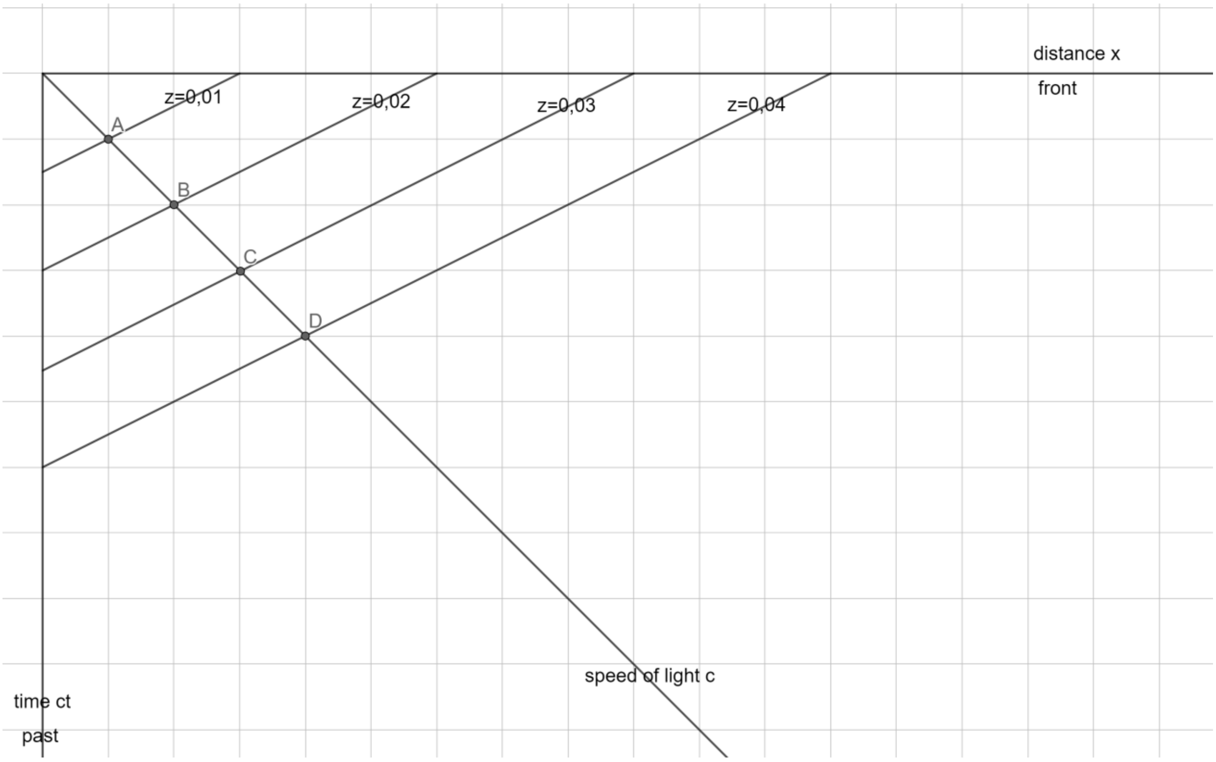


Figure 4: Space-time diagram

Here the redshift depends equally on the lookback time and the distance.
The quotient of redshift and distance at zero time is half the quotient of redshift and distance at zero time in Figure 2.
The quotient of redshift and time at zero distance is half the quotient of redshift and time at zero distance in Figure 6.



Space-Time Diagram

Figure 5: Space-time diagram

In this context, the redshift depends on both distance and look-back time, but it is influenced more by lookback time and less by distance.

All straight lines with the same redshift and a positive slope (as shown in Figures 3, 4, and 5) intersect both the x-axis (distance) and the ct-axis (time) within this quadrant.

A larger redshift corresponds to both a larger distance and a longer lookback time. In other words, the redshift is proportional to the distance and is decreasing in the course of time.

The magnitude of the slope determines the relative influence of these two factors:

A steeper slope indicates that the redshift is more dependent on distance.

A flatter slope indicates that the redshift is more influenced by lookback time.

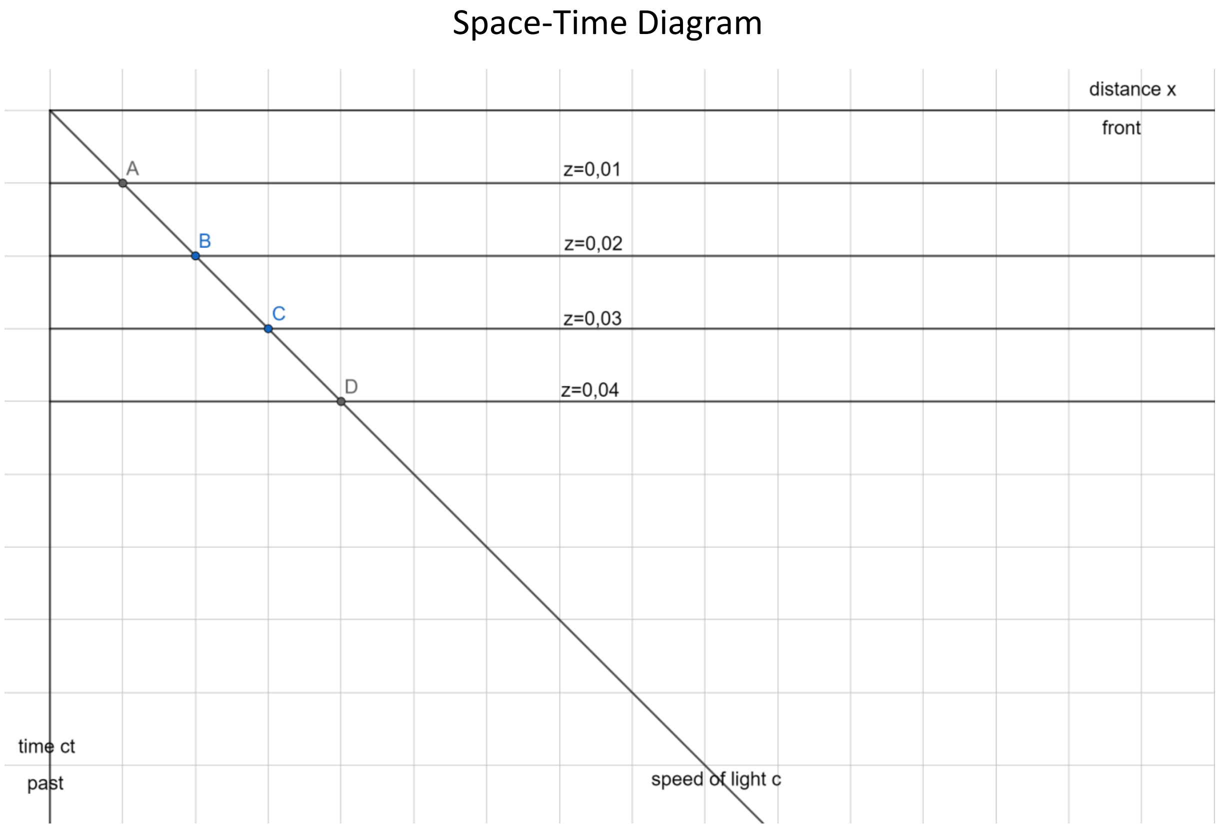


Figure 6: Space-time diagram

In this graph, the redshift depends only on the lookback time and not on the distance.

Space-Time Diagram

Figure 7: Space-time diagram

In Figure 7, there are two parallel lines that intersect the speed-of-light line and either the x-axis or the ct-axis.
The parallels that intersect the x-axis show a disproportionate (larger) ratio to distance and a negative correlation to lookback time, which means that the redshift increases strongly with distance and slightly in the course of time.
The parallels that intersect the ct-axis show a disproportionate (larger) ratio to lookback time and a negative correlation to distance. This means that the redshift increases strongly with the amount of the lookback time and thus decreases strongly over time, while decreasing slightly with distance.
These variations of the straight lines with the same redshifts in Figure 7 are also possible. Which of the examples in Figures 2 through 7 must be excluded?
All stars move, and any observed redshift of a star corresponds to motion away from the observer. Since motion is fundamentally related to changes in both space and time, the examples in Figures 2 and 6 must be ruled out in their pure form.
On the other hand, not only intersections with straight lines are possible on the speed-of-light line, but also intersections with odd lines.

5 Summary and Conclusions

There are countless possibilities of what is going on in the invisible regions of the universe. Each series of events on the straight lines in Figures 2-7 produces the same redshift-brightness diagram because they intersect the speed of light line at the same points A, B, C, and D.

These Figures 2-7 show an inverse relationship between redshift and distance on the one hand, and redshift and lookback time on the other.

In other words, the more redshift depends on distance, the less it depends on lookback time, and vice versa.

This is represented graphically by the slope of the straight lines in Figures 2-7.

What we need is the exact relationship between redshift, distance, and lookback time? Nobody knows.

However many things would be much simpler, if one assumed that the redshift depends almost exclusively on the lookback time:

The amazing idea that space itself expands (like yeast dough) would not be necessary [1].

The expansion rate of the universe would be constantly decreasing [3].

Dark energy [4, 5] and the cosmological constant (Einstein's biggest blunder) would not be necessary.

Many other details would change (Hubble constant, diameter of the visible universe, ...).

The ΛCDM model would no longer exist in its current form.

So there is a lot of work to be done.

Martin Schauer

Sources:

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