Cosmological Principle Explanation with the Special Relativity

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Abstract

Using special relativity, I succeeded in mathematically proving the cosmological principles regarding the uniformity and isotropy of the universe. The particle density distribution, centered on itself in all primordial inertial systems in this universe, was calculated as $\frac{1}{8}\left(\frac{r}{1-r}\right)^2$ in polar coordinates.

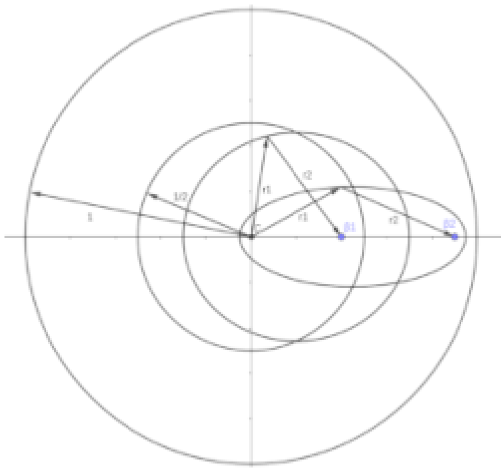
1 Introduction

In 1935, Arthur Milne proposed a uniform expansion cosmology based on special relativity. However, his argument was incomplete in many ways. In particular, he only explained the cosmic principles of uniformity and isotropy to some extent in one dimension and failed to explain them in three dimensions. In particular, it was a big mistake to cause confusion with sentences like "We have shown in chapter II that one-dimensional space it is possible to construct such a system of particle-observers satisfying Einstein's cosmological principle, i.e. such that each describes the system, from his own point of view, in the same way. We are now going to prove that it is impossible to construct such a system in three dimensions".

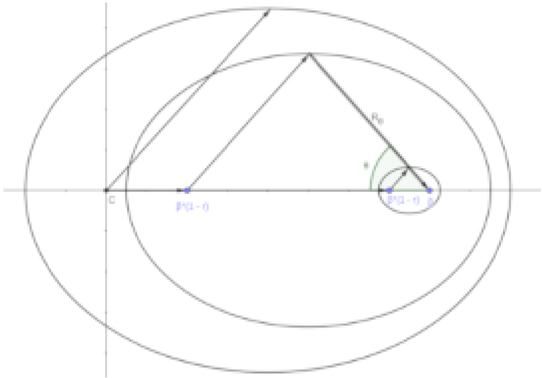
By introducing the concept of radar-measured distance based on the properties of ellipses, I simply proved that cosmological principles in three dimensions are embedded in special relativity.

The particle density distribution, centered on itself in all primordial inertial systems in this universe, was calculated as $\frac{1}{8}\left(\frac{r}{1-r}\right)^2$ in polar coordinates.

2 The shape of the universe



If the outermost part of the universe is moving away at the speed of light, the shape of the universe will appear as a sphere, half the size of the current universe, when viewed from the center. If we look at this from another inertial system, $\beta 1$ or $\beta 2$, which is moving away at a constant speed from the moment of the Big Bang, the outermost information in the universe that simultaneously arrives at the center point of that inertial system will form an ellipsoid. Of course, from the perspective of each inertial frame, it is obvious that it will appear as a sphere rather than an ellipsoid according to the principle of relativity.

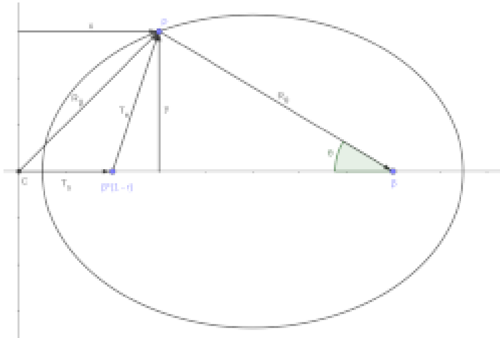


In a universe of age 1, if we try to describe a value r smaller than 1 which is inside the outer shell of the universe, based on the β inertial system, it can be described as a set of points that reflect the lights to converge when the lights departed from the β inertial system point located at $\beta(1-r)$ at the time (1-r), is reflected along the way, and return to converge β at the same time at time 1. These points form an ellipse, and the equation of the ellipse describing it is

$$R_\theta = \frac{r}{2}\frac{1-\beta^2}{1-\beta\cos(\theta)}$$

3 The age structure of the universe

Firstly, if verify the fundamental fact that the age of an ellipsoid, composing the same distance from the observer, remains uniform constant.



To express this based on center C, we need to know the relative speed β_p between the primordial inertial system corresponding to the event point P and the observation center C of the universe. When the speed of light is set to 1, its relative speed is the distance R_β between event P and observation center C divided by the size of the universe at that point in time. In this case, since the speed of light is 1, the size of the universe is the time of the event P, $T_s + T_e$. It is

$$\beta_p = \frac{R_\beta}{T_s + T_e}$$

. At this time, Ts is the time when the β inertial system reaches the distance of β(1-r) at the speed of β, so it is $T_s = \frac{\beta(1-r)}{\beta}$. And, since P is a point on an ellipse with major axis diameter r, Te satisfies $r = T_e + R_\theta$ in terms of distance. In this case, the speed of light is assumed to be 1, so the time is Te $= \frac{r - R_\theta}{c} = r - R_\theta$.

At this time, point P is moving away from point C at the speed of β_p , so according to special relativity, time passes more slowly relatively than point C. Thus the age of the universe at point P is

$$\sqrt{1-\beta_p^2}\,(T_s + T_e)$$

From this, it is obtained that

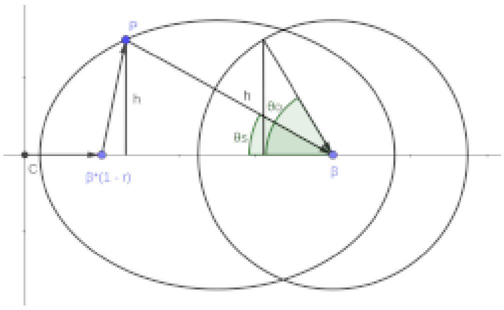
$$\sqrt{1-\beta^2}\,\sqrt{1-r}$$

And, since this is a value dependent only on r and β, which is unrelated to ϑ where the ϑ information that existed at the input time disappeared, it satisfies the isotropy that the universe should be seen equally in all ϑ directions. In addition, this is the age of the universe around it felt in all arbitrary primordial inertial systems β where time is slowly flowing at the speed of $\sqrt{1-\beta^2}$. Therefore, all observers of the primordial inertial system β see the age of the universe in area r distance away from themselves as $\sqrt{1-r}$, which is based on the standard of feeling that their own age is 1. And, this satisfies the uniformity of the universe that the universe viewed from all primordial inertial systems must be the same.

4 Matter density distribution of the universe

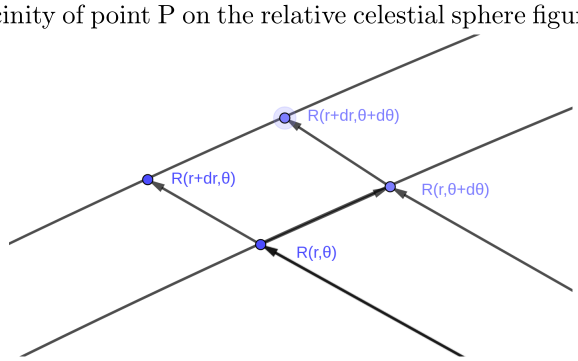
When a central observer looks at the center of an inertial system moving away, the density of matter appears to be higher because time passes more slowly in the receding inertial system. In the case of constant velocity expansion, the average distance between material particles becomes as tight as $\sqrt{1-\beta^2}$, so the three-dimensional density is $\frac{1}{\sqrt{1-\beta^2}^3}$, and considering special relativistic length contraction, it can be predicted that the observed material density will be $\frac{1}{(1-\beta^2)^2}$.

Calculating material density in polar coordinates is a bit complicated.



θ_o in the β inertial frame is θ_s from the central observer's point of view, and the density function assumed above was the formula for the central observer's position. Even if this density function is changed to the density function of the β inertial system position, it is necessary to check that isotropy is maintained without directionality and that it is the same in all inertial systems.

Since I am going to find the density, the volume element must be defined. In polar coordinates, ϑo is usually used as latitude, but here, latitude is given to φo, which will be used only once as the value of 0 near the equator. φo is the same as φ. Since it is near the equator, cos(φo)=1, which makes the calculation easier. In order to find the micro volume element based on the C inertial system, which is the form of dr $r\cos(\varphi_O)\,d\vartheta\,r\,d\varphi_o$ -> r^2 dr $d\vartheta o\, d\varphi o$ in the β inertial system, I will enlarge the vicinity of point P on the relative celestial sphere figure. Point P is expressed as $\vec{R}(r,\vartheta)$ from β to P.



Since it is a small area of an ellipse rather than a circle, simple definitions such as dr, rdϑo, and rdφo that are orthogonal to each other cannot be seen, but instead, definitions such as $\vec{R}(r+\mathrm{dr}, \vartheta)-\vec{R}(r,\vartheta)=\frac{d\,\vec{R}(r,\vartheta)}{dr}dr$ and $\vec{R}(r,\vartheta+d\vartheta)-\vec{R}(r,\vartheta)=\frac{d\,\vec{R}(r,\vartheta)}{d\vartheta}d\vartheta$ from the parallelogram can be used.

Since $R\,d\phi$ is in the z direction perpendicular to the xy plane, the definition of $r\,d\phi$ in a circle can be used as is. To calculate the density of the universe seen by the β observer, the needed area corresponding to dr $\times\, r\,d\theta$ from the micro volume dr $\times\, r\,d\theta \times r\,d\phi$ is $\frac{d\,\vec{R}(r,\theta)}{d\,r}\,d\,r \times \frac{d\,\vec{R}(r,\theta)}{d\,\theta}\,d\,\theta$. What we want to know is not the absolute density, but the ratio of the density of the point P to the density of the center β of the inertial system. So what is needed is not the actual micro volume, but the ratio of micro-volumes based on r and ϑ. So, I computed $\frac{d\,\vec{R}(r,\theta)}{d\,r} \times \frac{d\,\vec{R}(r,\theta)}{d\,\theta}$.

In this case, since each point P is the same distance from point β and is arbitrary ϑ, the observed events of particles around point P are not simultaneous with respect to the observation center C. Hence, the size of the universe at each P event based on C is different. Therefore, the area that is a parallelogram in this microdomain must be projected onto the normalized universe, and since this is the case of an infinitesimal domain, the characteristics of a parallelogram do not change, only the size changes.

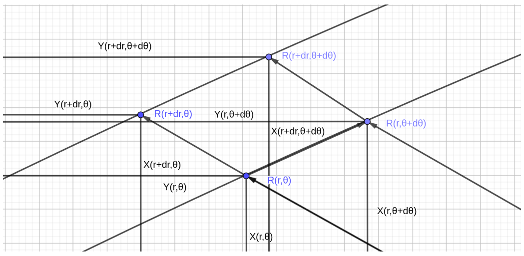
The expression corrected for that is $\frac{d\,\vec{R}(r,\theta)/T}{d\,r} \times \frac{d\,\vec{R}(r,\theta)/T}{d\,\theta}$, and since the z-axis is the celestial sphere based on the β inertial system, it becomes $r\,d\,\phi$, and since it only needs to be considered around $\phi \rightarrow 0$, it is actually only the value of the z-axis proportional to r. However, since the time of the point P event differs according to ϑ as mentioned above, the z-axis term must also be divided by the size (time) of the universe at that time point in the same way. Since the z term is always perpendicular to the previous parallelogram, it can be expressed as a scalar product without need of vector product, and the proportional expression of the final micro volume including this is

$$\frac{d\,\vec{R}(r,\theta)/T}{d\,r} \times \frac{d\,\vec{R}(r,\theta)/T}{d\,\theta} \cdot \frac{d\,\vec{R}(r,\theta,\phi)/T}{d\,\phi}$$

. This can be expressed conveniently in a determinant.

$$\begin{vmatrix} \frac{d\,\vec{R}(r,\theta)/T}{d\,r} \cdot \hat{X} & \frac{d\,\vec{R}(r,\theta)/T}{d\,r} \cdot \hat{Y} & 0 \\ \frac{d\,\vec{R}(r,\theta)/T}{d\,\theta} \cdot \hat{X} & \frac{d\,\vec{R}(r,\theta)/T}{d\,\theta} \cdot \hat{Y} & 0 \\ 0 & 0 & \frac{d\,\vec{R}(r,\theta,\phi)/T}{d\,\phi} \cdot \hat{Z} \end{vmatrix}$$

This can be expressed by the C-referenced Cartesian coordinate expression $X(r,\theta)\hat{X} + Y(r,\theta)\hat{Y}$, rather than the β-referenced polar coordinate expression R vector,



And, as for the Z-axis, φ-direction, since it is a value only of the z-axis, it simply can be obtained directly from the definition and is $\frac{d\vec{R}(r,\theta,\phi)/T}{d\,\phi} \cdot \hat{Z} = \frac{\mathrm{dZ}(r,\theta,\phi)/T}{d\,\phi} = \frac{r/2}{T}$. The reason why 1/2 is entered is that it is the celestial sphere in the β inertial system, and this has been explained through the figure of 'The observed universe'. With this and the Cartesian coordinate position expression $X(r,\theta)\hat{X} + Y(r,\theta)\hat{Y}$, the ratio of the micro volume is expressed as follows.

$$\begin{vmatrix} \frac{dX(r,\theta)/T}{dr} & \frac{dY(r,\theta)/T}{dr} & 0 \\ \frac{dX(r,\theta)/T}{d\theta} & \frac{dY(r,\theta)/T}{d\theta} & 0 \\ 0 & 0 & \frac{r/2}{T} \end{vmatrix}$$

And, by multiplying this by the basic material density function estimated earlier, we can obtain the polar coordinate expression of the density distribution function of the universe observed from each inertial frame.

$$\frac{1}{(1-\beta^2)^2}\begin{vmatrix} \frac{dX(r,\theta)/T}{dr} & \frac{dY(r,\theta)/T}{dr} & 0 \\ \frac{dX(r,\theta)/T}{d\theta} & \frac{dY(r,\theta)/T}{d\theta} & 0 \\ 0 & 0 & \frac{r/2}{T} \end{vmatrix}$$

The result is

$$\frac{1}{8}\left(\frac{r}{1-r}\right)^2$$

, which shows that the cosmological principles of uniformity and isotropy of the universe are established because it is not affected by any β or θ.

5 Discussion

- According to this theory, the total number of galaxies in the entire universe can be roughly calculated based on the fact that within a radius of 12 million light-years around the Earth, there are 152 galaxies. This calculation suggests that there are approximately 5 to 10 trillion galaxies. Although slightly more than the 2 trillion galaxies estimated by recent observations, this discrepancy may be attributed to the presence of the Milky Way in regions where the matter density is higher than the cosmic average or the possibility that more galaxies could be discovered with more powerful telescopes than the James Webb Space Telescope.
- Even without borrowing the power of other theories, it can explain the fact that there is almost no antimatter and only matter exists in the observable universe. Although the size of the universe is finite in the actual distance scale, it is infinite in size expressed in redshift, containing roughly the same matter and energy within the same redshift range, so among such infinite regions is the matter-dominant zone, the antimatter-dominant zone, and the complete annihilation zones may exist. Thus, theoretically, it is not problematic that matter predominates uniformly within this observed range.
- Theories such as 'baryon acoustic oscillations' cannot be the evidence of general relativity-based cosmology, and Benoit-Lévy and Chardin's Dirac-Milne cosmology has shown that such calculations can be made well even with the constant velocity expansion theory.

6 Conclusion

It has been demonstrated that the solutions to the cosmological principles lie within the framework of special relativity. While this outcome does not fit the tenets of modern cosmology rooted in general relativity, considering that special relativity holds a more foundational status as a law, it would be reasonable to accept it as a means to describe the shape of the universe.

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