Redshift Adjustment to the Distance Modulus

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The distance modulus is derived from the logarithm of the ratio of observed fluxes of astronomical objects. The observed fluxes need to be corrected for the redshift as the ratio of observed to the emitted energy flux is proportional to the wavelength ratio of the emitted to observed light according to Planck's law for the energy of the photon. By introducing this redshift adjustment to the distance modulus, we find out that the apparent "acceleration" of the expansion of the Universe that was obtained from observations of supernovae cancels out.

1 Introduction

In the present study a redshift adjustment to the distance modulus was introduced. The rationale is that the observed fluxes of astronomical objects with respect to the emitting body are being reduced by the effect of redshift. According to Planck's law, the energy of the photon is inversely proportional to the wavelength of light; therefore, the ratio of observed to emitted fluxes should be multiplied by the wavelength ratio of emitted to observed light.

2 Model development

Below is shown the derivation of the redshift adjusted distance modulus.

Let us recall the derivation of the distance modulus. The magnitude as defined by Pogson [1] is:

$$m = -2.5 \log F + K, \tag{1}$$

where m is the magnitude, F the flux or brightness of the light source, and K a constant. The absolute magnitude is defined as the apparent magnitude measured at 10 parsecs from the source.

By definition, the brightness is a measure of the energy flux from an astronomical object and depends on distance. Therefore, a redshift correction to the flux is derived from Planck's law for the energy of the photon

$$E = \frac{h \cdot c}{\lambda}, \tag{2}$$

where E is the energy of the photon, h the Planck's constant, and λ the light wavelength.

The ratio of observed to emitted energy flux is derived from eq. (2), leading to

$$\frac{E_{obs}}{E_{emit}} = \frac{\lambda_{emit}}{\lambda_{obs}} = \frac{1}{1+z}, \tag{3}$$

where E_{obs} and E_{emit} are respectively the observed and emitted energy fluxes, λ_{obs} and λ_{emit} are respectively the observed and emitted light wavelengths, and z the redshift.

As light is emitted from a source, it is spread out uniformly over a sphere of area $4\pi d^2$. Excluding the redshift effect, the brightness – expressed in units of energy per time and surface area – diminishes with a relationship proportional to the inverse of square distance from the source of light. Therefore, taking into account the redshift effect, the following relationship is obtained for the brightness:

$$F_{obs} \propto \frac{L_{emit}}{d^2} \cdot \frac{E_{obs}}{E_{emit}}, \tag{4}$$

where L_{emit} is the emitted luminosity, and d the distance to the source of light.

Combining eq. (1), (3) and (4), we obtain

$$m = -2.5 \log \left(\frac{L_{emit}}{d^2 \cdot (1+z)} \right) + K. \tag{5}$$

And, because z is close to zero at 10 Parsec:

$$M = -2.5 \log \left(\frac{L_{emit}}{100} \right) + K, \tag{6}$$

where M is the absolute magnitude.

Hence, the redshift adjusted distance modulus, eq. (5) minus eq. (6) is:

$$m - M = -5 + 5 \log d + 2.5 \log(1+z) \tag{7}$$

with d in parsec, and log is the logarithm in base 10.

3 Discussion

In the present study the distance modulus was adjusted to take into account the effect of redshifts on the observed fluxes of astronomical objects. Evidence of an "accelerating" Universe expansion was established based on the observation of supernovae [2]. This result was obtained by detecting a deviation from linearity on the distance modulus versus redshift plot in log scale for supernovae. In order to account for the redshift adjustment, the adjusted distance modulus $m - M - 2.5log(1 + z)$ should be plotted againt redshifts for the supernovae. A deviation of $m - M$ of about +0.5 magnitude was obtained at redshift 0.6. The redshift adjustment

$2.5log(1+z)$ is roughly equal to this deviation. By introducing the redshift adjusted distance modulus eq. (7) this deviation cancels out, and one may no longer conclude that the expansion of the Universe is accelerating.

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References

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