DETERMINATION THE AGE OF GALAXIES USING STRONG GRAVITATIONAL LENSING

Abdullah K. Ahmed
Department of Astronomy, College of Science, University of Baghdad, Iraq.

Abstract

Most of the known cases of strong gravitational lensing involve multiple imaging of an active galactic nucleus. The properties of lensed active galactic nuclei make them promising systems for astrophysical applications of gravitational lensing. So we present a simple model for strong lensing in the gravitational lensed systems to calculate the age of four lensed galaxies, in the present work we take the freedman models with (*k curvature index =0*) Euclidian case, and the result show a good agreement with the other models.

Introduction

Some of galaxies behave as a big lens relative to the Quasars behind them. This phenomena known as gravitational lensing which defined as the deflection of light by massive bodies [1].

Cosmology is concerned with extragalactic world. It's the study of the large scale structure of the universe extending to distances of billions of light years, i.e. a study overall dynamic and physical behavior of billions of galaxies spread across vast distances and of the evolution of this enormous system over several billon years [1]. One of these important study is the determination the galaxies age that leads us to limit approximately age of the universe. We will need her:

Distance Measuring using Freedman Models

If the observed object have some separation angle "θ" then the relation between separation angle "θ" that subtends a specific angle, the distance of the object "D_A" needs to be equal to the Euclidean formula. Fig.(1) shows the angular diameter distance [2].

The Friedman models are frequently used to interpret the cosmological observations. Our aim is driving final formula for the cosmological distance in the Euclidian case, which expressed by three factors (z, H0, q), where z is the redshift, H_0 Hubble constant, and q acceleration parameter, [1]:

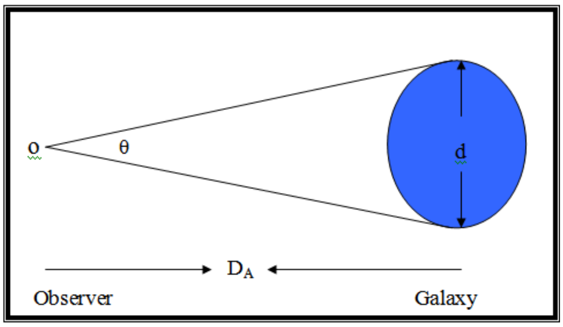


Fig. (1) : The angular diameter distance between a Galaxy G and observer O. [3].

From the equation:

$$\int_{t_1}^{t_o} \frac{c\,dt}{R(t)} = \int_0^{r_1} \frac{dr}{\left(1-kr^2\right)^{1/2}} \quad \text{.............................(1)}$$

Where, C speed of light, R (t) represent the cosmic expansion scale factor, r one of the spherical coordinates.

For *K=0* we get:

$$\int_0^{r_1} dr = r_1 = \int_{t_1}^{t_o} \frac{c\,dt}{R(t)} \quad \text{..................................(2)}$$

And from the equation:

$$R(t) \propto t^{2/3} \Rightarrow R(t) = c\,t^{2/3} \quad \Rightarrow R_o = c\,t_o^{2/3} \quad \text{...................(3)}$$

Then from eq.(3), it's easy to get:

$$R = R_o\, t^{2/3}\, t_o^{-2/3} \quad \text{.................................(4)}$$

Now, by substituting eq. (4) in eq.(2) we get:

$$r_1 = \frac{c}{R_o}\int_{t_1}^{t_o} t^{-2/3}\, t_o^{2/3}\cdot dt = \frac{c}{R_o}\, t^{-2/3}\cdot 3\left(t_o^{1/2} - t_1^{1/2}\right)$$

$$= \frac{3c}{R_o}\, t_o \left\{1-\left(\frac{t_1}{t_o}\right)^{1/3}\right\} \quad \text{..(5)}$$

And by using equation:

$$\frac{c\Delta t_o}{c\Delta t_1} - \frac{R(t_o)}{R(t_1)} = 1+z \quad \text{..........................(6)}$$

We get:

$$1+z = \frac{R(t_o)}{R(t_1)} = \frac{t_o^{2/3}}{t_1^{2/3}} = \left(\frac{t_o}{t_1}\right)^{2/3} \quad \text{...............(7)}$$

The Hubble constant can be expressed as follow:

$$H_o = \frac{\dot{R}_o}{R} = \frac{2}{3}\frac{R_o}{t_o} \Big/ R_o \Rightarrow H_o = \frac{2}{3}\frac{1}{t_o}$$

$$\Rightarrow t_o = \frac{2}{3}\frac{1}{H_o} \qquad 8$$

$$\text{..............................(8)}$$

Equation 5 can be written as follow:

$$r_1 = \frac{3c}{R_o} t_o \left[1 - \left\{\left(\frac{t_1}{t_o}\right)^{2/3}\right\}^{-1/2}\right]$$

$$= \frac{3c}{R_o}\frac{2}{3H_o}\left\{1-(1+z)^{-1/2}\right\} \quad \text{................(9)}$$

$$= \frac{2c}{R_o H_o}\left\{1-(1+z)^{-1/2}\right\}$$

The Angular diameter distance is given by:

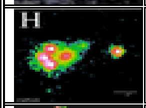
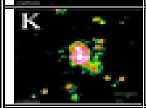
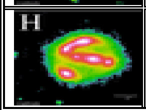
$$D_A = \frac{r_1 R(t_o)}{(1+z)} \quad \text{...................................(10)}$$

Using equation (9) the angular diameter distance can be calculate as follow:

$$D_A = \frac{2c}{H_o}\left\{(1+z)^{-1} - (1+z)^{-3/2}\right\} \quad \text{..........(11)}$$

Then from eq.(11) by taken H_o = 50 km s^{-1} Mpc^{-1}, q= 0, and from Table (1):

Table (1)
Redshift for the quasars from CASTLES Survey [4].

Image	System Name	Lens Redshift (Z)
	B0218+357	0.68
	RXJ0911+0551	0.77
	PKS1830-211	0.89
	B1608+656	0.63

The angular diameter distances D_A can be calculated for the Galaxies as shown inTtable 2. See Fig.(2).

Table (2)
Distances of quasars.

N	systems	D_A(Mpc)	D_A(MLY)
1	B0218+357	1360.5	4435.23
2	RXJ0911+0551	1402.5	4572.15
3	PKS1830-211	1433	4671.58
4	B1608+656	1333.3	4346.558

The Redshift

The wavelength of the light wave increases by a fraction z in transmission from galaxy G to us, provided $R(t_o) > R(t_1)$ the quantity R(t) is the time dependent curvature radius of the finite universe. In other words, Hubble observations of red shift are explained if we assume R (t) to be an increasing function of time. Also, it's useful to relate z to the velocity of the observed object v. When the galaxy G has the separation velocity v and this velocity is a significant fraction from c speed of light, we can use the spatial relativistic relation to define the redshift [3]:

$$1+z = \left[1+\frac{v}{c}\Big/1-\frac{v}{c}\right]^{1/2} \quad \text{..................(12)}$$

The spatial relativity predicted that no bodies have velocity grater than of light. Therefore when *v* = *c* then *z* gone to infinity.

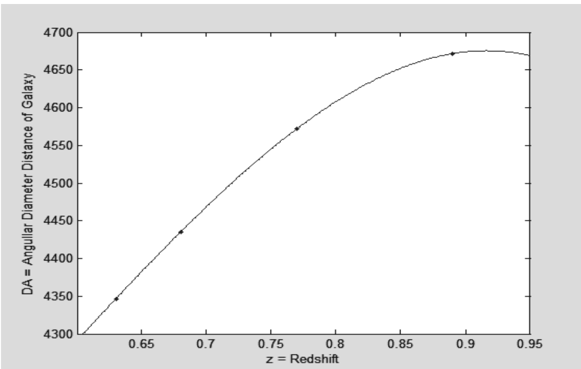


Fig.(2) : The angular diameter distance D_A as a function of redshift z of the observed source.

If we consider the earth is the center of the motion, we can with the help of eq.(12) determine the velocity of quasars which yields to determine the age of the galaxy, Then we adding the age of the earth which is 4.5 billion years, that was suggested currently from Lawrence Badash, 1989[5]. The procedure can be expressed as follow:

1. Determine the distance of the galaxy in parsec from the freedman solution.
2. Using Hubble's law:

$V= H_o D_A$ ....(13)

Where V the velocity of galaxy, H_o Hubble's constant and D_A distance in the expanding Universe, The subscripted "0" refers to the present epoch because in general H changes with time. The dimensions of H_0 are inverse time, but it is usually written [6]:

$H_0 = 100\ h\ Km\ s^{-1} Mpc^{-1}$.......................(14)

$T= 1/ H_o=9.78\times10^9\ h^{-1}\ yr$.....................(15)

Then from the big bang T is the time or it's the age from the earth to the galaxy, and then adds the earths age resulted the age of galaxy. See Table (3).

Table (3)
Distances and time of quasars.

N	systems	D_A (MLY)	t(year)
1	B0218+357	4435.23	14.7×10^9
2	RXJ0911+0551	4572.15	14×10^9
3	PKS1830-211	4671.58	13×10^9
4	B1608+656	4346.558	15.2×10^9

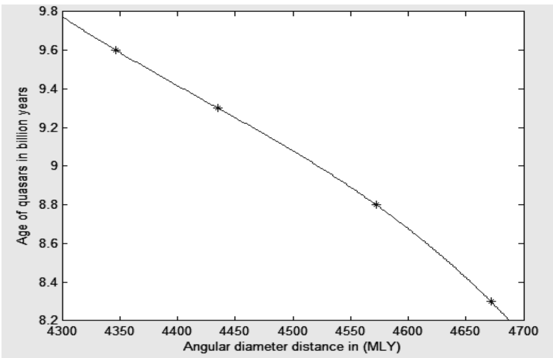


Fig.(3) : Age of quasars T as a function of Angular Diameter Distance D_A.

The Results and Conclusions

From the above results, we can conclude that:

The Friedman models are frequently used to interpret the cosmological observations, therefore, it can be used to find the distances of galaxies see Table (2).

We saw also the wavelength of the light wave increases by a fraction z in transmission from galaxy G to us eq.(12).

Finally from using the above, the age of galaxies can be determined from using strong Gravitational Lensing which is the main target of this search that leads us to imaging the age of galaxies which give some knowledge about the history of the universe, and support the Hubble equation about the universe.

References

[1] V. N. Jayant, "Introduction to Cosmology", Cambridge University pres, 1993.
[2] W. S. Robert, "Cosmological applications of gravitational lensing", Ph. D thesis, Potsdam University, London, Britannia, 2000.
[3] M. A. Ahmed, "Cosmological Applications of Gravitational Lensing", University of Baghdad, 2004.
[4] CASTLES Survey Web site: cfawww.harvard.edu/castles/.
[5] Lawrence Badash, "The Age of the Earth Debate", August 1989, by Scientific American, Inc. Microsoft ® Encarta ® 2008.
[6] David W. Hogg, "Distance measures in cosmology", Institute for Advanced Study, December 2000.

الخلاصة

أغلب منظومات التعدس الجذبي القوي تحتوي على صور متعددة لنواة مجرية فعالة, خصائص هذه النواة المجرية الفعالة والتي عانت صورتها تعدسا جذبيا جعلتها منظومات واعدة لتطبيقات فيزياء الفلك الخاصة بالتعدس الجذبي. لذا سنقدم هنا لنموذج بسيط للتعدس الجذبي القوي في منظومة تعدس جذبي لحساب عمر أربع مجرات تعدسية. في عملنا الحالي أستعملنا أحد نماذج فريدمان وهي الحالة الاقليدية والتي فيها ثابت تحدب الفضاء (k=0)، حيث أظهرت النتائج تطابق جيد مع الموديلات الاخرى.