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Equalibrium Chain Of Stars: Curve Path

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Abstract

The open (hyperbolic) model of the Universe is characterized by the values of q < ½. The transition between open and closed models of the Universe is characterized by the flat (parabolic) model which corresponds to the critical value q = ½. In terms of the mass density it follows from that the critical mass density in the present day Universe is given by which marks the flat model of the Universe. The closed and open models are similarly characterized respectively by $r_u > 1.0 \times 10^{-29}$ *gm* cm^{-3} *and* $r_u < 1.0 \times 10^{-29}$ *gm* $cm^{-3.}$ *The currently observed density of* $r^{obs} – 1.5 \times 10^{-30}$ *gm* cm^{-3} *then points in favor of the open model: but as we have already mentioned, the present day observational status is not sufficient to draw a definite conclusion in this regard. Extensive search, of course, is going on currently tundra we definite conclusion in this regard. Extensive search, of course, is going on currently in order to establish a more meaningful value of the mass density of the Universe. This is very important as it will determine whether our universe is open, closed or flat.*

Keywords: *Universe, Dynamical Nature, Galaxies, Interstellar.*

1- INTRODUCTION

In the earlier chapters we have attempted to introduce ourselves with the physical as well as the dynamical nature of stars and galaxies and also of the interstellar matter, out of which new stars are born. All these objects are the contents of the Universe. Besides these, the Universe also contains the intergalactic matter, radiation, magnetic field and cosmic rays. The question then naturally arises: what possibly is the physical and kinematical nature of the Universe itself, when considered in its entirety? Cosmology is the science which attempts to give a satisfactory answer to this fundamentals question regarding the understanding of the phenomena behind the Cosmos. A definite answer to this question has not, however, yes been found by the scientists. It turn out that the problems extremely complex and the attack to it has so far become only piecewise and in indirect manner. The basic requirement in formulating a comprehensive theory of cosmology lies in truly knowing some of the basic facts about the Universe. These are, the shape (geometry) and size, the mass density and the total mass content, the age, the phase of its present dynamical behavior, and its chemical evolution with time. All these information are very fundamental for the understanding of the nature of any object. For any individual objector a group of objects occupying any local region of space, this information is very difficult to acquire through experiments and theoretical postulates. But for the Universe as a whole, it is precisely these simple fats which pose great difficulties to be known. In fact, none of these basic facts has yet been known with any amount of definiteness when the Universe as a whole is concerned. Even the most powerful optical and radio telescopes available at present are unable to fathom the whole depth of the Universe, and whatever observations at large distances have been obtained, their true interpretations have very often eluded the scientists.

Nevertheless, the observations are very essential: any good theory of cosmology should not only to be based on the latest observations, but also should conform to any new set of observational acts that may be known in future. It is precisely on this line that the attempts have so far been made to build cosmological theories, but only with marginal success. Various models of cosmology have been built by the authors under various assumptions. But none of these models can be singled out as an ideal one. Each appears to be vulnerable to drawbacks when tested with observational results. Not only that, observations themselves have not yet come to the level on the basis of which a final conclusion can be drawn this is particularly true in the case of object at very great distances. Evidently, it sis these objects that can provide basis for discrimination between the merits of the different models. But since these distant objects are very faint, not only, that uncertainties creep in the results, but also that the correct interpretation of the observations become increasingly difficult with distance. It appears therefore, that when we attempt to understand the true physical as well as geometrical nature of the universe. We are inadequately equipped both with the observational as well as with theoretical attainments.

2- ONE STEP AHEAD

In the early years of this century beginning from 1912. V.M. Slipher of the Lowell Observatory measured large radialvelocitites in a number of nebulae. A few of these showed velocities of approach, while most others were found to be moving away from us with deferent velocities ranging as high as 1800 km s^{-1}. These observations could not be correctly interpreted at that time because there extragalactic nature was not known. It was only through the extensive observational works of Edwine P. Hubblein 1920s thata correct explanation of Slipher's observations was revealed. These nebulae were discovered to be external galaxies and those showing approaching velocity were known to be members of the local group of galaxies. In late 1920's Hubble computed the radial velocity of recession of a large number of nearby galaxies on the one hand, and on the other. Could ascertain the distances of many of these galaxies by using the arouse distance indicator. Hubble's work soon revealed that the velocities of recession of galaxies were, in fact, directly proportional to their distances. The work was further carried out by Hubble and Humason through the subsequent years with fainter and fainter (so more and more distant) galaxies which only confirmed Hubble's original finding. Hubble's law was thus established for the galaxies flying away in all directions. This law has often been called the law of red shifts since the recessional speeds are revealed by lines in the spectra of galaxies shifted towards longer wavelengths (red end).

Once Hubble's law was established on the observational basis, the main difficulty then rested on the accrete evaluation of the constant of proportionality H., the problem of correctly evaluating H is basset with many difficulties and an absolutely satisfactory value is yet tube determined. Nevertheless, various working values of H have been used from time to time. Hubble himself used a value of 540 kms^{-1} Mps^{-1} a value too large to be accepted during the subsequent years. Hubble's value was greatly in error as he did not correct the measured distance for interstellar absorption, unknown at the time of Hubble's work. The later values of H usually range from 50 to 150 km s^{-1} Mpc^{-1} Much work has been done in 1960s and early 1970s and the value of 75 km s^{-1} Mpc^{-1} on the basis of latest date. Many astronomers are currently in favor of using this last value. It may be useful to mention here that for the evaluation of H one has to observe galaxies lying within a narrow range of distances. The lower limit of the range is determined by the average random velocities of the galaxies in the radial direction. This average is of the order of 200km s^{-1} and only those galaxies whose recessional velocities supersede this average have to be observed for the purpose. Assuming the value H= 70km s^{-1} Mpc^{-1} which means that galaxies at a distance of 1 Mps will recede at the rate of 70 km $s^{-1.}$ The minimum distance at which observation will be meaningful for the purpose is – 3Mps. The upper limit of the distance range is determined by distance to which the distance indicators such as large H II regions. Globular clusters, novae, etc. can be used. This distance can be roughly taken as – 25 Mpc. Thus, for the evaluation of H one has to compute by some independent method the distances of galaxies lying in the range between 3to25Mpc. The rich cluster of galaxies in Virgo which lies in this range has been widely used for the purpose.

Whatever uncertainties may be there in determining the value of H, the observed red shifts can have only one interpretation, that the galaxies in all distance to the galaxy. This leads to the conclusion that at least at the present time the Universe is expanding. All galaxies and clusters of galaxies are flying away from us with speeds proportional to their distances. Here, of course, we have tacitly made two assumptions: first, the brightest cluster galaxies in different clusters have the same intrinsic luminosity, and secondly, the observed redshift is due to expansion. Both these assumptions, particularly, the second one may not be correct. But at present, there is no verified physical law which can replace the expansion hypothesis and therefore, the latter is generally accepted as the correct one. Thus, the redshift being a measure of the recessional speed of a galaxy, indicates a linear distance-velocity relation to exist between the galaxies which are motto far. But whether this linear relation holds also for galaxies at much greater distances cannot best abolished on the basis of current observations. If the speeds were uniform throughout then it becomes easy to calculate the time scale of the Universe which is the time elapsed since the expansion began. If to be this time. Then t_o = DIV = H^{-1} which is – 1.33 x 10^{10} years for H = 75 km s^{-1} Mpc $^{-1}$ and - -2 x 10^{10} years for H= 50 km s^{-1} Mpc^{-1}. Thus, considering the latter value of H. one can conceive that all the matter in the universe was together in a sup dense form and at extremely high temperature about 2 x 10^{10} years ago when. Possibly, a gigantic explosion took place and as a result material has been flying apart since then. The time to can thus be considered as the age of the Universe in its present phase. At this stag he the question arises whether the rate of expansion of the Universe remained constant throughout or has it undergone a deceleration as its age advanced. At present, the cosmologists do not have a definite answer to this question. But according to Newton's law of gravitation, since every mass element attracts every other lament, the Universe possibly could not undergo a free expansion. The force of gravitation must have produced a deceleration on the flying galaxies whose speeds of recession must therefore have gradually decreased. If this is true, then the rate of expansion was faster in early days of the Universe than it is now, and its actual age would be somewhat less than that calculated now, which may be considered as the extreme upper limit of the age. In the case of deceleration, $t_{0,}$ H^{-1}. The difference between these two ages is illustrated schematically.

An extreme upper limit of the age of the Universe according to the current observational data combined with theoretical concept of the Universe is thus about 2 x 10^{10} years, when one assumes that its expansion rate has been uniform since the beginning. This age may be compared with the independently calculated ages of other astronomical objects. For example, all geological studies and radioactive decay anlyses have shown that the age of the Earth is < 4 x 10^9 years. In fact, the greatest age on Earth is predicted by Pb-U dating which yields anupper age limit of 3.5 x 10^9 years. The upper age limit of lunar rocks borne to the Earth by the Apollo Mission has been calculated to be 4.5 x 10^9 years. The analyses of meteorite structures have also ascertained the age of 4.5 x 10^9 years for these interplanetary objects. Curiously enough. This is exactly the order fo the age that has been predicted for the Sun on the basis of stellar evolution theory. Thus, all these independent and different studies indicate that the solar system is probably not older than 5 x 10^9 years-much less than our calculated age of the Universe. But in the Galaxy there are several othor objects which are believed to be much older than the solar system. The best examples are globular clusters, old galactic clusters, RR Lyrate variables and subdwarfs. But as is currently understood by astronomers, none of these objects are oprobably older than 1.5 x 10^{10} years. From both observational and theoretical viewpoints therefore, the estimated age of 2 x 10 ^{10} years of the Universe with and uncertainty of $\underline{+}$ 50 per cent., arising out of the uncertainly in evaluating the Hubble's constant H seems to be quite reasonable.

Lastly, we can attempt to answer in a very simple manner the question: how large is the Universe? The extreme upper limit of the velocity with which a galaxy can move away is c, the speed of light. So the extreme upper limit of distance to which a galaxy can move during the age of the universe is equal to ct_0 = 2 x 10 ^{28} cm or = 6600 Mpc. This is the order of the size (the radius) of the Universe at present.

It must be emphasized that the observed fact that galaxies are receding equally in all directions does not imply that we are occupying the central position of the Universe. In fact, an observer situated at any region of the Universe, will have the similar view.

Suppose observers at two different regions O and O' see a galaxy at P where, using Victorial distance,

OO' = $D_{O'}$ OP=D and O'P=D'

Then, D' = D- $D_{0'}$

Also, V = Dd/dt = HD and

V' = dD'/dt =H (D – $D_{O)}$ = HD',

by Gubble's law. Thus Hubble's law equally holds for a galaxy at any- point P when it is observed from any two point O and O'. Hence, so for as the recession of galaxies is concerned, the Universe looks the same from all points. We shall further discuss this point in Section.

3- A BINARY SETTING

When distances to galaxies and clusters of galaxies are known accurately, it becomes a simple matter to calculate intergalactic distances and compute the number density of galaxies over a given volume of space. The average mass density will follow from a multiplication of the average number density be the average mass of a galaxy. On the basis of the current observational data, the observed mass density of the universe has been computed to be ρ_{pbs} - 1.5 x 10^{-30} $gmcm^{-3}$. The observed density of the luminous matter is – 20 per cent of this value.

If the present Universe was created with a gigantic explosion of a super massive body as the Big Bang theory postulates, the expansion velocity will be decelerated by the self gravitation of the matter. Whiter the expansion of the Universe will altogether be halted at some future time is actually determined by computing by computing the magnitude of the deceleration parameter defined by

$$Q = - \frac{RR}{R^2} = - \frac{R}{H^2 R}$$

Where R =HR cZ which represents the Hubble law. We assume that all the quantities considered are the present- day values, R (t) being the radius of the present-day Universe. The present day matter density ρ_u is related to q by

$$\rho_u = \frac{2H^2 q}{4\pi G}$$

G being the constant of gravitation. For H = 70 kms^{-1} Mpc^{-1}

$$R_u \approx 2 \text{ x } 10^{-29} \text{ q gmcm}^{-3}$$

It turnout that q is related to the curvature of space. For the model of the Universe, with positive curvature (one of the Fried man models) the declaration will have to be sufficient as to bring the expansion to a halt and reverse it. This is then the closed or oscillatory Universe with an oscillation time of

$$T = \frac{2\pi q}{H\ (2q-1)^{3/2}}$$

This time becomes meaningful only when q> 1/2, which therefore is the condition for a closed universe.

The open (hyperbolic) model of the Universe is characterized by the values of q < ½. The transition between open and closed models of the Universe is characterized by the flat (parabolic) model which corresponds to the critical value q = ½. In terms of the mass density it follows from that the critical mass density in the present day Universe is given by which marks the flat model of the Universe. The closed and open models are similarly characterized respectively by r_u > 1.0 x 10^{-29} gm cm^{-3} and r_u < 1.0 x 10^{-29} gm cm$^{-3.}$ The currently observed density of r^{obs} – 1.5 x 10^{-30} gm cm^{-3} then points in favor of the open model: but as we have already mentioned, the present day observational status is not sufficient to draw a definite conclusion in this regard. Extensive search, of course, is going on currently tundra we definite conclusion in this regard. Extensive search, of course, is going on currently in order to establish a more meaningful value of the mass density of the Universe. This is very important as it will determine whether our universe is open, closed or flat.

The actual discrimination between the open, flat and closed models of the Universe requires the determination of a distinct value of q. this can we achieved only by observations at very great distances where Z $\geq$ 0.4 with H = 70 km s$^{-1,}$ the above redshift corresponds to a distance of about D – 2000 Mpc. At these distances, only the brightest galaxies in clusters can be used assistance discriminators. We chantry to understand the concepts of the open, flat and close cosmological models by a quite common analogy derived from of Newtonian mechanics. We know that if a body on the Earth is thrown with a kinetic energy corresponding to a velocity less than the escape velocity (11.2 km s^{-1}), it will return back to the Earth. This case is analogous to the closed universe model in which the sufficiently high density of matter in the Universe (ρ_u > 1 x 10^{-29} gm cm^{-3} and q> ½) produces enough gravitational deceleration to halt its expansion. the flat cosmic model is analogous to the case in which the kinetic energy given it the body is just sufficient to provide it the escape velocity which the kinetic energy given to the body is just sufficient to provide it the escape velocity which subsequently moves in a parabolic orbit and comes to rest at infinity. The mass density in this model equals the critical vaue of 1 x 10^{-29} gm cm^{-3} and q = ½. If, on the other hand, the kinetic energy given to the body corresponds to a velocity in excess of the escape velocity, it will move to infinity in a hyperbolic orbit with some finite menetic energy. This base finds analogy with the open Universe model which corresponds to (ρ_u > 1 x 10^{-29} gm cm^{-3} and q< ½. The following simple mathematical treatment will make the point more easily comprehensible.

Let us suppose that the Universe is an expanding sphere of constant mass M but whose radius R (t) and density ρ (r) are changing in time as it expands. Then,

$$M = \frac{4}{3}\pi\rho(t)\ R^3(t) \ = \text{constant}$$

And its equation of motion is

$$R = -\ \frac{GM}{R^2}$$

yields the energy integral

$$\frac{1}{2}R^2\ -\ \frac{GM}{R}\ = E$$

E being the total energy which is constant. Combining we get

$$q = \frac{1}{2} - \frac{E}{R^2}$$

Where R > o in an expanding Universe. Thus yields the following three cases:

1. $E < O, q > \frac{1}{2}$,
2. $E = O, q > \frac{1}{2}$,
3. $E > O, q > \frac{1}{2}$,

The first case corresponds to the closed universe; the second represents a flat Universe while the third represents an open Universe. These are shown schematically.

4- THE PRIMARY GOAL OF COSMOLOGY

The primary goal of Cosmology is to construct models of the Universe that will survive the tests of current observations and of those that may be made in future. Many model shave so far been constructed which represent various outlooks regarding the overall view of the Universe. All these models are however, based on the validity of a fundamental postulate which has been called the Cosmological Principle. The main contention of this principle is that the Universe presents the same picture at nay particular epoch in whichever direction we may look from whatever position, except for local irregularities, which are of statistical nature. The above statement physically embodies the isotropy and homogeneity of the Universe. Thus cosmological principle consists in taking for granted the concept that the Universe is isotropic arise as to how far this assumption may be considered valid on the basis of observations?

It turns out that the answer to this basic question is fortunately not baset with much complexity. Observations do really tend to confirm that the large-scale aspect of the Universe is isotropic and homogeneous. We have already seen that the Hubble's law of expansion of no matter which direction of the Universe we look to, the type and number density of galaxies are essentially the same. Of course, the colors of galaxies become increasingly redder as we look to greater distance on account of increasing red shifts

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