Hubble's Constant: The Clock of the Universe

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Abstract

Hubble's Constant is an experimental relationship between the speeds and separations of galaxies. It is shown that this information can be combined with the results of differential calculus to obtain an estimate of the value of the outward acceleration of each galaxy. On this basis, it is found that the speed of each galaxy increases with time while the corresponding separations from Earth vary as the square of this quantity. This relationship in turn indicates that the value of Hubble's Constant increases linearly with time, which means that it serves as a clock of the universe. These results are seen to be consistent with the "expanding universe" cosmological theory, but stand in contradiction to Einstein's supposition that the curvature of space is sufficient to ultimately allow for a slowing down of the expansion and even reverse it if there is sufficient mass for this to occur. Finally, it is shown that when the Laws of Thermodynamics are applied backward in time that the expectation is that state of matter is reached in which the value of the entropy of the universe is zero.

Keywords: Hubble's Constant, Big Bang explosion, Small net accelerations of the galaxies, Origin of the universe, Laws of Thermodynamics, Conservation of Energy. Open or closed universe

I. Introduction

In previous work[1] it has been shown that it is possible to combine experimental data for the distances and velocities of galaxies with results of differential calculus to estimate the value of the net acceleration of the galaxies. Edwin Hubble was able to measure the distances separating the various galaxies from the Earth and this information was combined with measurements of the red shifts of lines of the same galaxies which were obtained by Hubble's colleague, Milton Humason. From a purely qualitative point of view, these data showed that the galaxies are moving away from the Earth, in agreement with the general conclusion of an expanding universe. It was found that the ratio of the distance of a given galaxy to its speed relative to Earth is nearly the same in all cases for which measurements are available. This ratio has come to be known as Hubble's Constant. It has a value of approximately 10^5 ly /(mi/s). Accordingly, when $H = 10^5$ is defined as above in standard units of s ly/mi, the distance L is measured in mi and the speed v in mi/s, the following equation can be assumed to be valid to a good approximation :

$$L = HXv \, , \tag{1}$$

where X is the number of miles in a light year (5.8786×10^{12} mi/ly).

II. Estimating the Acceleration Value

If attention is centered on a single galaxy, it is possible to use standard formulas from differential calculus which assume a *constant* acceleration value A for its motion *away from the Earth*. Since HX=L/v in eq. (1) is a constant throughout the universe, it follows that the ratio $\Delta L/\Delta v$ of a given galaxy over an elapsed time Δt will essentially be the same as L/v, i.e. that H (or HX) will not change appreciably over this period of time. Accordingly, the current values of the speed v of the galaxy and its distance from earth L can be combined to obtain an estimate of A, as follows:[1]

After time Δt has elapsed relative to some as yet unspecified initial time t_0 on the basis of the standard formulas of differential calculus, one obtains a change in speed of $\Delta v = A\Delta t$ and corresponding change of distance of $\Delta L = A\Delta t^2/2$ relative to their respective current values of v and L, respectively. Elimination of Δt then leads to the following relation between A, Δv and ΔL:

$$A = \frac{\Delta v^2}{2\Delta L} \tag{2}$$

Substitution of $HX = \Delta L/\Delta v = L/v$ in eq. (2) then yields:

$$A = \frac{\Delta v}{2HX} = \frac{\Delta v}{t_X} \tag{3}$$

with $t_X = 2HX = 1.176\text{x}10^{18}$ s $= 3.726\text{x}10^{10}$ y.

It is interesting to note that eq. (2) is consistent with a determination of the acceleration due to gravity g in a local field. In that case, a freely falling object of mass m will attain a kinetic energy of 0.5 mv^2 when it has reached a speed v at a distance L from the origin relative to a standing start. At this point in time, the decrease in gravitational energy according to standard Newtonian theory is mgL. Equating these two energy values leads to an equivalent result to that for the acceleration A in eq. (2), namely $g = v^2/2L$.

One way to interpret the above results is simply to assume that t=0 refers to the time of the Big Bang. The first application of eq. (3) considered in Ref. 1 is for the present time frame when the speed of the given galaxy has reached its current value of v, i.e. it is assumed that $\Delta v = v$. The galaxy Hydra, which is known to have a speed of approximately $3.8\text{x}10^4$ mi/s has been used as an example.[1] Substitution of this speed gives a value for Hydra's current acceleration of 3.23x

10^{-14} mi/s^2. This amounts to 1.1706×10^{-10} ft/s^2. This value can be compared to the value of g at the surface of Earth of approximately 32 ft/s^2, which is 2.73×10^{11} times larger.

It needs to be emphasized that A refers to a "residual acceleration." It is the result of a nearly equal competition between gravitational forces and the inertial forces which originated in the Big Bang explosion. It is clear from eq. (3), however, *that gravity is losing the battle at every stage.* The acceleration A obviously causes the galaxy to slightly increase its speed, but as this happens, the value of A increases as well since it is always proportional to v. The changes are extremely small in all cases but they are always in the same direction, with the galaxies all heading farther out into space at an ever increasing rate. Moreover, it is clear that eq. (3) is perfectly consistent with the concept of an *expanding universe*. The farther out the galaxy, the faster it moves in every case. This combined motion preserves the constancy of H, at least over a relatively small period of time. This result is not surprising considering how eq. (3) has been derived.

III. How Old Is the Universe?

Another area in which eq. (3) can prove instructive is in resolving the question of the age of the universe. Since $\Delta v = A\Delta t$, one can compute the value of the elapsed time Δt relative to t=0 by considering the case at the present time when the speed of the galaxy (it doesn't matter which one because the formulas are applicable to all) is equal to v. Substitution of this value in eq. (3) then allows the amount of time since t=0 to be computed in order for the speed of the galaxy to have reached the current value of v:

$$A = \frac{\Delta v}{t_x} = \frac{v}{t_x} = \frac{A\Delta t}{t_x}, \qquad (4)$$

whereupon elimination of A yields the interesting result:

$$\Delta t = t_x \, , \tag{5}$$

that is, the elapsed time needed to attain the *present* galaxy velocity of v *is* t_x*=37.26 billion years.*

There is a problem with the above determination, however. As we go backward in time, as shown in Ref. 1, the value of Hubble's constant decreases. By the time t=0 is reached, it has a value of zero. It would therefore be more realistic to employ an average value of this constant over the entire period of time. For example, it would be reasonable to estimate this quantity as the average of Hubble's constant from its present value of t_x to the final value of zero. In other words, it is more realistic to use $0.5t_x$ in the denominator of eq. (3) than t_x. This would mean that the sum of all Δv values would add up to the current value of v *twice as quickly as before*. That would mean in turn that the age of the universe is estimated to be $0.5t_x$ = 18.63 billion years. That value fits in much better with the estimated experimental value of t_u = 16 billion years. The discrepancy of 2.6 billion years can be put down to the inaccurate average value of $0.5t_x$ assumed above, so this result is an indication that eq. (3) for computing the acceleration of each galaxy is in reasonable agreement with experiment.

The elapsed time Δt for the galaxy to reach its current value of L in mi can also be calculated with the aid of eq. (3):

$$\Delta L = L = HXv = \frac{A\Delta t^2}{2} = \frac{v}{2t_x}\Delta t^2 \, , \tag{6}$$

whereby the current value of the galaxy's speed v in mi/s has been assumed in this equation.

The simple mathematical nature of the characteristics of constant acceleration can be used to good advantage in another important way. As motion of the galaxy proceeds, one can use the formulas to compute both the changes in its distance and speed, Δv and ΔL, for a given amount of time Δt, in terms of the present acceleration value $A = v/t_x$ from eq. (3):

$$\Delta v = A\Delta t = \frac{v\Delta t}{t_x}, \tag{7}$$

$$\Delta L = \frac{A\Delta t^2}{2X} = \frac{v}{2Xt_x}\Delta t^2. \tag{8}$$

The factor X has been included in eq. (8) to account for any potential change in units. For example, if ΔL is to be given in ly, then X is the conversion factor required to change from ly to mi [see the definition after eq. (1)] when the speed v has the unit of mi/s (note that both t_x and Δt have the unit of s). Since ΔL/Δv=L/v over at least a short period of elapsed time [see the discussion after eq. (1)], it follows that the corresponding change ΔH in the Hubble Constant is equal to ΔL/Δv; hence, from eqs. (7,8) one obtains:

$$\Delta H = \frac{\Delta L}{\Delta v} = \frac{\frac{v}{2Xt_x}\Delta t^2}{\frac{v\Delta t}{t_x}} = \frac{\Delta t}{2X}. \tag{9}$$

IV. Hubble's Constant as the Clock of the Universe

The concept of constant accelerations for the galaxies leads very easily to the results of eqs. (7) and (8) for the dependence of their speeds v and separations L from present-day Earth. In particular, v varies as the first power of Δt and ΔL as the square thereof. Consequently, it comes as no surprise that the ratio of distance to speed, which is Hubble's Constant, turns out to be directly proportional to Δt.

The term "constant" for this quantity clearly refers to the fact that the value of the ratio is, at least to a good approximation, the same for all galaxies *at the current time.* What eq. (9) indicates, however, is that Hubble's Constant is time-dependent and is definitely not constant in this respect. As will be shown below, at the time of the Big Bang explosion ($\Delta t=0$), Hubble's Constant had a value of zero. In other words, if one goes backward in time, the *distance L decreases faster* than the corresponding value of v for each galaxy. The universe gradually shrinks as we look backward in time to the point at which the universe started. Their H=L/v ratio is also equal to zero at that point in time, as one can see by taking the limit of this quantity at t=0 in eq. (8).

It is possible to use eq. (3) to predict the speed of a given galaxy at a later time Δt, namely as the sum of the current speed v and the increased speed $\Delta v = A\ \Delta t = v\ \Delta t/t_x$. To be accurate, however, the elapsed time Δt must be relatively short. This is because eq. (3) assumes that H is constant, which means that $t_x = 2HX$ must be nearly constant as well. This is a key consideration if the goal is to use the equation to predict changes in speed since the Big Bang occurred. For example, if one would like to compute the speed of the galaxy at a time half-way between the present and the time of the Big Bang, it is reasonable to assume from eq. (9) that the value of H at that time is only one-half of its current value. Therefore, in applying eq. (3), one has to alter it by replacing t_x by $t_x/2 = HX$ to obtain the value of Δv over this period of time. The failure to do so, would mean that the value of Δv is underestimated by a factor of two.

Based on the above considerations, it is reasonable to assume that Hubble's Constant varies linearly with time t, whereby t=0 corresponds to the time of the Big Bang explosion:

$$H(t) = \frac{Ht}{t_q}. \tag{10}$$

According to this formula, Hubble's Constant would reach its current value of H=100000 ly s/mi when $t=t_q$; t_q is preferred to the estimated average value of $0.5t_x=HX$. It would have a null value at the time of the Big Bang (t=0). Consistent with this relation for Hubble' s Constant, it would be reasonable to also assume a linear dependence for galaxy speeds as suggested by eq. (7):

$$v(t) = \frac{vt}{t_q}, \tag{11}$$

whereby v is taken to be the current value of the speed in each case.

Along the same line of argument, the corresponding formula for distances is:

$$L(t) = L\left(\frac{t}{t_q}\right)^2. \tag{12}$$

The t^2 dependence in this case is consistent with eq. (8). It also causes the ratio of L to v (Hubble's Constant) to be consistent with eq. (10). Finally, the analogous argument also suggests that acceleration a is linearly dependent on t:

$$a(t) = \frac{at}{t_q}, \tag{13}$$

which is consistent with eq. (3).

V. Relationship with Cosmological Theories

As discussed previously,[1] there are three main cosmological theories to explain the origin of the universe.[2] The steady-state theory certainly does not mesh well with all the evidence of a Big Bang explosion. The second assumes that the Big Bang not only occurred, but that its force continues to the present day to push the known galaxies farther into space, eventually taking them all the way to infinity, however that may be defined. The third theory assumes on the contrary that the universe is oscillating between explosion and collapse.

The latter theory is based in large part on belief in Einstein's Theory of General Relativity (GR) which he introduced in 1916.[3] According to Einstein, the gravitational pull on massive bodies can be expressed as a curvature of space.[4] It has been shown,[5] however, that what actually occurs is a *displacement of star images, not the bending of light.*

It is commonly believed in the astrophysical community that the only way to satisfactorily explain the displacement of star images and related phenomena is by way of GR. Nothing could be further from the truth. In 1960 Schiff published a method[6] which *assumed that light travels in a perfectly straight line.*[7] His method makes use of a conclusion that Einstein made about the speed of light in his 1907 paper[8] in which he enunciated the Equivalence Principle. He used his 1905 theory to claim that *the speed of light decreases as it gets closer to a massive body such as the Sun.*

In Schiff's view,[6] the bending of light can easily be explained without making any assumptions about "curved space-time." It should also be noted, however, that Schiff admitted that his method did not satisfactorily explain another key phenomenon, namely the advancement of the perihelion of Mercury's orbit. This failure clearly detracted from the attempt to convince physicists that his method was a genuine competitor with GR. In more recent studies,[5,9-11] however, Schiff's method has been extended (referred to as the Unified Scaling method[12]) so that it has become applicable to the Mercury orbit as well, and with comparable accuracy as is obtained with GR.

The latter work has gone largely unnoticed by the astronomical community, however. As a result, a great deal of credence is given to GR, including to its famous cosmological predictions. It is claimed, for example, that the degree of curvature in space may be sufficient to cause the expansion of the universe to slow down and ultimately, if there is sufficient mass, even to reverse course. Once one sees that there is another way to quantitatively explain the key effects of the displacement of star images and the precession of Mercury's perihelion, however, it becomes imperative to much more thoroughly scrutinize the predictions of GR in this regard.

The great advantage of the Uniform Scaling method[12] is that it makes no assumptions whatsoever based on either GR[2] or Schiff's method.[6] Rather, it simply combines the experimental fact of Hubble's Constant with the quantitative relations that one uses to describe the motion of ordinary objects that are under the influence of a *constant acceleration*. The results are shown in eqs. (10-13) for the galaxy speeds, separations and accelerations, respectively.

The calculations with the present model given above indicate that that the speed v(T) of any given galaxy grows *linearly* with time, as well as does the corresponding acceleration value. This is clearly incompatible with both the steady-state universe model and the oscillating universe prediction of GR. The result is not dependent in any way on the value of the total mass of the universe, but is based instead entirely on the experimental evidence provided by measurements of the value of Hubble's Constant. Gravitational and inertial forces are assumed to be in continuous competition with one another, but no concrete information regarding the strength of either is required to obtain the final results of the theory. It is clear, however, that the strength of the inertial forces always outweighs that of gravitation, in agreement with the expanding universe theory of cosmology.

VI. Thermodynamics and the Expanding Universe

The Laws of Thermodynamics can be closely connected to the theory of the Big Bang. The Second Law states, for example, that the entropy of the universe is always increasing because of the overall effect of so-called irreversible processes. This means that as we go backward in time, the opposite is true, namely entropy ($S=k\ln\Omega$; k is Boltzmann's constant) is always decreasing. The degeneracy factor Ω is commonly related to the general term "disorder."

The Third Law states that S is positive definite, consistent with the above definition. This means that the minimal value possible for S is 0 at which point $\Omega = 1$; this corresponds to *perfect* *order.* In the context of Big Bang theory, this can be seen as the point in which there is only a single possible state for all the matter of the universe. One can make the case that the Laws of Thermodynamics have been consistently in place since the origin of the universe, i.e. t=0. Entropy/disorder has been increasing ever since. In any event, such a conclusion fits perfectly with the theory of an ever-expanding universe.

Similar remarks can be made with respect to energy. There is no evidence of any process in which energy is not conserved. It is necessary in each case to compute the value of the conserved energy by taking account of Einstein's mass-energy relation, $E=mc^2$, whereby m is the inertial mass of a given system. Accordingly, the total energy released in the Big Bang explosion is equal to the sum of the inertial masses of all currently existing systems, including black holes and as yet un-observed masses, in the entire universe multiplied by c^2. The energies (hν) of all photons must be included in this calculation, in which case the corresponding inertial mass is equal to $h\nu/c^2$ for each photon.

Since the unit of energy varies with the state of motion of each rest frame, in accordance with the prescriptions of the Uniform Scaling method, this means that different observers will *not* measure the same value of the total energy, even though the corresponding absolute value of the total energy is the same for everyone. It can also be concluded that the sum of the gravitation masses of all the stars and planets of the universe must be less than the sum of the inertial masses since the gravitational mass is always equal to the rest mass of the system, i.e. excluding kinetic energy.

In summary, the Laws of Thermodynamics are consistent with the existence of a Big Bang explosion at the beginning of time (t=0). Any cosmological theory of the universe that depends on violations of these laws needs to be scrutinized accordingly.

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