Hubble based distance ladder for all distances

Introduction and relevance

In 1931, Hubble and Humason presented: "THE VELOCITY-DISTANCE RELATION AMONG EXTRA-GALACTIC NEBULAE", presenting the relation between estimated *distance* "D" and redshift "z": $z \approx H.D / c$, in which "H" is the (now called) Hubble constant and "c" is the speed of light. Edwin Hubble *assumed* that speed "v" was the main cause of redshift of galaxies based on the low-speed Doppler-effect ($z \approx v / c$). The speed "v" is then a combination of universal expansion speed "v_{exp}" and local speed "v_0" ($v = v_{exp} + v_0$). We thus get the Hubble law ($v_{exp} \approx H.D$). The authors present you with the *Advanced* Hubble law as a combination of speed and distance.

Formula (1) explains all of the original redshift measurements of Hubble and Humason, but gives a very different outlook on the speed and distance of very remote galaxies. The relevance of this formula is great, no more "dark energy", and no more *increasing* "dark energy" to accelerate galaxies, while it fits all the known redshifts of galaxies like a glove! No more Big Bang, but a "Hubble Horizon", a horizon in space-time, which is the same to all observers at any location and at any time. Supported by the "comoving coordinates" of Robertson and Walker, while explaining the "cosmic inflation era". Cosmic inflation is a property of the past, not a specific era, leading to a better cosmological model, the Einstein-Minkowski-Robertson&Walker (EMRW) model.

Need for an advanced Hubble law

The redshift-*distance* relation according to Hubble is $z \approx H.D / c$. The authors support that redshift is related to both distance and speed. The redshift caused by local speed is not contested. However, the cause of the redshift of large-distance galaxies is not established. Hubble *assumed* that speed was the main cause, leading to the Hubble law. The authors base the *Advanced* Hubble law on both local speed and distance, something Hubble and Humason could (and should) have done:

$$z = v_0 / c + H.D / (c - H.D) \quad [\,] \qquad \textit{Advanced}\text{ Hubble Law} \qquad (1)$$

In this formula is "v_0" the proper (local or peculiar) receding speed of the galaxy in [km/s], is "H" the Hubble constant in [km/s/Mpc], is "D" the distance in [Mpc], and is "c" the speed of light in [km/s]. Note that this formula supports both the relation between low-speed and redshift $z = v / c$ for local speed, the *speed* term, as well as the relation between distance and redshift $z = H.D / (c - H.D)$, the *distance* term. This distance term is for the low values of "z" and "D" which Hubble and Humason observed, about equal to: $z \approx H.D / c$, their observed relation as published!

Firstly, let us look at four galaxies to see the practicality of formula (1). We will look at three ranges of redshift:

Low-range	$z < 0.002$	proper speed dominant
Mid-range	$0.002 \leq z \leq 0.01$	dominance uncertain
High-range	$z > 0.01$	cosmic inflation dominant

These ranges are established on the presumption that local galaxy speeds do not normally exceed 600 [km/s], which is true for our own local group of galaxies, but certainly not exceed 3000 [km/s]. We can thus ignore proper speed for redshifts above one with an error of at most 1%.

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NGC 3109 and Andromeda, in the category in which *proper speed* is dominant

These are two galaxies within our local group of galaxies with good distance estimates (by several estimation techniques like triangulation and Cepheid variables) and excellent redshift measurements. Let us see how the *Advanced* Hubble Law works out for these two galaxies in our local group. Since we have both "z" and "D", we can compute the proper (local or peculiar) speed of both galaxies. We will also compare the proper (local or peculiar) speed to the total speed "v" as currently specified. The difference is thus the universal expansion speed *if* that would be the cause of the cosmic redshift. The authors will argue that cosmic inflation is the cause of the distance term, not universal expansion speed. The Hubble constant "H" is taken as 67.8 [km/s/Mpc], the latest estimate.

	Redshift "z" [ ]	Distance "D" [Mpc]	Proper speed - heliocentric "v_0" [km/s]	
NGC 3109	0.001 345	1.33	313	(v currently specified as 403 [km/s])
Andromeda	–0.001 001	0.778	–353	(v currently specified as –301 [km/s])

Note that the proper speed "v_0" does not deviate much from the currently specified total speed "v", which includes the *presumed* universal expansion speed caused by the ever increasing "dark energy". Also note that Andromeda is approaching our sun (heliocentric) faster than is currently specified!

Galaxy M87, where dominance of distance or proper speed is *uncertain*

Galaxy M87, the galaxy with the massive black hole in its center, is in a farther category of distances and redshifts at z = 0.004 58, in which dominance is uncertain. Based on the specified distance of 16.4 [Mpc] and again "H" as 67.8 [km/s/Mpc], we get using formula (1):

	Redshift "z" [ ]	Distance "D" [Mpc]	Proper speed -heliocentric "v_0" [km/s]	
Messier 87	0.004 58	16.4	167	(v currently specified as 1,284 [km/s])
Messier 87	0.004 58	18.8	0	if the proper speed is zero
Messier 87	0.004 58	16.4	0	if the Hubble constant equals 78 [km/s/Mpc]

The effect of the receding proper speed of 167 [km/s] contributes 0.000 56 to the redshift measurement in formula (1). If this is correct, it is our first example where the distant term and thus cosmic inflation is dominant over proper (peculiar) speed in respect to redshift. Note that if the proper speed would be zero, the distance estimate would come to 18.8 Mpc. Alternatively, at the specified distance of 16.4 [Mpc], the "H" value would come to 78 [km/s/Mpc].

Unfortunately, we cannot measure proper speed easily, if at all. Distances are often estimated with an accuracy of about 10%. The only thing we can measure accurately is redshift. That makes establishing the correct Hubble constant "H" a project for the future. At this point in time we can with confidence say that the Hubble constant lies within the 67 to 90 [km/s/Mpc] range, the latter value comes from the Pioneer 10&11 “anomaly”, see our book “Repairing Robertson-Walker’s Solution”.

Galaxy GN-z11, in the category in which *distance* is dominant

Galaxy GN-z11 is the farthest galaxy found, in a high-range category where proper speed is ignored. Based on the provided redshift of 11.09 and again “H” as 67.8 [km/s/Mpc], we get to a distance of 4,056 Mpc:

	Redshift “z” [ ]	Distance “D” [Mpc]	Proper speed (heliocentric) “v_0” [km/s]	
GN-z11	11.09	4,056	0	(v currently specified as 92% of “c”)

For GN-z11, the *distance* term is dominant, although proper speed is hard to establish. This distance “D”, expressed in billions of light-years, equals 13.2 [Bly] , 92% of the Hubble length of 14.4 [Bly].

Distance formula for high-redshifted galaxies

As you can see in formula (1), redshift “z” increases progressively up to the Hubble length “D_H” where $D_H = c / H$. At high-range distances the term v / c becomes negligible. Assuming local speed is zero, formula (1) can be worked around to do the opposite, determining distance “D” as function of redshift “z”:

$D = \{z / (z + 1)\}.c / H$ [m] distance to redshift relation (2)

Formula (2) shows how a redshift z = 1 means half of the Hubble distance. The Big Bang is located at a redshift of infinity, at the other side of a spherical universe at a distance in *today’s units* meter of c / H, see our book “Repairing Robertson-Walker’s solution”.

Root causes of the distant term, cosmic redshift

Apart from receding speed relative to the sun (heliocentric), redshift is caused by gravitation, cosmic inflation, and transversal galaxy speed. (See for more information about cosmic inflation our other articles). These three factors all come to the same outcome, a different clock speed at the galaxy under investigation from the clock speed on earth. In the cosmic inflation era, the clock must have ticked extremely fast relative to our clock speed on earth. We know that the cosmic inflation era would have an extreme redshift if we could measure it. Unfortunately the largest *measured* redshift of a galaxy amounts to eleven (GN-z11) and the largest *deduced* redshift is 1,092 of the Cosmic Microwave Background Radiation (CMBR) from the Era of Last Scattering (ELS).

Analyzing observations

Based on the energy conservation of photons ($dt_0 = 0$ according to Einstein), we can deduce that the redshift caused by a faster clock (time contraction or cosmic inflation) equals z + 1. In other words, when we look at galaxies around redshift nine, we should observe star formation to be ten times *faster*.

However, if the redshift would be caused by the relativistic Doppler Effect (current thinking), the star formation would be observed to proceed ten times *slower*. Let us see what NASA/ESA have to say about the speed of star formation. If the authors are right, star formation of galaxies at redshift nine is observed to proceed ten times *faster*. If current cosmology is right, star formation of galaxies at redshift nine would be observed to proceed ten times *slower*.

Proof of Cosmic Inflation of z + 1

Let us see what the NASA/ESA Hubble Space Telescope tells us about star formation of galaxies around redshift nine in the article "*Hubble finds hundreds of young galaxies in the early Universe*"[1]:

"The findings also show that these dwarf galaxies were producing stars at a furious rate, ***about ten times faster*** than is happening now in nearby galaxies".

Redshift nine and star formation ten times quicker, that is cosmic inflation of redshift plus one proven by observation! In the cosmic inflation era, the clocks ticked about 10^{12} times faster (trillion times faster) than our clocks tick now! The redshift at that time, if it could be measured, would thus be about 10^{12}! The authors conclude that cosmic inflation is not a property of a specific era, but a property of the entire cosmic past, which equals z + 1. This cosmic inflation influence on redshift is the *distant* term in formula (1). Cosmic inflation is considered seriously in the cosmology of *this* century:

Wikipedia: "In 2002, three of the original architects of the theory were recognized for their major contributions; physicists Alan Guth of M.I.T., Andrei Linde of Stanford, and Paul Steinhardt of Princeton shared the prestigious Dirac Prize "for development of the concept of inflation in cosmology". In 2012, Alan Guth and Andrei Linde were awarded the Breakthrough Prize in Fundamental Physics for their invention and development of inflationary cosmology", supporting cosmology based on cosmic inflation.

Consequences of cosmic inflation

The increasing redshift over distance is not an accelerating universe, but an increasingly faster clock the more we look back in time, explaining fast star formation and the cosmic inflation era. Therefore, there is no need for "dark energy". Furthermore, a faster clock means a shorter unit second on the (theoretical) cesium clock of the cosmic past. The cesium clock being representative for the progress of physics, means that *all* physics, not just star formation and universal expansion, went z + 1 faster in the cosmic past. Physics works in the comoving coordinates as defined by Robertson and Walker! In other words, although the unit second was a lot smaller in the past, the laws of physics listen to the units of that cosmic time, not to our *current* units second, meter, kilogram, and Coulomb!

Proof of smaller unit Joule of the past

The CMBR comes from the "era of last scattering" (ELS), when the universe became translucent. The temperature must have been about 2978 [K] at the ELS, based on comoving coordinates. Physics in comoving coordinates means that when we cool down a mixture of hydrogen and helium

[1] www.nasa.gov/mission_pages/hubble/hst_young_galaxies_200604_prt.htm

on earth, it becomes translucent at that same temperature of 2978 [K]. However, according to Planck's law, we get the same radiation, as observed here and now of the CMBR, as a black body on earth at 2.725 [K].

Since light does not loose energy according to Einstein's relativity ($dt_0 = 0$), we must conclude that the unit Kelvin and thus the unit Joule were about 1093 (2978 / 2.725) times as small as these are now! All basic units (second, meter, kilogram, and Coulomb) must thus have been z + 1 = 1093 times as small, the principle of comoving coordinates of Robertson and Walker at work! This leads us to a whole new cosmological model based on comoving coordinates and cosmic inflation of z + 1. Let us get back to Einstein's cosmological model of 1917.

Einstein's 3-sphere leads the way

In 1917, Einstein proposed a spherical universe as the three dimensional (3D) "surface" within a 4D reference frame, the "3-sphere". A 3-sphere can be seen as circles in all directions, something we simply cannot imagine. However, Einstein abandoned this model when he saw the work of Hubble and Humason in 1931. The authors have, with the knowledge of *this* century, adapted Einstein's model for cosmic inflation. We can revive Einstein's 3-sphere with a simple addition, the 4D radius is both space and time ($R_4 = c.t / \pi$), in which time "t" is measured in our current units second. Minkowski would be very pleased with such a modification, he argued: "space and time as separate entities will disappear into some kind of a union". The model of the universe of the authors is therefore called the "EMRW" model, in honor of Einstein, Minkowski, Robertson, and Walker.

The EMRW model of the universe

The EMRW model is a 3-sphere with time and radius directly related by $R_4 = c.t / \pi$. It means that we are living in the middle of space, but on the edge of time. The past is within the 3-sphere and the future lies outside of the 3-sphere space-time. At the origin of this model is the Big Bang, but that is a model in the units of now. In comoving coordinates (in the smaller units of the cosmic past), the Big Bang is infinitely long ago, there was no Big Bang in terms of real physics. A better name for that horizon in space-time is the "Hubble Horizon". The Hubble Horizon is similar to a horizon at sea, you can see the barrel on the horizon, you can reach the barrel, but the horizon remains at the same distance.

Proof of the 3-sphere space-time model, the EMRW model

Theoretical proof is found in the "Perfect Cosmological Principle", the EMRW model is homogenous (the same everywhere) and isotropic (the same in all directions) in *both* space *and* time. Further theoretical proof comes from Robertson&Walker's comoving coordinates and Minkowski's space-time. Additionally, observational proof is found in the distribution of galaxies, which peaks at redshift one, proving the 3-sphere of Einstein in space. The far lower volume of a 3-sphere results in a density of the universe which is twenty times higher than currently estimated, obliterating the need for "dark energy" and most of the "dark matter".

Summary

Hubble's work is advanced in the separation of the distance effect from the speed effect, resulting in new distance ladders, formulas (1) and (2), and a new cosmological model, a 3-sphere space-time.

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More information

Want to know more about the universe, look at www.loop-doctor.nl: "Repairing Robertson-Walker's Solution". Our books repair Einstein's Relativity for Noether's theorems[2]. We hope you get as many "aha" experiences as we did,

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[2] Noether E. "Invariant variation problems" translated by Tavel M. TTSP 1971 p. 186-207