Are our textbooks wrong? Astronomers clash over Hubble's legacy

April 5 2013, by Dan Majaess

Images of Galactic nebulae and a supernova remnant that were obtained via the Hubble Space Telescope, which is named after astronomer Edwin Hubble. The honor was bestowed upon E. Hubble given his seminal contributions to astronomy. Credit: spikedrocker/deviantart

Edwin Hubble's contributions to astronomy earned him the honor of

having his name bestowed upon arguably the most famous space telescope (the Hubble Space Telescope, HST). Contributions that are often attributed to him include the discovery of the extragalactic scale (there exist countless other galaxies beyond the Milky Way), the expanding Universe (the Hubble constant), and a galaxy classification system (the Hubble Tuning Fork). However, certain astronomers are questioning Hubble's pre-eminence in those topics, and if all the credit is warranted.

"[The above mentioned] discoveries … are well-known … and most astronomers would associate them solely with Edwin Hubble; yet this is a gross oversimplification. Astronomers and historians are beginning to revise that standard story and bring a more nuanced version to the public's attention," said NASA scientist Michael J. Way, who just published a new study entitled "Dismantling Hubble's Legacy?"

Has history clouded our view of Hubble the man? Or are his contributions seminal to where we are today in astronomy?

Assigning credit for a discovery is not always straightforward, and Way 2013 notes, "How credit is awarded for a discovery is often a complex issue and should not be oversimplified – yet this happens time and again. Another well-known example in this field is the discovery of the Cosmic Microwave Background." Indeed, controversy surrounds the discovery of the Universe's accelerated expansion, which merely occurred in the late 1990s. Conversely, the discoveries attributed to Hubble transpired during the ~1920s.

Prior to commencing this discussion, it's emphasized that Hubble cannot defend his contribution since he died long ago (1889-1953). Moreover, we can certainly highlight the efforts of other individuals whose seminal contributions were overlooked without mitigating Hubble's pertinence. The first topic discussed here is the discovery of the extragalactic scale.

Prior to the 1920s it was unclear whether the Milky Way galaxy and the Universe were synonymous. In other words, was the Milky Way merely one among countless other galaxies?

Astronomers H. Shapley and H. Curtis argued the topic in the famed Island Universe debate (1920). Curtis believed in the extragalactic Universe, whereas Shapley took the opposing view (see also Trimble 1995 for a review). In the present author's opinion, Hubble's contributions helped end that debate a few years later and changed the course of astronomy, namely since he provided evidence of an extragalactic Universe using a distance indicator that was acknowledged as being reliable. Hubble used stars called Cepheid variables to help ascertain that M31 and NGC 6822 were more distant than the estimated size of the Milky Way, which in concert with their deduced size, implied they were galaxies. Incidentally, Hubble's distances, and those of others, were not as reliable as believed (e.g., Fernie 1969, Peacock 2013). Peacock 2013 provides an interesting comparison between distance estimates cited by Hubble and Lundmark with present values, which reveals that both authors published distances that were flawed in some manner. Having said that, present-day estimates are themselves debated.

Hubble's evidence helped convince even certain staunch opponents of the extragalactic interpretation such as Shapley, who upon receiving news from Hubble concerning his new findings remarked (1924), "Here is the letter that has destroyed my universe." Way 2013 likewise notes that, "The issue [concerning the extragalactic scale] was effectively settled by two papers from Hubble in 1925 in which he derived distances from Cepheid variables found in M31 and M33 (Hubble 1925a) of 930,000 light years and in NGC 6822 (Hubble 1925c) of 700,000 light years."

However, as table 1 from Way 2013 indicates (shown below), there were numerous astronomers who published distances that implied there were

galaxies beyond the Milky Way. Astronomer Ian Steer, who helps maintain the NASA/IPAC Extragalactic Database of Redshift-Independent Distances (NED-D), has also compiled a list of 290 distances to galaxies published before 1930. Way 2013 added that, "Many important contributions to this story have been forgotten and most textbooks in astronomy today, if they discuss the "Island Universe" confirmation at all, bestow 100% of the credit on Hubble with scant attention to the earlier observations that clearly supported his measurements."

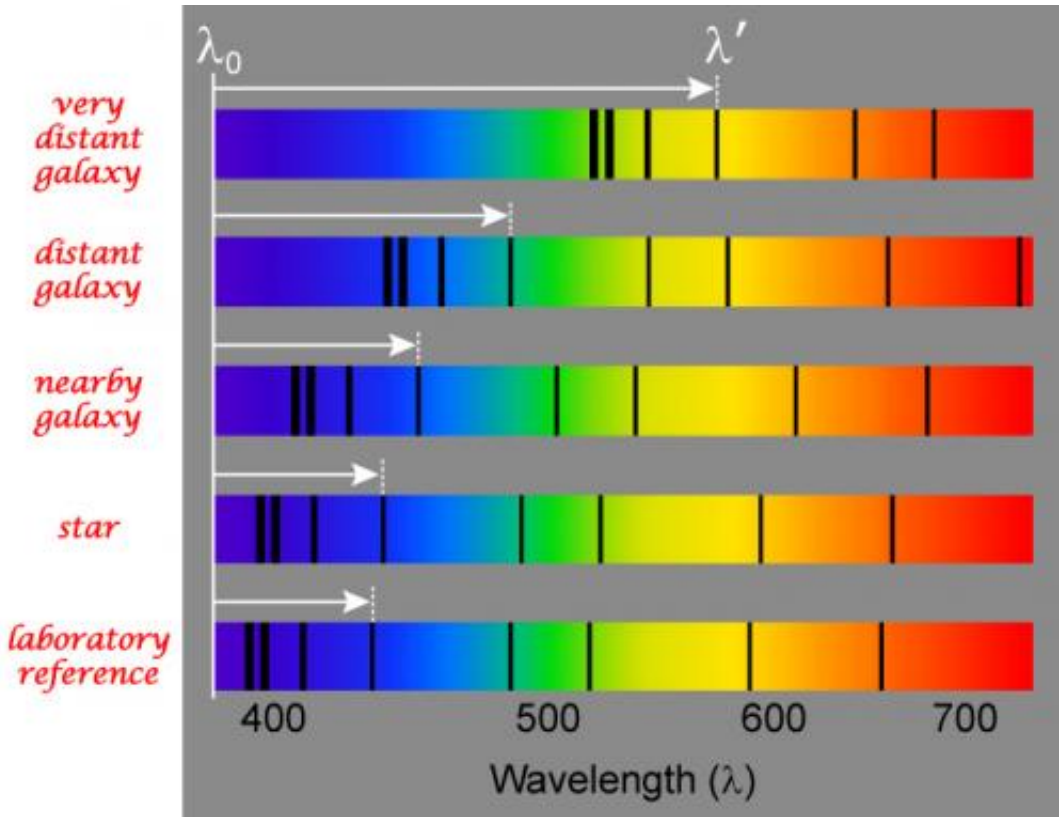
Reference	Object	Distance[a]	Method
Herschel (1786)	M31	<17,200 [b]	color/magnitude
Nichol (1850)	"cluster"	154,800[c]	magnitude comparison
–		302,505	–
Clark (1890)	M31	564?	nova of 1885
Clark (1903)	M31	<1000	Size
Bohlin (1907)	M31	19	parallax
Very (1911)	M31	4,000	diameters
Very (1911)	M31	1,600	S Andromedae
Wolf (1912)	M31[d]	32,000	diameters
Curtis (1915b)	spirals	10,000	astrometry/radial velocity
Pease (1916)	NGC 4594	25,000	astrometry/radial velocity
Curtis (1917)	M31	20,000,000	novae
–	–	100,000	novae[e]
Shapley (1917)	M31	1,000,000	"bright stars"
van Maanen (1918)	M31	250	parallax
Lundmark (1919)	M31	650,000	novae
Curtis (1920)	misc	4,000,000	novae
–	misc	1,000,000	novae
–	misc	500,000	novae
Lundmark (1921h)	M33	1,000,000	"bright stars"
Luplau-Janssen & Haarh (1922)	M31	326,000	novae[f]
Öpik (1922)	M31	1,500,000	luminosity/mass
Hubble (1922d)	M33	100,000	"stars"
Shapley (1923)	NGC 6822	1,000,000	diameters/"bright stars"
Hubble (1925a)	M31/33	930,000	Cepheids
Hubble (1925c)	NGC 6822	700,000	Cepheids,"bright-stars"
Lundmark (1925)	M31,M87	1,400,000	novae
–	–	8,000,000	novae
Lundmark (1925)	M104	56,000,000	Öpik (1922) method
Hubble (1926a)	M33	850,000	Cepheids,Blue-Giants
Hubble (1929c)	M31	900,000	Cepheids,novae
M31 value (Dec. 2012)[g]	M31	2,588,440	19 Methods

Way 2013 notes, "Table 1 lists all of the main distance estimates to spiral

nebulae (known to this author) from the late 1800s until 1930 when standard candles began to be found in spiral nebulae [galaxies]." Credit: Way 2013/arXiv

Thus Hubble did not discover the extragalactic scale, but his work helped convince a broad array of astronomers of the Universe's enormity. However, by comparison to present-day estimates, Hubble's distances are too short owing partly to the existing Cepheid calibration he utilized (Fernie 1969, Peacock 2013 also notes that Hubble's distances were flawed for other reasons). That offset permeated into certain determinations of the expansion rate of the Universe (the Hubble constant), making the estimate nearly an order of magnitude too large, and the implied age for the Universe too small.

Hubble's accreditation as the discoverer of the expanding Universe (the Hubble constant) has generated considerable discussion, which is ultimately tied to the discovery of a relationship between a galaxy's velocity and its distance. An accusation even surfaced that Hubble may have censored the publication of another scientist to retain his pre-eminence. That accusation has since been refuted, but provides the reader an indication of the tone of the debate (see Livio 2012 (Nature), and references therein).



Top, spectra for galaxies that are redshifted. Credit: JPL/Caltech/Planck

Hubble published his findings on the velocity-distance relation in 1929, under the unambiguous title, "A Relation Between Distance and Radial Velocity Among Extra-Galactic Nebulae". Hubble 1929 states at the outset that other investigations have sought, "a correlation between apparent radial velocities and distances, but so far the results have not been convincing." The key word being convincing, clearly a subjective term, but which Hubble believes is the principal impetus behind his new effort. In Lundmark 1924, where a velocity versus distance diagram is plotted for galaxies (see below), that author remarks that, "Plotting the radial velocities against these relative distances, we find that there may be a relation between the two quantities, although not a very definite one." However, Hubble 1929 also makes reference to a study by Lundmark 1925, where Lundmark underscores that, "A rather definite

correlation is shown between apparent dimensions and radial velocity, in the sense that the smaller and presumably more distant spirals have the higher space velocity."

Hubble 1929 provides a velocity-distance diagram (featured below) and also notes that, "the data indicate a linear correlation between distances and velocities". However, Hubble 1929 explicitly cautioned that, "New data to be expected in the near future may modify the significance of the present investigation, or, if confirmatory, will lead to a solution having many times the weight. For this reason it is thought premature to discuss in detail the obvious consequences of the present results … the linear relation found in the present discussion is a first approximation representing a restricted range in distance." Hubble implied that additional effort was required to acquire observational data and place the relation on firm (convincing) footing, which would appear in Hubble and Humason 1931. Perhaps that may partly explain, in concert with the natural tendency of most humans to desire recognition and fame, why Hubble subsequently tried to retain credit for the establishment of the velocity-distance relation.

Hubble 1929 conveyed that he was aware of prior (but unconvincing to him) investigations on the topic of the velocity-distance relation. That is further confirmed by van den Bergh 2011, who cites the following pertinent quote recounted by Hubble's assistant (Humason) for an oral history project, "The velocity-distance relationship started after one of the IAU meetings, I think it was in Holland [1928]. And Dr. Hubble came home rather excited about the fact that two or three scientists over there, astronomers, had suggested that the fainter the nebulae were, the more distant they were and the larger the red shifts would be. And he talked to me and asked if I would try and check that out."

Hubble 1929 elaborated that, "The outstanding feature, however, is the possibility that the velocity-distance relation may represent the de Sitter

effect, and hence that numerical data may be introduced into discussions of the general curvature of space." de Sitter had proposed a model for the Universe whereby light is redshifted as it travels further from the emitting source. Hubble suspected that perhaps his findings may represent the de Sitter effect, however, Way 2013 notes that, "Thus far historians have unearthed no evidence that Hubble was searching for the clues to an expanding universe when he published his 1929 paper (Hubble 1929b)." Indeed, nearly two decades after the 1929 publication, Hubble 1947 remarks that better data may indicate that, "redshifts may not be due to an expanding universe, and much of the current speculation on the structure of the universe may require re-examination." It is thus somewhat of a paradox that, in tandem with the other reasons outlined, Hubble is credited with discovering that the Universe is expanding.

The term redshift stems from the fact that when astronomers (e.g., V. Slipher) examined the spectra of certain galaxies, they noticed that although a particular spectral line should have appeared in the blue region of the spectrum (as measured in a laboratory): the line was actually shifted redward. Hubble 1947 explained that, "light-waves from distant nebulae [galaxies] seem to grow longer in proportion to the distance they have travelled It is as though the stations on your radio dial were all shifted toward the longer wavelengths in proportion to the distances of the stations. In the nebular [galaxy] spectra the stations (or lines) are shifted toward the red, and these redshifts vary directly with distance–an approximately linear relation. This interpretation lends itself directly to theories of an expanding universe. The interpretation is not universally accepted, but even the most cautious of us admit that redshifts are evidence either of an expanding universe or of some hitherto unknown principle of nature."

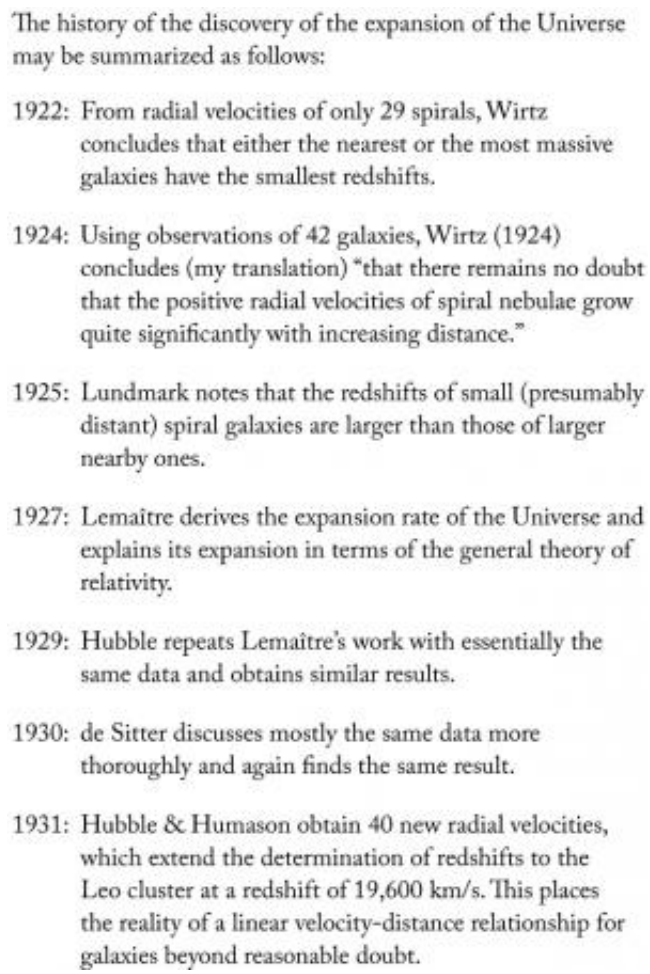
As noted above, Hubble was not the first to deduce a velocity-distance relation for galaxies, and Way 2013 notes that, "Lundmark (1924b): first

distance vs. velocity plot for spiral nebulae [galaxies] …Georges Lemaitre (1927): derived a non–static solution to Einstein's equations and coupled it to observations to reveal a linear distance vs. redshift relation with a slope of 670 or 575 km/s/Mpc (depending on how the data is grouped) …" Although Hubble was aware of Lundmark's research, he and numerous other astronomers were likely unaware of the now famous 1927 Lemaitre study, which was published in an obscure journal (see Livio 2012 (*Nature*), and discussion therein). Steer 2013 notes that, "Lundmark's [1924] distance estimates were consistent with a Hubble constant of 75 km/s/Mpc [which is close to recent estimates]." (see also the interpretation of Peacock 2013). Certain distances established by Lundmark appear close to present determinations (e.g., M31, see the table above).

So why was Hubble credited with discovering the expanding Universe? Way 2013 suggests that, "Hubble's success in gaining credit for his … linear distance-velocity relation may be related to his verification of the Island Universe hypothesis –after the latter, his prominence as a major player in astronomy was affirmed. As pointed out by Merton (1968) credit for simultaneous (or nearly so) discoveries is usually given to eminent scientists over lesser-known ones." Steer told Universe Today that, "Lundmark in his own words did not find a definite relation between redshift and distance, and there is no linear relation overplotted in his redshift-distance graph. Where Lundmark used a single unproven distance indicator (galaxy diameters), cross-checked by a single unproven distance to the Andromeda galaxy, Hubble used multiple indicators including one still in use (brightest stars), cross-checked with distances to multiple galaxies based on Cepheids variables stars."

Concerning assigning credit for the discovery of the expansion of the Universe, Way 2013 concludes that, "Overall we find that Lemaitre was the first to seek and find a linear relation between distance and velocity in the context of an expanding universe, but that a number of other

actors (e.g. Carl Wirtz, Ludwik Silberstein, Knut Lundmark, Edwin Hubble, Willem de Sitter) were looking for a relation that fit into the context of de Sitter's [Universe] Model B world with its spurious radial velocities [the redshift]." A partial list of the various contributors highlighted by van den Bergh 2011 is provided below.



The history of the discovery of the expansion of the Universe may be summarized as follows:

1922: From radial velocities of only 29 spirals, Wirtz concludes that either the nearest or the most massive galaxies have the smallest redshifts.

1924: Using observations of 42 galaxies, Wirtz (1924) concludes (my translation) "that there remains no doubt that the positive radial velocities of spiral nebulae grow quite significantly with increasing distance."

1925: Lundmark notes that the redshifts of small (presumably distant) spiral galaxies are larger than those of larger nearby ones.

1927: Lemaître derives the expansion rate of the Universe and explains its expansion in terms of the general theory of relativity.

1929: Hubble repeats Lemaître's work with essentially the same data and obtains similar results.

1930: de Sitter discusses mostly the same data more thoroughly and again finds the same result.

1931: Hubble & Humason obtain 40 new radial velocities, which extend the determination of redshifts to the Leo cluster at a redshift of 19,600 km/s. This places the reality of a linear velocity-distance relationship for galaxies beyond reasonable doubt.

"The history of the discovery of the expansion of the Universe may be summarized [above]," van den Bergh 2011. Credit: van den Bergh/JRASC/arXiv

Way and Nussbaumer 2011 assert that, "It is still widely held that in 1929 Edwin Hubble discovered the expanding Universe … that is

incorrect. There is little excuse for this, since there exists sufficient well-supported evidence about the circumstances of the discovery."

In sum, the author's personal opinion is that Hubble's contributions to astronomy were seminal. Hubble helped convince astronomers of the extragalactic distance scale and that a relationship existed between the distance to a galaxy and its velocity, thus propelling the field and science forward. His extragalactic distances, albeit flawed, were also used to draw important conclusions (e.g., by Lemaitre 1927). However, it is likewise clear that other individuals are meritorious and deserve significant praise. The contributions of those scientists should be highlighted in parallel to Hubble's research, and astronomy textbooks should be revised to emphasize those achievements A fuller account should be cited of the admirable achievements made by numerous astronomers working in synergy during the 1920s.

There are a diverse set of opinions on the topics discussed, and the reader should remain skeptical (of the present article and other interpretations), particularly since knowledge of the topic is evolving and more is yet to emerge. Two talks from the "Origins of the Expanding Universe: 1912-1932" conference are posted below (by H. Nussbaumer and M. Way), in addition to a talk by I. Steer from a separate event.

The Way 2013 findings will appear in the "Origins of the Expanding Universe: 1912-1932", and a preprint is available on arXiv. The topic concerning the discovery of the galaxy classification system (i.e., the Hubble Tuning Fork diagram) was omitted from the present discussion, but is discussed by Way 2013.

Source: Universe Today

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