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UNIVERSE IS FLAT FROM ASTRONOMICAL TO ATMOSPHERIC / OCEANIC DISTANCES

Arpit D Trivedi
Assistant Professor
Physics Department,
G .M Momin Women's College, Rais School Campus, Thane Rd., Bhivandi, 421302, India
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Abstract : In this paper, Statisistical analysis is performed on various Hubbles diagrams and Doppler Radar plots for atmospheric and Oceanographic studies. Best Line-Fit method is applied. The slope of the linear relationship provides a robust measurement of H_0. Hubble's Law, by itself, cannot prove the universe is flat, as it only describes the relationship between a galaxy's distance and its recession velocity. However, when combined with observations of the cosmic microwave background (CMB), it provides evidence for a flat universe. Phenomenologically Hubbles Diagram involving redshift-velocity diagram based on spectrophotometry is based on Doppler effect for Light when applied for Atmospheric and Oceanic winds, we get the same statistical behavior. These all phenomena had applied Light Doppler effect in the Astronomical, Atmospheric and Oceanic regimes. The claim that Inflation Theory predicts that the universe must be flat with $\Omega_{total} = 1 \pm 10^{-4}$ is largely accurate. We have inferred from all the above statistical Analysis is that O(4) is prevalent right from Astronomical (Mpc) scales to Atmospheric(miles) to oceanic scales (nautical miles). The value $\pm\, 10^{-4}$ in the context of inflation theory and a flat universe refers to the incredible precision with which the universe's total density must be tuned to the critical density. The prediction that inflation drives the density parameter to $\Omega_{total} = 1$ with a very small tolerance, such as $\pm\, 10^{-4}$. In summary, the prediction of a nearly flat universe to a precision of 10^{-4} is not a coincidence but a direct, testable consequence of the specific physics driving inflation. This precision requires the inflaton, a scalar field potential which slowly rolls down with O(4) in it's potential energy landscape to be almost perfectly flat, and smooth to power the necessary exponential expansion.

IndexTerms analytical framework contains.- : *Hubbles Law, Hubbles constant, Atmospheric sciences, Oceanoigraphic Sciences, Doppler effect, Radar, Cosmological factor Ω, redshift, recession velocity, Big Bang Theory, Inflation theory, flat universe, roll-off, peculiar velocity, Light curves, radial velocity, Hubbles Law, Hubble time, Hubble volume, Hubble Distance, Friedmann equation, Cepheids, RR Lyrae, Super Novae, photometry, spectrophotometry, Spectral energy distribution SED, Time Dilation, standard deviation, mean square slope.*
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I. INTRODUCTION

The universe is expanding. The radial velocity of a galaxy relative to us is proportional to the distance of the galaxy from us; thus the cosmic expansion can be represented by the "Hubble law": $v = H_0 d$, where v is the radial velocity (ordinarily expressed as km/sec),D is the distance (as Mpc), and H_0 is the Hubble constant (as km/sec/Mpc) at the present epoch. [1] The reciprocal of the Hubble constant gives the Hubble time—the time since the Big Bang origin of the expansion, assuming deceleration to have been negligible. [2][11] Radial velocities are easily measured, so determining the value of H_0 reduces to the problem of measuring distances to galaxies. In practice, because galaxies have random motions, it is necessary to determine distances to fairly remote galaxies, at distances of hundreds of megaparsecs. Measuring the distances to supernovae provides an alternative to the classical approach of estimating the distances to galaxies themselves.

II. Big Bang Theory and Inflation

The Big Bang is the theory describing the universe's expansion from a hot, dense state, while the theory of cosmic inflation is an extension that posits an extremely rapid, exponential expansion occurred in a tiny fraction of a second before the hot Big Bang phase. Inflation explains several problems with the standard Big Bang model, such as why the universe is so uniform (the horizon problem) and so flat. When inflation ended, the energy that drove it was converted into the matter and radiation of the Big Bang, which then continued to expand at a slower rate. [35]
Inflation is a period of extremely rapid, accelerated expansion in the very early universe, while Hubble's Law describes the current universe's ongoing expansion. Inflation happened long before the universe cooled and expanded enough for Hubble's Law to become observable today.[36]

III. Hubble's Law from Redshift

Hubble's Law is considered a Fundamental relation between recessional velocity and distance. The relation between recessional velocity and redshift depends on cosmological model except for small redshifts.

For any given galaxy, the recession velocity dD/dt is increasing over time as the galaxy moves to greater distances, however H actually decreases with time, if we look at some fixes distance D, Later galaxies will pass that distance at a smaller velocity than earlier ones.[3],[4].[5].[6],

The velocities and distances that appear in Hubble's Law, not directly measured, velocities are inferred from redshift $z = \frac{d\lambda_z}{\lambda}$ of radiation and distance is inferred from brightness.The brightness can also be correlated with Hubble's parameter.

The redshift z is also described as a redshift velocity, which is recessional velocity that would produce the same redshift, if it caused a linear Doppler shift. The redshift velocity can also exceed the speed of Light using Fizeau-Doppler formula. (This formula will not work for large velocity values).[7][8][9][17].

$$z = \frac{\lambda_0}{\lambda} - 1 = \frac{\sqrt{1+\frac{v}{c}}}{\sqrt{1-\frac{v}{c}}} - 1 \approx \frac{v}{c} \qquad (1)$$

Redshift can be measured for H-α line for distant quasars. More generally, Redshift to recessional velocity is translated for small redshift. Redshift-distance Law is non-linear.

IV. Hubbles Law by Recessional velocity

Suppose a galaxy is at a distance D and this distance changes with time at a rate dD, we call this rate of recession, the recession velocity v_r[18][19].

$$\frac{D(t)}{D(t_0)} = \frac{R(t)}{R(t_0)} \qquad (2)$$

If light is emitted from a galaxy at time t_e and received by us at t_0, it is redshifted due to the expansion of the universe, and this redshift z is simply

$$z = \frac{R(t_0)}{R(t_e)} - 1 \qquad (3)$$

Suppose a galaxy is at distance D, and this distance changes with time at a rate d_tD. We call this rate of recession the "recession velocity" v_r:

$$v_r = d_tD = \frac{d_tR}{R} D \qquad (4)$$

We now define the Hubble constant as

$$H = \frac{d_tR}{R} \qquad (5)$$

and discover the Hubble law:

$$v_r = HD \qquad (6)$$

If the distance is not too large, all other complications of the model become small corrections, and the time interval is simply the distance divided by the speed of light:

$$z = \frac{R(t_0)}{R(t_e)} - 1\, H(t_0) \sim -\frac{D}{c} H(t_0) \qquad (7)$$

or

$$cz \approx DH(t_0) = v_r \qquad (8)$$

Hubble's Law is a Fundamental relation between (i) the recessional velocity associated with expansion of universe. (ii) the distance to object, the connection between redshift and Distance is a crutch to connect Hubble's Law with observation. The relation cz = v is an approximation valid at low redshifts.

The relative velocity with which gravitationally interacting galaxies move relative to each other.[20] is called peculiar velocity. Peculiar velocities gives rise to red shift-space distortions.[25]

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V. Time-dependence of Hubble parameter

Hubble constant is a constant in space only at fixed time. It varies with time, so called Hubble's parameter. All observations are in distant past. In accelerating universe H decreases with time and the recession velocity of one galaxy increases, but different galaxies passing a sphere of fixed radius, cross sphere more slowl;y at later times.[12[13] [23] Seeing objects recede from earth is not an indication that earth is near to center from which expansion is occurring, but every observer in an expanding universe will see objects receding from them.[16][22]

VI. Units derived from H

Hubble parameter is also denoted in dimensionless h.

$$\frac{cz}{H_0} \sim 2998\, z\, Mpc^{-1} \qquad (9)$$

The Hubble constant H_0 has units of inverse time; the Hubble time t_H is simply defined as the inverse of the Hubble constant.[50] The Hubble time is the age it would have had if the expansion had been linear, and it is different from the real age of the universe because the expansion is not linear.[36][24]
$D = cH^{-1}$ in the equation for Hubble's law, $v = H_0D$ reveals that the Hubble distance specifies the distance from our location to those galaxies which are *currently* receding from us at the speed of light.[12][13]
Some cosmologists even use the term Hubble volume to refer to the volume of the observable universe, although this has a radius approximately three times larger.

VII. Shape of the universe

The Hubble parameter, H(t), is a function of cosmic time, defined as the rate of change of the universe's scale factor, a(t), divided by the scale factor itself: H(t) = ȧ(t) / a(t).
The scale factor, a(t), describes how the relative distances between objects in the universe change over time.
The Friedman eqn. describes the current state of the universe.[37][38]

$$H^2 = [\left(\frac{\dot{a}}{a}\right)]^2 = \frac{8\pi G\rho(t)}{3} - \frac{kc^2}{a(t)^2} + \frac{\Lambda c^2}{3} \qquad (10)$$

where H is the Hubble parameter, *a(t)* is the scale factor , G is the gravitational constant , ρ(t) is the energy density, k is the normalised spatial curvature of the universe and equal to −1, 0, or 1, and Λ is the cosmological constant.

VIII. Overview of the project

Statistical calculations of various linear plots in Figures(1 to 6) have been carried out. Table (1 to 6) shows the standard deviations of various quantities, mean square slope and slope. They have been calculated using Statistics package in MS Excel.
The formula for the slope (often symbolized by b or m) of the least squares fit is given by the product of the correlation coefficient and the ratio of the standard deviation σ_y to standard deviation σ_x ,

$$b = r * (\sigma_y/\sigma_x) \qquad (11)$$

IX. Experimental methods: Photometry and spectrophotometry

Photometry (measuring brightness) of variable stars generates light curves, which are plots of brightness over time. These light curves reveal the star's period of variation. For specific types of variables like Cepheids and R R Lyrae stars, their period is directly linked to their intrinsic luminosity through a Period Luminosity relation. By comparing this known Luminosity to their apparent Brightness (measured via photometry), astronomers can calculate their distance using the inverse-square law. The shape and characteristics of the light curve also provide clues about the star's physical properties, including its temperature and other aspects of its luminosity and physical state.
Distance of the cepheid variable stars is calculated using the Luminosity values derived from absolute magnitude using Modulo Formula. [10]
Astronomers calculate a star's True Luminosity (L) using the Modulo Formula relation:

$$m - M = 5\,\log_{10}\frac{d}{10pc} \qquad (12)$$

$$m - M = -2.5\,\log_{10}\frac{L}{L_\odot} \qquad (13)$$

Distance of the cepheid variable stars is calculated using the Luminosity values derived from absolute magnitude M and apparent magnitude m, Luminosity L and Luminosity of Sun, $L_\odot$ using Modulo Formula. [10]
We can use the Distance-Brightness plot of cepheid variables to measure Distances to the galaxy for distances upto 50 MPc. From Luminosity value, we can calculate Temperature and other stellar conditions, like gas-velocities, evolution of stars, their mass and radius. Fourier Transform of Photometric data compared alongside Blackbody spectra also provides data about Temperature, composition and other physical conditions like rotation of the star. [21].[22],[23].
In photometry, the Spectral Energy Distribution (SED) of a star is a graph plotting the star's energy output across various wavelengths, derived from broad-band photometric data. It acts like a simplified spectrum, providing a measure of a star's total emitted light at different colors. By comparing a star's measured SED to theoretical blackbody curves and other models, astronomers can determine its physical properties, such as temperature and the presence of surrounding dust.
Time dilation and color change measured from MultiBand Light curves for SNe-Ia provides the value of redshift necessary to measure Distances using Hubbles Law upto billions of Light Years. Redshifts are calculated by comparing the spectra of the variable with the Template spectra of a Library of known galaxy or quasars.

X. Experiments on Light curves of Cepheid Variables and Super Novae

We are considering various plots viz.1. Fig. 1 Hubble diagram considering Light curves for SNe -Ia. Fig. 2. Hubble plot considering 25 Cepheid variables along Fig. 3. Hubble plot considering 1777 Cepheid variables. Fig. 4. Dopplerfrequency shift for different Radar frequencies. Fig. 5 plot of Doppler Radar shift for sea waves with U_{WD} , the wind speed.

In a Hubble diagram, light curves for Cepheid variable stars and Type Ia supernovae are used to calculate the distances to galaxies. The diagram plots these calculated distances against the galaxies' recessional velocity, which is measured from their redshift.

Type Ia supernovae light curves are used as described.

Type Ia supernovae are exploding white dwarf stars that serve as "standardizable candles" for measuring much greater distances than Cepheids can reach.

A Type Ia supernova light curve shows a rapid increase in brightness followed by a gradual decay.While not perfectly identical, Type Ia supernovae can be "standardized" by analyzing their light curves. A fainter supernova, for example, will have a more rapid decay. This relationship allows astronomers to determine its intrinsic brightness. By comparing the corrected intrinsic brightness to the observed apparent brightness, astronomers calculate the supernova's distance. These observations extend the Hubble diagram to very large distances and are used to study cosmic expansion over vast cosmic timescales. Observations of distant Type Ia supernovae famously revealed that the expansion of the universe is acceleration The absolute magnitude of the supernova ($M_V = -19.5$); and that absolute magnitude, when assigned to SNe Ia that appear in remote galaxies, gives their distances.

In this way, H_0 has been determined to be about 60 km/sec/Mpc, in good agreement with the supernova physical methods. The corresponding Hubble time is 17 Gyr.[14][15]

X. 1 Experiment 1: Analysis of Hubble diagram of SNe Ia Light curves.

We have worked on few statistical calculations on Hubble Diagram. **Refer Sec. Publication and Article Source 1.**

The absolute magnitude of the supernova ($M_V = -19.5$); and that absolute magnitude, when assigned to SNe Ia that appear in remote galaxies, gives their distances. In this way, H_0 has been determined to be about 60 km/sec/Mpc, in good agreement with the supernova physical methods. The corresponding Hubble time is 17 Gyr.[14][15]

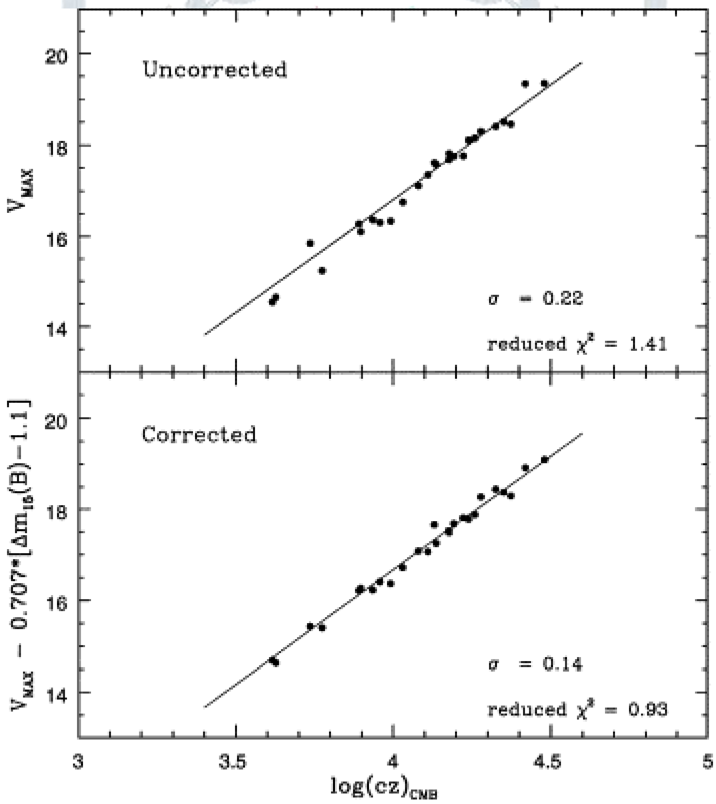

Figure 1: *'Hubble Diagram' for a sample of well deserved Sne Ia* ***Top****: The apparent visual magnitude of supernova at maximum brightness is plotted against the logarithm of the parent galaxy radial velocity (km/sec). If SNe Ia had identical peak absolute magnitudes, the point would fall on the straight line.* ***Bottom:*** *A correction for a relation between the peak magnitude and the light curve decay rate has been applied to reduce the scatter about the straight line.*

The readings below have been worked out from the image in the **Ref. . Sec. Publication and Article Source 1.**

***Table 1:** The Table depicts Period-Luminosity plot for the sample points selected from the image in Fig. 1*

Sr. no.	log(cz)	v(max)
1	4	17
2	3.5	14
3	3.9	16
4	4.5	18.5
5	3.7	15
6	4.3	18

***Table 1.1:** The statistical quantities calculated for Fig. 1*

Sr. no.	: Statistical quantities	Values
1	σ_x	0.371
2	σ_y	1.774
3	R	0.9864
4	Slope	4.716
5	$<slope>^2$	4.55

Various quantities, on a sample containing stars in the image in Fig.1, were calculated. They included standard deviations of the apparent visual magnitude of the supernova at maximum brightness and the logarithm of the parent-galaxy radial velocity (km/sec), correlation coefficient r ,slope of the above graph using statistical formulas in MS Excel. The slope was calculated by Linear Least squares Fit method. And the values are listed in the Table 6. The slope of the graph of Magnitude vs. log period comes out to be 4.716.

X.2 Experiment 2: Analysis of Period-Luminosity plot of 25 variable stars in SMC

A Cepheid variable is a pulsating star whose brightness changes in a predictable, periodic way.

Astronomers measure a Cepheid's apparent brightness over time to produce a light curve, which reveals its pulsation period.[26][27][28]

A fundamental property of Cepheids is the period-luminosity relationship: the longer the pulsation period, the greater the star's intrinsic (absolute) brightness.

By comparing the star's intrinsic brightness (from its period) with its apparent brightness (how bright it looks from Earth), astronomers can calculate the star's distance.

The distances to galaxies containing Cepheids are plotted on the diagram against their recessional velocity to determine the Hubble constant, which describes the expansion rate of the universe.

We have worked on statistical calculations on the Plot of 25 variable stars in Small Magellanic Clouds from Leavitt's 1912 paper. **Refer Section c.Publication and Article Source: 2.**

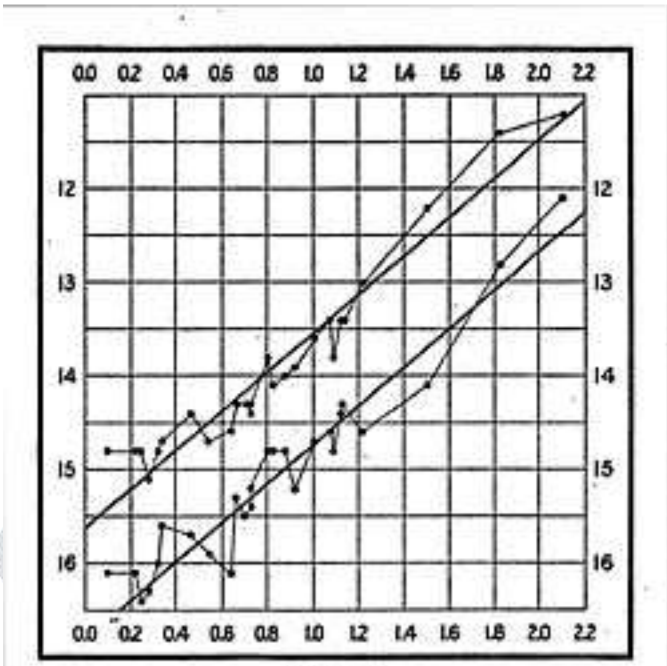

FIG. 2.

Figure 2: *Publication: Leavitt Henirettа S, Pickering Edward C, Harvard College Observatory Circular, vol 173, pp 1-3Pub Date: March 1912. The horizontal axis is the logarithm of the period of the corresponding Cepheid and the vertical axis is it's apparent magnitude. The lines drawn correspond to the stars's minimum and maximum brightness 2. Plot of 25 variable stars in Small Magellanic Clouds from Leavitts 1912 paper.*

A sample of the readings along with the image from the **Ref. Section c.Publication and Article Source: 2.** have been worked out.

Table 2*: The Table depicts Period-Luminosity plot of the sample points selected from the image in Fig. 2.*

Variable star	D (Mpc)	V (km/s)	Log D	Log v
NGC 1316	16	1761.3	1.21	3.24
SN 2003	23.1	8502.3	1.36	3.92
NGC 2935	35.2	2274	1.546	3.356

Table 2.1: *Statistical quantities calculated for Fig. 2*

Sr. no.	: Statistical quantities	Values
1	σ_x	0.903
2	σ_y	4.6014
3	R	0.96422
4	Slope	3.89072
5	$<slope>^2$	4.91

Considering the plot in Fig. 2, various quantities, standard deviations of the logarithm of the period of the corresponding Cepheid, and the standard deviation of its apparent magnitude, correlation coefficient r ,slope of the above graph using statistical formulas from MS Excel. The slope was calculated by Linear Least squares Fit method. And the values are listed in the Table 6. The slope of the above graph of apparent Magnitude vs. log period comes out to be 4.716.

X.3 Experiment 3 :Analysis of Period-Luminosity plot of 1777 variable stars in SMC

We also worked out statistical calculations on the Period-Luminosity plot, initially discovered in 1908 and plotted by Heniretta Leavitt in 1912, from her study of 1777 o variable stars in the Magellanic Clouds. **. Refer Sec. Publication and Article Source 3.**

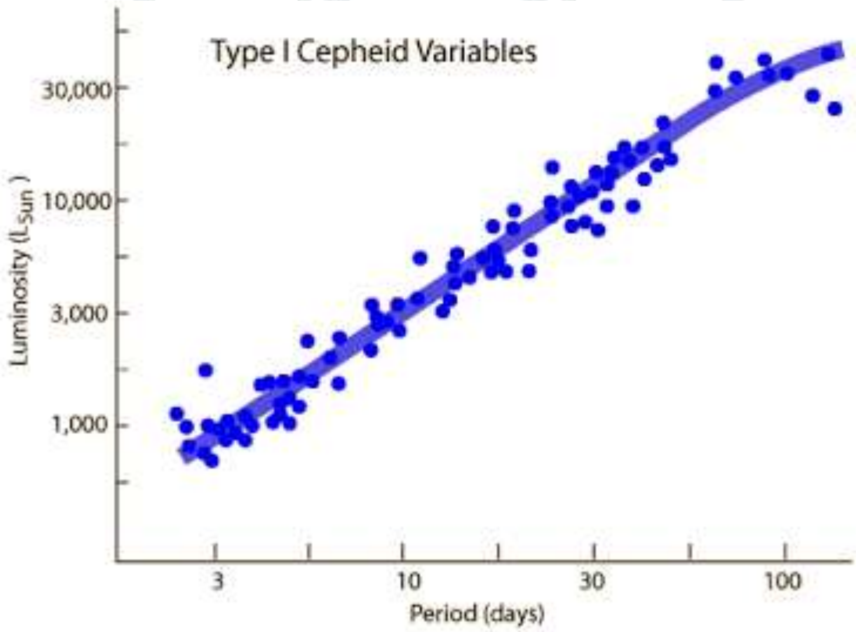

Figure 3: *Period-Luminosity of 1777 variable stars in Small Magellanic Clouds (image from hyperphysics.phy-astr.gsu.edu)*

Table 3: *The Table depicts Period-Luminosity plot of the sample points selected from the image in Fig. 3.*

Variable star	D (Distance)	Z (Redshift)	Luminosity B	Log (B)	Days	m – M
SN 2019rga	142.5	0.0126	3861.6	3.586	16.17	35.77
SN 2019 tga	72.44	0.0106	3186.3	3.503	14.17	34.3
SN 2019 odl	331.1	0.063	18959	4.277	18	37.6
SN 2019 lqn	450.8	0.0716	22682.7	4.355	18.67	38.27
SN 2019 ahg	388.4	0.042	12600	4.1	17.7	37.3
SNlqn 2019dfa	64.86	0.025	7719.3	3.887	14.46	34.06
SN 2019daj	203.23	0.038	11400	4.056	16.94	36.54
SN 2019 vsa	71.12	0.006	1830.6	3.262	14.66	34.26

Table 3.1: *Statistical quantities calculated for Fig. 3*

Sr. no.	:Statistical quantities	Values
1	σ_x	0.391
2	σ_y	1.752
3	R	0.8462
4	Slope	3.78
5	$<slope>^2$	3.79

Considering a sample of stars from the above image in Fig. 3, various quantities were calculated. They included standard deviations of the absolute magnitude of the supernova at maximum brightness and the logarithm of the period of parent-galaxy radial velocity (km/sec), correlation coefficient r ,slope of the above graph using statistical formulas in MS Excel. The slope was calculated by Linear Least squares Fit method. And the values are listed in the Table 6. The slope of the graph of apparent Magnitude vs. log period comes out to be 3.78.

XI. Applications of Doppler Radar in Atmospheric Sciences and Oceanic studies.

We are also considering redshift due to Radar in Doppler effect for two fields: atmospheric science and ocean sea waves. Radar uses the Doppler effect to measure velocity by analyzing the frequency shift between a transmitted and reflected radio wave. Radar systems emit radio waves and then detect the reflected waves. Radar systems measure this frequency shift to directly calculate the target's radial velocity.

In astronomy, redshift is the stretching of visible light waves from distant objects moving away from us, shifting them towards the red end of the spectrum. This redshift is then used to calculate the object's recessional velocity. A positive redshift $z > 0$ indicates an object is moving away.

Radar uses radio waves, while astronomical redshift uses light waves. Radar is used for applications like weather forecasting, traffic enforcement, and aviation. Redshift is used to understand the expansion of the universe, galactic distances, and the movement of stars.

For the Analysis of this experiment on Radar Doppler frequency shift . **Refer Sec. Publication and Article Source 4.**

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The doppler frequency *shift* of an echo signal reflected from a moving target is

$$f_d = \frac{2v\cos\theta}{\lambda} \quad (14)$$

where
f_d is the frequency shift in hertz,
v is the velocity of the target in meters/second,
λ is the wavelength in meters,
θ is the angle defined by the direction of target travel and the radar line of sight to the target.
The relative velocity is $v_r = v \cos \theta$. The doppler frequency shift per knot of relative velocity (f_d/v_r) is plotted in Fig. 4. Where v_r is in knots and λ is in meters.

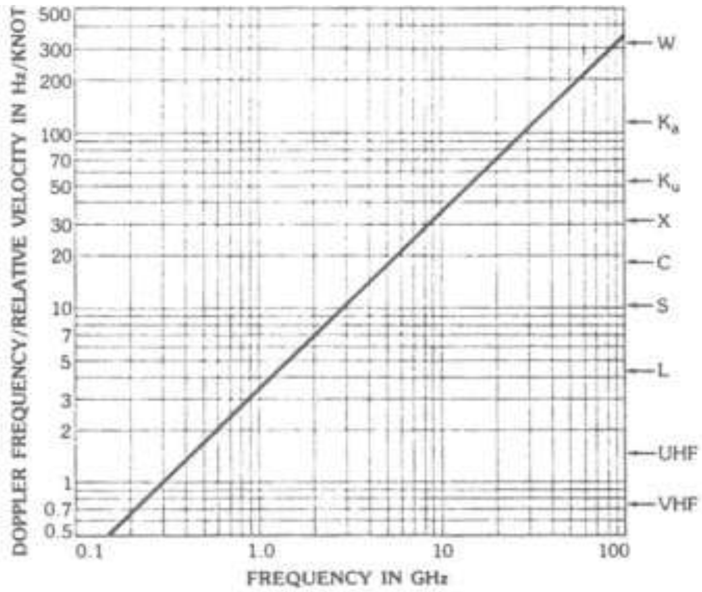

Figure 4: Doppler Frequency shift per unit relative velocity (hertz/knot) as a function of radar frequency.

A sample of the readings have been obtained by working on the image from the Section: **Publication and Article Source 4.** frequency in GHz.

Table 4: *The Table depicts the readings for Doppler frequency shift per unit relative velocity (hertz/knot) and radar frequency in GHz.*

Sr. No.	Frequency GHz	Doppler shoft (Hz/knot)
1	0.2	0.7
2	0.3	1
3	0.4	1.5
4	0.5	1.8
5	0.7	2.5
6	0.9	3
7	1	3.5
8	10	38
9	100	350

Table 4.1: *Statistical quantities calculated in Fig. 4*

Sr. no.	: Statistical quantities	Values
1	σ_x	33.899
2	σ_y	115.12
3	R	0999
4	Slope	3.81
5	$<slope>^2$	3.499

Considering Fig. 4, various quantities were calculated. They included standard deviations of Doppler frequency shift f_d per unit relative velocity v_r , and the standard deviatioin of logarithm of radar frequency f, correlation coefficient r ,slope of the above graph using statistical formulas. The slope was calculated by Linear Least squares Fit method . And the values are listed in the Table 6.

The slope of the above graph of Doppler frequency vs. log frequency also comes out to be 3.81.

XI.2 Experiment 5: Analysis of Radar Doppler effect of ocean waves

The low-incidence Ka-band real-aperture radar rotary scan regime has the capability of measuring the Doppler shift caused by ocean waves, known as the wave-induced Doppler velocity (U_{WD}). The Doppler shift of microwave radar sea surface echoes serves as the foundation for sea surface current field retrieval.

There is close correspondence between wind speed and sea surface roughness because wind modulation of the sea surface changes sea surface roughness. The wind induced Doppler shift measures orbital velocity of the waves for different wind speeds in different directions and wave angle .

For the study of Doppler induced sea waves, we had referred the following Article: . **Refer: Sec. Publication and Article Source 5.**

Figure 5 shows the variation in U_{WD} and it's s.d. with wind speed in the downward, crosswind and upwind directions at incidence angles of 6° and 12°. The s.d. of U_{WD} increases slowly with wind speed in downward and upward directions. The values of Mean Square Slope and correlation coefficient for the two quantities, wind induced Doppler U_{WD} and wind velocity has also been considered from the same Article.

There is symmetry in the U_{WD}–wind speed curve, which is insensitive to the variation in the incidence angle. The values of Mean Square Slope and correlation coefficient for the two quantities, wind induced Doppler U_{WD} and wind velocity has also been provided in the same article. The slope of the plots in Fig.5 for Downwind direction for both 6° and 12°had been calculated to be 4.312.

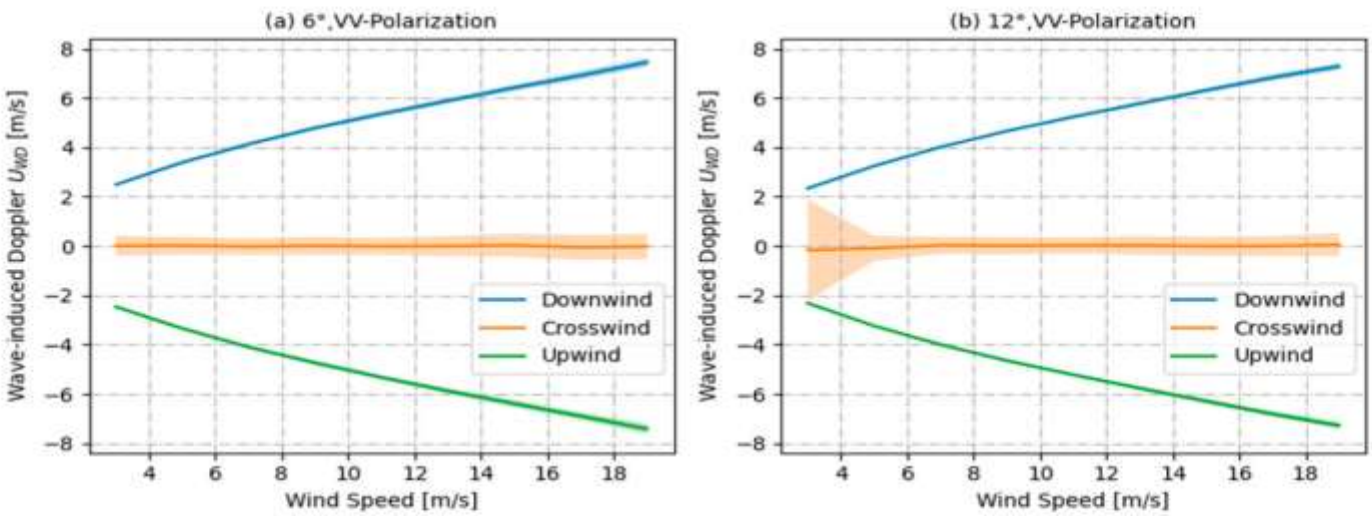

Figure 5: Variation in U_{WD} and standard deviation with wind speed for radar incidence angles of 6^0 and 12^0, azimuth angles of 0^0, 90^0 and 180^0 wind direction without swell. The colored solid line indicates U_{WD}, and the corresponding colored shading iis the standard deviation.

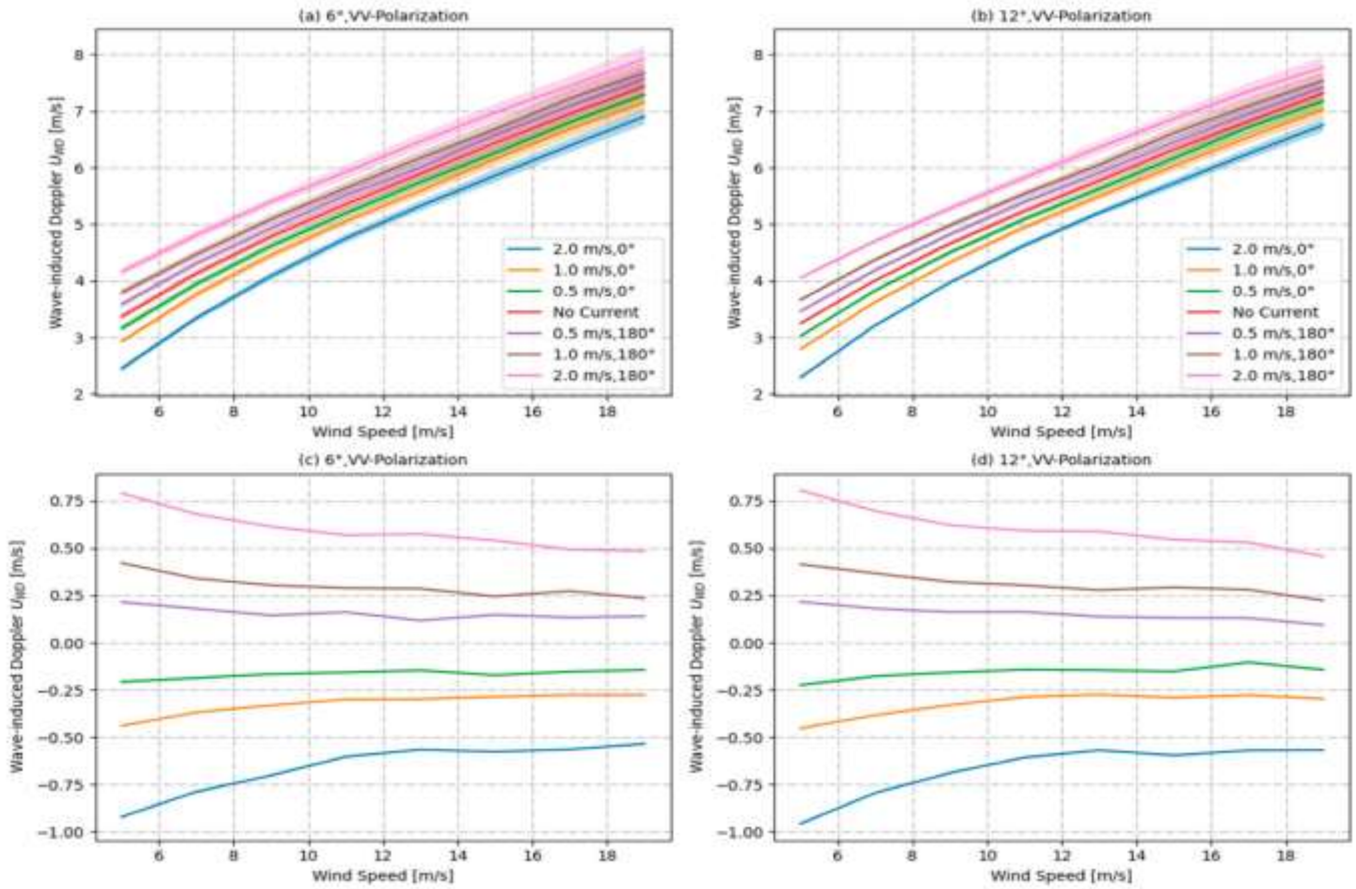

Figure 6: *(a,b) represent the variation in U_{WD} with wind speed for Radar incidence angle of 6^0 and 12^0, wind speed of 10 m/s and surface current of of 0.5, 1 and 2 m/s, when they are downward and upwind direction and the corresponding colored shading of sd(c, d) correspond for (a, b) and indicate the direction in U_{WD} between presence and absence of current.*

The statistical values are written from **Section: Publications and Artiicle Source. 5.** The value of the slope is calculated for Log graph is 4.312.

The readings below have been worked out from the image in the **Section: Publications and Artiicle Source. 5.**

Table 5*: The Table depicts the variation in U_{WD} with wind speed readings for wind induced Doppler frequency shift for sea waves.*

Sr. no.	(windspeed) m/s	Log (wind speed)	U_{WD} m/s	Log U_{WD}
1	6	0.77	4	0.6
2	10	1	5	0.699
3	8	0.903	4.5	0.653

***Table 5.1**: Statistical quantities calculated for Fig. 5*

Sr. no.	: Statistical quantities	values
1	σ_x	0.5
2	σ_y	2
3	R	099
4	Slope	4.312
5	$<slope>^2$	3.96

XII. Analysis and Summary

Statistical calculations of various linear plots in Fig. 1 , Fig. 2, Fig. 3, Fig.4 and Fig. 5 were carried out and Table no. 6 shows the standard deviations σ_x , σ_y of various quantities on x-axis and y-axis of the plots, and the mean square slope and the slope is calculated using the statistical package in MS EXCEL.

Table 6: Statistical calculations of the standard deviations σ_x , σ_y of various quantities on x-axis and y-axis of the plots, and the

***Table 6**: Statistical calculations of the standard deviations σ_x ,,σ_y of various quantities on x-axis and y- axis of the plots, and the mean square slope, $< slope >^2$, and the slope b is calculated using the statistical package in MS EXCEL on various observations of Hubble Diagram and Doppler Radar.*

mean square slope $<slope>^2$ and the slope m is calculated using the statistical package in MS EXCEL on various observations of Hubble diagrams and Doppler Radar.

Type of Observations	σ_x	σ_y	R	$<slope>^2$	Slope b
Hubble diagram, Fig.1	0.371	1.774	0.9864	4.55	4.716
Plot of 25 Cepheid variables, 1908, Fig. 2	0.903	4.6014	0.96422	4.91	3.84
Plot of 1777 Using Cepheid variables, Fig. 3	0.391	1.752	0.8462	3.79	3.78
Doppler Radar due to a moving target in atmospheric sciences, Fig. 4	33.899	115.12	0.999	3.499	3.81
Fig.5 Ka band real aperture radar for sea waves,(both upwind and downwind, of 6° and 12° VV Polarization,	2	0.5	0.99	3.96	4.312

I. Discussion and Results

The Inflation theory in the Standard Big Bang Model makes an important prediction, that the universe must be flat with $\Omega_{total} = 1 \pm 10^{-4}$. Ω_{total} is the ratio of the universe's average energy density to the critical density required for a flat universe. A universe with Ω_{total}= 1 has a flat geometry and a universe with zero curvature, which is "flat" or Euclidean.

The observed flatness of the universe today means that its initial density must have been exceptionally close to the critical density. Any minuscule deviation from this critical value in the early universe would have been magnified over billions of years, leading to a much more curved universe than what is observed.

In all the above log graphs, we found both the mean square slope and the slope values are centred around 4. The value of the slope of the above Hubbles plot denotes the roll-off, which has the value of 4 in the log scale. i.e. O(4), the actual size is 10^4 times that of the relative expanded scale. For eternal inflation to set in , all one needs is that for probability for a scalar field to increase in a given Hubble sized volume during Hubble time interval. The roll-off should be of the order 4, O(4) i.e. relative expanded size to the actual scale size is of O(4). of 6° and 12°.

The scale factor (a) re presents the relative size of the universe over time, while Hubble's constant (H_0) is the current rate of expansion of that universe, defined as the time derivative of the scale factor divided by the scale factor itself, or $H_0 = \dot{a}/a$. The scale factor describes how the universe has expanded since the Big Bang, and Hubble's constant quantifies how fast that expansion is happening now.

This is true even for other plots viz., Doppler profile for atmospheric studies and also Doppler Ka band radar profile for sea waves as all the above log plots have a central value of slope 4. For all these cases, the roll-off comes out to be of the order 4.

CMB anisotropies also have been measured to be $\frac{\Delta T}{T}$ = 1- 2 x 10^{-4}**,** in the Rayleigh Jeans part of the spectrum for rich clusters along the line of sight toward the cluster centre. The CMB is the afterglow of the Big Bang, and its photons have been traveling through the expanding universe since the time of recombination. The nearly constant Hubble parameter during this period ensures these fluctuations have a nearly scale-invariant spectrum, a prediction robustly confirmed by observations of the CMB and large-scale structure.

CMB anisotropies are small temperature variations that are a direct imprint of the early universe's density fluctuations, which are the seeds for large-scale structure formation like galaxies and galaxy clusters**.** Any initial curvature of the universe is stretched to near-flatness, leading to the flat geometry observed today. As the universe expands, the wavelengths of these photons are stretched, causing them to shift from shorter, hotter wavelengths to longer, colder ones. [31] [32] [33]

XIII. Conclusion

The roll-off for all the fluid flows right from the size of sea surface to size of atmospheres and even the size of expansion of universe all are of the order 4. This value of expansion size has remained the same, as was imprinted in the early primordial universe after the recombination era. So until a limit, Hubbles parameter is a constant, but later on, beyond this limit, Hubbles parameter has a constant roll-off with time.

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