Galaxies as probabilities

(11-06-2024)

CJ Blackwood
Michigan Theoretical Dynamics Institute
cjblackwood@mtdi.org

Abstract:

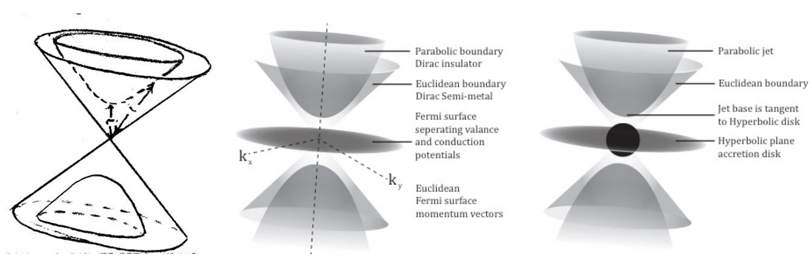
In this discussion, on probability and measurement, we explore the probabilities associated with the galactic boundaries we have established for gravity, "Dark Matter" (DM) and "Dark Energy" (DE). We demonstrate a clear solution to the current tension between measurements of the Hubble constant, (H_0), using measurement frames of reference (MFR), for global and local galactic phase probabilities. We show that all global measurements of H_0 require a local calibrator for the establishment of any distance ladder. Using the phase probabilities associated with Fermi-Dirac statistics and De-Broglie matter waves, we explore how local calibrators establish both mode and mean for any global measurements of the Hubble constant, and demonstrate why measurements using the Tip of the Red Giant Branch (TRGB), carbon stars (JAGB) and water masers are connected to boundaries established by the galactic central black hole (BH). In this paper we also demonstrate the nature of global phase measurements and discuss why both measurements of the Cosmic Microwave Background (CMB) and The Leavitt Law, using SN1a Supernova cannot be used as local distance ladders, without a local distance calibrator. Our concluding discussion establishes the galactic probabilities in the early universe that allow for the formation of Super Massive Black Holes (SMBH), Galactic Clusters, (GC) and Spiral Galaxies (SG). Local and global phase probabilities are then related to the topological limits we established in our recent papers, "Measuring the Universe Parts I and II".

Introduction

We will assume the reader is familiar with our earlier work, as we explore galactic probabilities for measurement in a mathematically closed universe. As you will remember, our previous two papers, *"Measuring the Universe Parts I and II"*, established the topological boundaries for gravity, DM and DE. We demonstrated the ΛCDM standard model, and all "forces" in that model, can be equated to measurement frames of reference, (MFR) limited by statistical probability. In this paper, we will open with a quick review of the topological boundaries for measurement probabilities in real and imaginary space and review the nature of both Hyperbolic and Euclidean MFR at galactic scales and discuss how statistical MFR can be equated to all "forces" in the current standard model of particle physics. We follow with *Section 1.1- Establishing a topological mean for global and local phase probabilities,* establish both the global and local phase mean for all Lorentz invariant probabilities at global scales. We tie the local mean directly to measurements of the central BH. We then discuss the nature of local galactic phase measurements limited by Fermi-Dirac statistical boundaries. We then establish the link between the Fermi-Dirac mean and measurements of degenerate matter in TRGB stars. *Section 1.2- Establishing the local galactic mode with De-Broglie matter waves and the fine structure constant,* establishes the local phase mode using measurements of JAGB Carbon stars and the limits established by De-Broglie probabilities at the quantum scale. *Section 2.0-Global phase probability and the Planck constant,* discusses the global nature of the Planck constant and provides a quick summary chart of the galactic probabilities as they are related to local and global phase probabilities and demonstrate how measurements of current standard candles, (TRGB, JAGB) can be equated to local phase boundaries through their quantum boundaries. *Section 2.1 – The Leavitt Law as a global measurement of the least action principle* discusses the current tension between measurements of the Hubble constant and why measurements of the Leavitt Law cannot be used as a local distance ladder without a local calibrator. We demonstrate that both the Leavitt Law and Cosmic Microwave Background (CMB) act as global, and flat, measurements of the Planck constant. Our final section, *Section 3.0 – Phase probabilities in the early universe,* reviews some of the recent JWST results and links the early appearance of Super Massive Black Holes (SMBH), Galaxy Clusters (GC) and Spiral Galaxies (SG) to local and global phase probabilities.

1.0 – Measurement frames of reference, topology and statistical probability

In Part I of *"Measuring the Universe" [21],* we introduced a new model for the early universe that explains the nature of DE and DM using the limits of geometric completeness, conformal topology and statistical probability. We demonstrated that all "forces" in the, current, standard model of physics, can be equated, statistically, and geometrically, to complete measurement frames of reference. In our model, all measurement frames of reference are mathematically, geometrically and statistically closed measurements. In Part II *[22],* we established the closed nature of statistical frames of reference and tied them, directly to the topology of Bill Thurston and the limits of the 3-sphere *[1].* The closed nature of measurement theory is in perfect alignment with both General Relativity (GR) and quantum theory and can provide a natural bridge between the, seemingly opposing, frames of reference. As we have demonstrated, many times, completeness in measurement theory and topology also allows us to equate this model to the statistical probabilities associated with the current model of High Energy Particle Physics (HEP), Quantum Chromo-dynamics (QCD) and Electroweak Theory (EW). In this discussion, we will explore how statistical probability and geometric completeness, at the quantum scale, are related to measurement frames of reference, and probability, at galactic scales. The topology of completeness, defined by Thurston's limits on a 3-sphere, can provide the scaffolding for measurement theory at any scale *(Figure I)*.



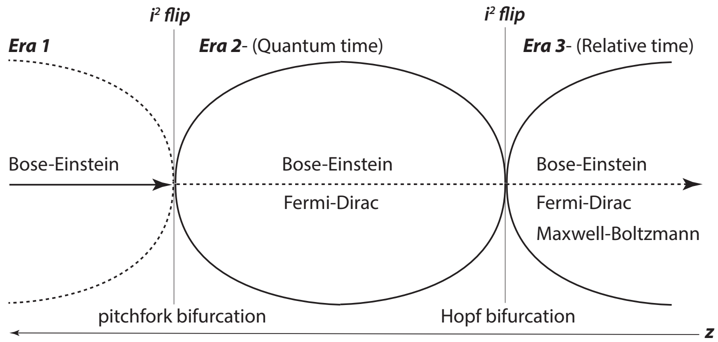
(Figure 1) *The conformal Hyperboloid metric, described by Thurston, can be tied to the conic and parabolic components of Black Hole Jets in AGN as well as the quantum probabilities associated with measurements of topological insulators.*

Topological completeness at quantum and galactic scales, allows us to equate different measurement frames of reference and model all aspects of the current standard model of physics without the need for "fields" or "forces". We use these principles to explain the current "tension" between measurements of the Hubble constant and the early appearance of Super Massive Black Holes (SMBH), Galaxy Clusters (GC) and Spiral Galaxies (SG). In the following sections we shall demonstrate how topological completeness and statistical probability form the basis for global and local phase probabilities at the galactic scale, driven by quantum statistical phase boundaries. It is the measurement of geometric, and statistical, completeness that led Max Planck to his original discovery of the constant of least action, that we now refer to as the Planck constant. In an interview, he gave in 1931; Planck admitted that he was forced to turn to statistics, even though it conflicted with his convictions about the limits of the laws of physics:

"It was clear to me that classical physics could offer no solution to this problem, and would have meant that all energy would eventually transfer from matter to radiation. ...This approach was opened to me by maintaining the two laws of thermodynamics. The two laws, it seems to me, must be upheld under all circumstances. For the rest, I was ready to sacrifice every one of my previous convictions about physical laws. ... [One] finds that the continuous loss of energy into radiation can be prevented by assuming that energy is forced at the outset to remain together in certain quanta. This was purely a formal assumption and I really did not give it much thought except that no matter what the cost, I must bring about a positive result."

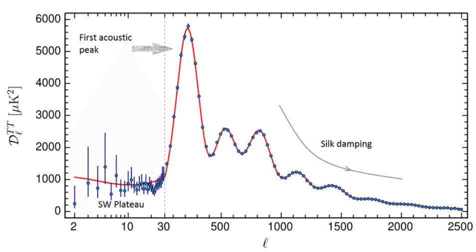
Max Planck. The Observer January 25, 1931

Planck's discovery of quanta, that could only be described statistically, was a leap of faith. He understood that he had to sacrifice many of his preconceptions to achieve his goal of defining the limits of the Raleigh-Jeans Law as exhibited by a perfect blackbody. It is important to remember that Planck relied on a closed statistical measurement to define the limits for his quanta of least-action. We will take advantage of the closed nature of the Planck constant to help us define the boundaries between global and local phase probabilities. *(Figure 2)* shows how phase probabilities evolve throughout our model. All statistical probabilities for measurement have evolved from the previous eras, defined solely by Fermi-Dirac and Bose Einstein statistical boundaries. In our measurement era, we exist at the speed of light confined by statistical probability and the laws of thermodynamics.



(Figure 2) *Our model is based on the evolution of a statistical blackbody. Each phase space is Lorentz invariant and follows the limits of geometric completeness. This results in the globalization of local bifurcation nodes. Era 3 shows how our local universe driven is by all three statistical MFR and the rules of Lorentz invariance. A Hopf transition allows us to equate all topological potential to spin, allowing for the appearance of SMBH in the early universe.*

Era 3 is the local era we live in now. The Planck constant is the constant of least action for all Lorentz invariant measurements. The Planck constant is defined, to very high degree of accuracy, by measurements of Baryonic Acoustic Oscillations, (BAO), and temperature variations in the Cosmic Microwave Background (CMB) made by the Planck collaboration *(Figure 3)*.

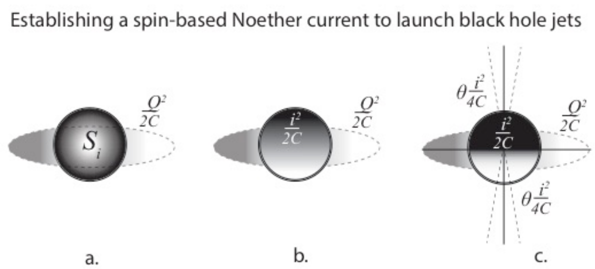


(Figure 3) *The measurement of BAO by the Planck Collaboration represents one of the most accurate measurements of the Planck constant. (The Planck Collaboration A&A 641, A7 2020)*

It is this, highly accurate, definition of the Planck constant that will help us define global, and local, phase probabilities at the galactic scale. As a global probability, the Planck constant imposes phase limits at quantum and galactic scales of Lorentz invariance. By treating galaxies as probabilities, we hope to demonstrate that many of the preconceptions we have about measurements at galactic scales must be discarded in favor of a statistical interpretation of measurement at all scales. In the next section we discuss the nature of local galactic probabilities driven by the topology of the central galactic BH.

1.1 – Establishing a topological mean for global and local phase probabilities

In our paper "A black hole as ideal spin capacitor" *[17]*, we established the quantum rules associated with a BH conversion of mass to spin using, complex, Noether potential. In our model, the topology of the BH, and accretion disk, act as statistical potential in both the real and imaginary plane, *(Figure 4)*.

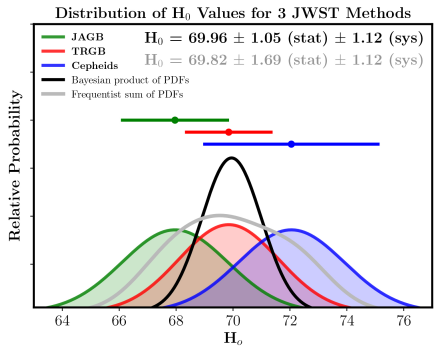


(Figure 4) *The real and imaginary nature of spherical coordinates and Noether rings, allows us to model the interior of a BH as an ideal spin capacitor*

Because spin potential is a topological concept, a BH "capacitor" can equate to Fermi-Dirac or Bose Einstein statistics using Markov chain probability *[12], [13], [14]*. Spin potential acts outside of Maxwell-Boltzmann (MB) statistics and can only be described using Bose-Einstein and Fermi-Dirac statistics *[12], [13], [14]*. For this reason, any local galactic mean must satisfy both the topological demands of GR as well as the quantum probabilities associated with Fermi-Dirac statistics. Maxwell-Boltzmann statistics are driven by the thermodynamics of the accretion disk. In our model, the topology of the BH, and accretion disk, act as statistical potential in both the real and imaginary plane *[17]*. The galactic central BH sets the, Markovian, time scale for the galaxy. Bayesian time is set by the ideal black body statistics of the accretion disk. *For local galactic probabilities tied to this potential, the BH establishes both Markovian and Bayesian time for all relative matter*. In this discussion, and as a general rule, all local galactic phase measurements are relative to the central BH and it's accretion disk. All local phase measurements must also conform to global phase measurements, like the CMB. The difference is that global phase probabilities are not tied to the galactic central BH or accretion disk.

In our last paper *[22],* we demonstrated that all galaxies and galactic clusters have a topological center that defines the hyperbolic plane in galactic conformal topology. We also demonstrated that our topological mean was an exact match with TRGB measurements of the Hubble constant [2], [3], [4]. Local phase probabilities are held to the hyperbolic plane of GR and all the boundaries of Lorentz invariance at quantum and relative scales. Any measurement statistical mean or mode must also be *locally* Lorentz invariant as well as conform to global phase boundaries. We can establish the mode and mean for all local galactic probabilities using the limits provided, at the quantum scale, by JAGB and TRGB statistical measurements and their calibration to the H_2O mega-maser in NGC-4258 *[2].* H_2O Mega-masers (MM) are particularly sensitive to the statistics of both the accretion disk and the quantum central BH. Like the central BH, MM is highly polarized and operates at the brightness temp of a perfect black body. The measurement of the quantum jump between resonant frequencies establishes the local phase probabilities for MM at the quantum scale. A*ny calibration to a Mega-Maser, at the local quantum scale, is also a calibration to the galactic center BH and local galactic phase measurements*. We can demonstrate how this works using the, current, tension in measurements of the Hubble constant.

We will assume the reader is, thoroughly, familiar with this current disagreement between measurements of the Hubble constant. The four candles we will discuss, in this analysis, are measurements of BAO in the CMB *[6], [9],* Tip of the Red Giant Branch (TRGB) *[2], [3], [4],* JAGB carbon stars *[2], [5],* and measurements of the Leavitt Law, using SN1a supernova *[2], [3], [9]*. We will use the recent, pioneering, work by (Freedman and Madore 2024*)[2]* to reference measurements of TRGB, JAGB and SN1a candles that are calibrated to the central BH utilizing the water maser from NGC 4258. Additional measurement candles, like DESI *[9],* and gravitational wave measurements, will be handled as Addendum. *(Figure 5)* shows us the relative probability measurements of the Hubble constant using different standard candles that are all calibrated to the water maser located in NGC 4258. As you can see, TRGB relative probabilities establish a statistical mean for the measurement frames of reference.



(Figure 5) *PDFs for the values of H_0 based on the three calibrations: JAGB (green), TRGB (red) and Cepheids (blue). The width of each individual Gaussian represents the statistical uncertainty. The error bars shown above, which use the same color-coding, represent the systematic uncertainties (see §5). The 1σ statistical uncertainties are determined from the 16th and 84th percentiles for the Frequentist sum of the distributions (shown in gray), and decreased by $\sqrt{N-1}$. The curve in black is the Bayesian product of the three PDFs.*

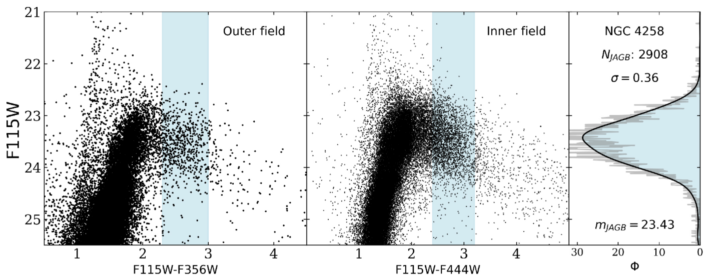
At the quantum scale, TRGB measurements depend on the Helium flash of a red giant. The Helium flash is triggered the boundary between matter and degenerate matter. Like the statistics of the water maser in NGC 4258, degenerate matter follows the limits of quantum statistics *and*, the rules of GR. We can use TRGB measurements to establish a local phase mean because the Fermi-Dirac statistical boundaries of degenerate matter can be equated to the quantum limits established by the Landau-Zener equations. Landau levels establish a local Fermi-Dirac phase mean, using only the limits of topology. Topological equivalencies, to the Landau-Zener equations, and Landau levels, is well established in quantum physics and, therefore, not necessary for the scope of our discussion. What is important is that we will use the same topological equivalencies for quantum and relative actions *at all scales of measurement*. This is the basis of Lorentz invariance. As we noted earlier, our topological mean, limited by the speed of light, is an exact match to measurements of the Hubble constant as determined using the TRGB measurement frame of reference *[2]*.

$$H_0 = \frac{2\pi i^2}{c^2} = .699i^2 = local\ TRGB\ phase\ mean$$

Using TRGB measurements to establish a topological galactic mean allows us to equate local phase probabilities, tied to galactic central BH, to global phase boundaries that are established by the rules of Lorentz invariance. It is our establishment of the link to topology that will allow us to connect quantum and relative phase potentials, at all scales of measurement. To establish the statistical *mode* for global, and local, phase measurements we must have a candle that is the same across all galaxies but also tied to the, local, statistics of the central BH the local mean. In the next Section, we will show how JAGB measurements *[2], [5],* of carbon stars fulfill these requirements for the establishment of a local phase mode.

1.2-Establishing the local galactic mode with De-Broglie matter waves and the fine structure constant.

The galactic mean, using TRGB measurements of Fermi-Dirac statistical boundaries, must have a mode that matches the same topological probabilities but acts at all scales of measurement in the galactic plane. One of the requirements for the establishment of a local phase mode is the consistency of the mode across all galaxies, galactic clusters and even dust throughout the universe. The other requirement is the ability to vector our local phase mode measurements towards the galactic center black hole. Local galactic measurements require us to have a common mode for phase probabilities across galactic measurements, at all scales. This will require us to establish a local mode that also is a global phase probability in the Euclidean plane. JAGB measurements of carbon stars provide a local phase probability that is consistent in color and luminosity across all galactic probabilities and can be calibrated to the central black hole using the water maser in NGC4258 *(Figure 6)*.



(Figure 5) *Color-magnitude diagrams for the two fields in our geometric anchor, NGC 4258.The JAGB stars were selected within the light blue shaded regions. The JAGB stars in the inner and outer fields were combined to make this aggregate JAGB LF. The number of JAGB stars within °æ0.75 mag of the mode is plotted in the upper right corner, as well as the dispersion for those stars about the mode. The measured JAGB magnitude is also shown in the bottom right.*

We can set the JAGB mode for all local phase measurements, using the local, and global, phase probabilities found in the De-Broglie matter wave equation and the fine structure constant. The De-Broglie equations tell us that matter, like light, can be described as a particle and a wave. Matter wave potential allows us to adhere to global and local phase probabilities while establishing the local galactic mode. Matter wave equations are based on the ratio of mass and momentum to Planck's least action constant:

$$\lambda = \frac{h}{mv} = \frac{least\ action\ constant}{momentum}$$

De-Broglie waves are probabilities and, therefore have both a mode and mean. They can be used to describe global and local phase probabilities at all scales of Lorentz invariance because can operate in the real and imaginary plane. As we established in our last two papers [21], [22], that Euclidean MFR exist as imaginary potential for any measurements in the hyperbolic plane. Global phase probabilities, like DM and DE, exist as parallel measurements in the Euclidean plane. Local hyperbolic phases are limited by the speed of light, but global phase potential, in matter waves, can exceed the speed of light. These aspects of De-Broglie wave potential are well established and do not require new physics. We can use the same topological equivalency that we used to establish a phase mean to equate to De-Broglie matter wave probabilities, in hyperbolic and Euclidean space:

$$\lambda = \frac{h}{mv} = \frac{least\ action\ constant}{momentum} = \frac{2\pi i^2}{c^2}$$

We can now use the relationship between local and global phase velocities and momentum, in the De-Broglie equations, to establish the local phase mode. The relationship between local and global phase velocities can be stated as:

$$v_l = \frac{\vec{k}c^2}{v_g}$$

Where $(\vec{k})$, is the local, and global, phase vector, (v_g) is the local relative phase velocity and (v_p) the global phase velocity. A common vector, at the particle and galactic scale, allows us to equate local phase probabilities to De-Broglie parameters. Because global phase potential can exceed the speed of light we can state it as an imaginary boundary with a common vector. A common vector for real and imaginary phase potential allows local phase probabilities, at all scales of measurement, to equate to the black body probabilities found in the central BH and accretion disk. We can use our topological equivalency to establish the inverse relationship between the scales of local and global phase probabilities

$$v_l = \frac{\vec{k}c^2}{v_g} = \vec{k}2\pi i^2$$

Because it is dimensionless, and scalable, we can use the fine structure constant as a local phase mode tied to the topology of the global mean. The fine structure constant can be stated as:

$$\alpha = \frac{e^2}{2\varepsilon_0 hc}$$

Like the Planck constant and the speed of light, the permittivity of free space, ε_0, is a global, and local, phase probability. We can also re-state the elementary charge (e) as a global topological and electro-dynamic probability. If we equate our topological value of geometric completeness to the elementary charge of the electron we can convert the fine structure to a topological phase probability:

$$e^2 = 2\pi i^2$$

$$\vec{k}\alpha = \frac{\vec{k}e^2}{2\varepsilon_0 hc} = \frac{\vec{k}\pi i^2}{4\varepsilon_0 hc}$$

Like the Planck constant and the speed of light, the permittivity of free space, ε_0, is a global phase probability. Like all of our relative measurements we convert the permittivity of free space to Electro-volts, ($\varepsilon_0 = 55.263494\ \mathrm{e^2 eV^{-1} um^{-1}}$). Because the fine structure constant is a dimensionless constant, we can use it as a local scalar tied to the topology of the global, and local, De-Broglie phase mean.

$$\alpha = \frac{\vec{k}e^2}{2\varepsilon_0 hc} = \frac{\vec{k}2\pi i^2}{4\varepsilon_0 hc} = \frac{\vec{k}\pi i^2}{2\varepsilon_0 hc} = \frac{\vec{k}.796165747i^2}{2\varepsilon_0} = \vec{k}\frac{.796165747i^2}{110.526988} = \vec{k}.007203360i^2$$

By equating the elementary charge to a topological probability we are able to use our equivalency as a non-dimensional mode for all local galactic probabilities tied to the central BH. We have now set the local mode and mean for any galactic phase probability using both the limits of topology and the boundaries between quantum and relative phases of matter. Both local phase mode and local phase mean are tied to the statistics of the central BH and the water maser in NGC-4258. In the next section, we will demonstrate why global phase measurements lie outside the boundaries we have established for all local phase probabilities and why they cannot be used to establish a local distance ladder without a local calibrator – tied to the statistics of the galactic plane.

2.0 – Global phase probability and the Planck constant

When Max Planck first developed the idea of quanta, he was solving a very specific problem. The Raleigh–Jeans law, did not hold at the shortest wavelengths for an ideal black body. He found that a perfect black body (BB), could only be described statistically. This, conclusion, lead him to the development of his constant of least action, which we refer to as the Planck constant, (h). As we will demonstrate, the Planck constant is found in global, and local, galactic phase probabilities – *at all scales*.

The most accurate measurement of the Planck constant has been performed by the Planck experiment [6], using measurements of BAO in the CMB. Measurements of the CMB using BAO are flat measurements of the Planck constant that force a global probability across all galaxies. We can use these measurements to set the Planck constant as a global phase requirement for any Lorentz invariant MFR. The parameters set by the Planck Collaboration measurements of BAO are very clear:

"The acoustic oscillations in ℓ seen in the CMB power spectra correspond to a sharply-defined acoustic angular scale on the sky, given by $\theta_* \equiv \frac{r_*}{D_M}$ where, r_* is the co-moving sound horizon at recombination quantifying the distance the photon-baryon perturbations can influence, and, D_M is the co-moving angular diameter distance that maps this distance into an angle on the sky. Planck measures

$100\,\theta_* = 1.04097 \pm 0.00046$ (68 %, Planck TT+lowE), (7)

corresponding to a precise 0.05 % measurement of the angular scale θ∗ = (0.◦59643±0.◦00026). The angular scales of the peaks in the polarization spectrum and cross-spectrum are different, The quantity DM is (1+z)DA, where DA is the usual angular diameter distance, since the polarization at recombination is sourced by quadrupolar flows in the photon fluid, which are out of phase with the density perturbations. The polarization spectra can, however, be used to measure the same acoustic scale parameter, giving a stringent test on the assumption of purely adiabatic perturbation driving the oscillations. From the polarization spectra we find

$100\,\theta_* = 1.04156 \pm 0.00049$ (68 %, Planck TE+lowE),
$100\,\theta_* = 1.04001 \pm 0.00086$ (68 %, Planck EE+lowE),

in excellent agreement with the temperature measurement. The constraint from T E is of similar precision to that from TT: although the polarization data are much noisier, the TE and EE spectra have more distinct acoustic peaks, which helps improve the signal-to-noise ratio of the acoustic scale measurement. Using the combined likelihood we find:

$100\,\theta_* = 1.04109 \pm 0.00030$ (68 %, TT,TE,EE+lowE),

a measurement with 0.03 % precision. Because of its simple geometrical interpretation, θ_* is measured very robustly and almost independently of the cosmological model. It is the CMB analogue of the transverse baryon acoustic oscillation scale $\frac{r_{drag}}{D_M}$ measured from galaxy surveys, where r_{drag} is the co-moving sound horizon at the end of the baryonic-drag epoch. In ΛCDM, the CMB constraint can be expressed as a tight 0.04 %-precision relation between r_{drag} h and Ω_m as:

$\left(\frac{r_{drag}h}{Mpc}\right)\left(\frac{\Omega_m}{0.3}\right)^{0.4} = 101.056\ \pm .036$ *(68 %, TT,TE,EE +lowE)"*

(Planck 2018 results. VI. Cosmological parameters, 2018)

Planck measurements of the CMB are built using *a flat ΛCDM model*. Global phase probabilities, like Planck measurements of the CMB are Euclidean, and, therefore, allow for parallel MFR. All local phase probabilities are tied directly to the hyperbolic probabilities of the central BH and accretion disk. *(Table 1)* summarizes the local and global nature of each standard candle as it relates to the topological phase probabilities we discussed earlier:

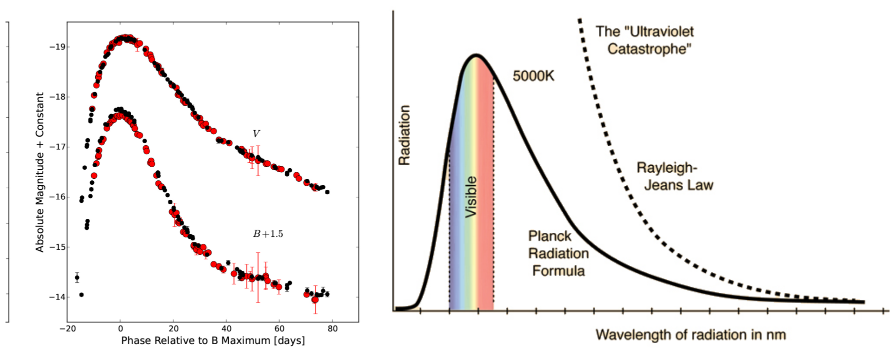
(Table 1)- Global, and local, phase probabilities

Measurement Frame of Reference	Standard Candle	Statistical topology
Measurement of the Leavitt Law	SN1a Supernova Period/Luminosity	Global Euclidean
Measurement of the CMB	Speed of Sound, BAO	Global Euclidean
Fermi-Dirac galactic mean	Slope of the TRGB, Red giant Helium flash	Local Hyperbolic and Global Euclidean
De-Broglie galactic mode	JAGB, Carbon star color consistency across galaxies	Local Hyperbolic

Euclidean measurements and global phase probabilities can be modeled as conics. They exist in the 2-dimensional plane as potential for hyperbolic measurement. Planck measurements of the BAO, and Leavitt Law measurements, must be complete statistically and geometrically. If you will recall, from our last paper *[22]*, the universe is actually both open and closed. It is the measurement frame of reference that determines probabilities in real space. The Euclidean, global phase probabilities of BAO measurements and micro-fluctuations in the CMB are all related to global phase measurements of the Planck constant, coupling, and the Maxwell-Boltzmann statistics of an ideal perfect thermal black body. Measurements of the CMB are extremely accurate, but exist at all points in space. Because Euclidean phase probabilities allow for parallel measurements, we can use measurements of the Planck constant, as defined by measurements of the CMB, to tie all global thermodynamic phase probabilities together in a single conic. This is done, by creating topological equivalencies to Landau levels. While a topological discussion of the nature of Landau probabilities sounds tempting, it is, again, beyond the scope of this discussion. In the next section we discuss how the Leavitt Law is actually a global measurement the Raleigh-Jeans limit, using SN1a Supernova, and, like measurements of the CMB, cannot be used as a local distance candle without a local distance calibrator that is tied to the galactic plane, established by the central BH.

2.1-The Leavitt Law as a global measurement of the least action principle

The Leavitt Law is a measurement of the linier relationship between the luminosity and period in SN1a supernova explosions. Because the Leavitt Law represents the statistical relationship between luminosity and period it is not tied to galactic probabilities of the galactic center BH. The Leavitt Law is a global probability for all SN1a measurements. Because the Leavitt Law global is measured as a global phase, it is measured in Euclidean space. Euclidean global phase measurements of the Leavitt Law can be parallel to global CMB measurements, but at a different scale. If we consider that any statistically complete measure of the Leavitt Law is a closed probability, we can equate the measurement of SN1a period/luminosity relationship to the quanta used by Max Planck to describe an ideal black body and the limits of the Raleigh-Jeans Law. If we examine the extinction curve of Type 1a and compare it to the curve generated by the PLANCK experiment, we can clearly see the same sharp rise and Rayleigh-Jeans cut-off that defines all measurements of the Planck constant using an ideal black body *(Figure 6).*



(Figure 6) *(On the left) A comparison between the BV absolute magnitude light curves of SN 2015F (black circles) and SN 2004eo (red points; Pastorello et al. 2007). Both Supernova show remarkably similar light curves, and the main difference between them is that SN 2004eo is slightly fainter by ~ 0.1 mag. (on the right) we show the limits of the Raleigh-Jeans Law and the Planck curve of an ideal black body.*

Because Supernova explosions act at the ultraviolet limit, any luminosity measurements are limited to a statistical measurement of limits of the Raleigh-Jeans Law. Therefore, *the period/luminosity relationship established by any measurement of the Leavitt Law represents a global measurement of the Planck constant and cannot be used to measure a local value of the Hubble constant.* Like the Planck collaboration measurement of the CMB, measuring the Leavitt Law relies on a flat global measurement of the Planck constant that is not vectored to the galactic plane established by our galactic mean and mode. The Leavitt Law tells us that a no matter how big a Cepheid's magnitude, the relationship, between the period and luminosity, is a constant. We can use the Planck constant as a constant of least action to describe this relationship globally. Planck's law tells us that:

$$E_q = hv = \frac{hc}{\lambda}$$

Where E_q, is the energy stated in quanta, h is the Planck constant, v the frequency and λ the wavelength. The Leavitt Law can be stated as the relationship between period and luminosity

$$M = h\frac{p}{l}$$

Equating the two scales of the Planck constant to global and local phase probabilities allows us to also equate SN1a Supernova to the quanta used by Max Planck to describe the statistical limits attached to any black body measurement.

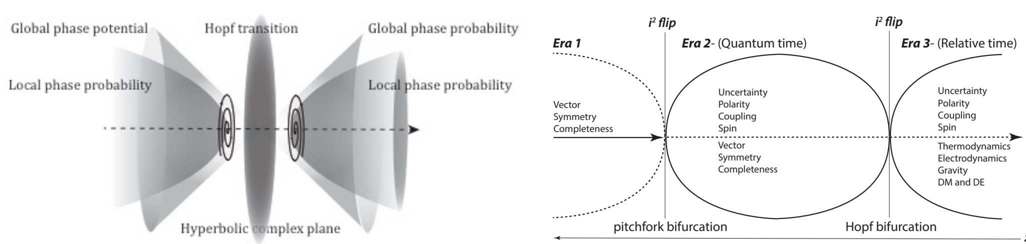
$$E_q = M_q = h\frac{p}{l} = hv = \frac{hc}{\lambda}$$

In our final section, we shall “circle” back to our establishment of DE and DM as closed probabilities, in a universe defined by mathematical and geometric completeness.

3.0 – Phase probabilities in the early universe

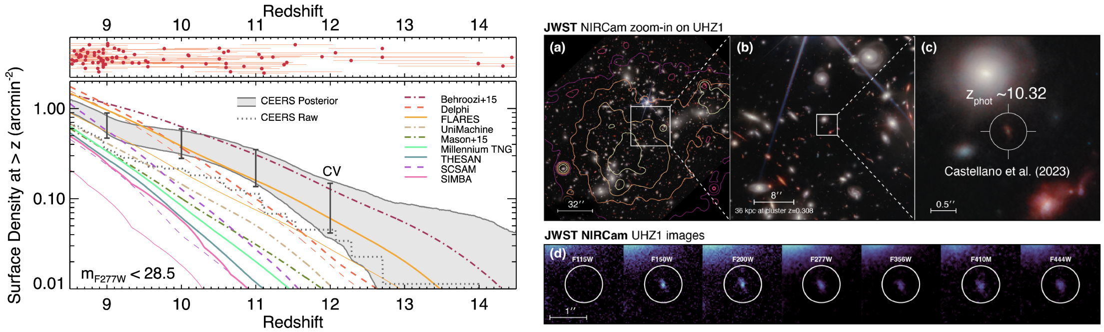
In “Measuring the Universe Parts I and II”, we established the topological nature of both “Dark Energy” and “Dark Matter. We can use the same topological and statistical measurements for DM and DE at the local phase level to tie all galactic phase probabilities to the topology of the central black hole. As we demonstrated, both DM and DE are Euclidean boundaries for completeness that allow for parallel measurements. Galaxies exist in the hyperbolic plane, limited by the speed of light. The hyperbolic plane of GR lies perpendicular to the Euclidean topological probabilities we associate with DM and DE. Essentially galaxies then become complete both topologically and statistically by including both hyperbolic and Euclidean frames of reference. Topological boundaries for completeness drive the statistical phase nature of the early universe.

In our model, we demonstrated how a, Hopf, transition allows for the transition between statistical boundaries *at global and local scales*. We will assume the reader is familiar with our model of the early universe, as established in our last two papers *[21], [22]*. A Hopf topological transition allows us to pass statistical spin potential through the complex plane between eras and to add spin to all global and local phase probabilities *(Figure 7)*. A transition through the complex plane, allows us to use our topological mode and mean in all statistical Eras.



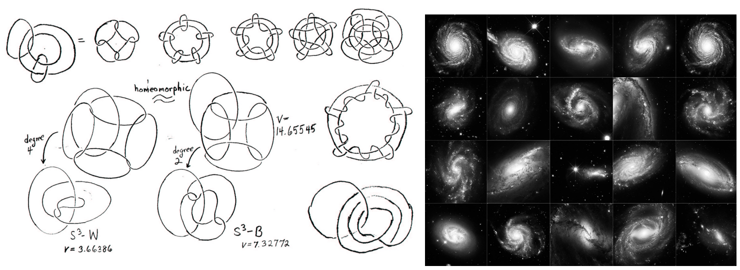
(Figure 7) *As the universe expands it is required to follow phase space limitations. Forces in this model are equated to global phase space boundaries required by geometric completeness and the rules of relative measurement.*

Complex potential from the previous Era provides the statistical potential for the early appearance of SMBH, galactic clusters and galaxies. In our model, a SMBH exists as ideal spin potential that can only be described statistically. They are formed from global phase spin potential and, therefore their early appearance in our universe should come as no surprise *(Figure 8)*. As we have been discussing, global phase probabilities operate in Euclidean space and provide the global statistical boundaries for all local measurements. If we consider SMBH to be a global, Euclidean, phase probability it would explain their appearance in the early universe. As quantum statistical objects, black holes can act as global phase probabilities in Euclidean space. As an ideal spin capacitor, a black hole operates using the same statistical basis as Quantum Electro-dynamics (QED) and Quantum Chromo-dynamics (QCD). The horizon becomes the line between quantum statistical potential and the black Body probabilities of the disk. Galactic Clusters and early massive galaxies are also probabilities in a statistical model driven by thermodynamic probability and the limits of GR.



(Figure 8) *The left panel shows the redshift distribution of the CEERS sample. The observed surface density of galaxies lies above most predictions at z > 10, and above. This confirms early results based on smaller samples that the observed abundance of $z \gtrsim 10$ galaxies significantly exceeds most pre-launch, physically motivated expectations. On the right, we show one example of SMBH in the early universe. The JWST, NIRCam, image of the surroundings of UHZ1, and a zoom-in NIRCam image of UHZ1 in Panels (b and c). Panel (d) JWST images of UHZ1 in seven filters. The galaxy is detected in all JWST bands except for F115W. The non-detection in the bluest F115W band clearly indicates the dropout nature of the galaxy and suggests that it is located at z ≈ 10.*

As local phase probabilities, galactic measurements are all relative and limited by the speed of light. All local phase probabilities are well described by the limits of GR found at the horizon of a black hole and the black body statistics of the BH accretion disk. The topology and statistics of the galactic plane are, clearly, set by the central black hole. We have shown how local phase probabilities are tied to Lorentz invariance at the quantum and galactic scales and how global phase probabilities set all scales for the Planck constant. Like the knot equivalencies that we established in our last paper *[22]*, galactic probabilities can all be extended to larger structures *(Figure 9).*



(Figure 9) *There are as many homeographic knot equivalents as there are galaxies in the universe. Knots can combine to form larger structures like galactic clusters and the galactic web while still maintaining hyperbolic completeness. We show just a few examples of Thurston's drawings of knot equivalents next to a compilation of Hubble galaxy images.*

Galactic clusters and the cosmic web are examples of the same relationship between the Hyperbolic and Euclidean boundaries for geometric completeness. Each galaxy represents a local, hyperbolic phase probability that has global Euclidean phase requirements. The relationship between local and global phase probabilities is the same as the topological relationship between the hyperbolic and Euclidean planes. By attaching all local phase measurements to the central BH we have attached the topology of DM and DE to the hyperbolic plane of GR., Euclidean phase measurements, like the CMB or the Leavitt Law, exist as global phase probabilities because their measurement is not affected by the statistics of the galactic plane. Like De-Broglie potential, global phase potential can exceed the speed of light and, therefore, can describe probabilities that exist at the scale of the black holes, galaxies, galactic clusters and the cosmic web. Our topological equivalents, for DM and DE, exist as global geometric boundaries that establish completeness for all global, and local, phase probabilities. We hope we have demonstrated that local phase probabilities driven by De-Broglie waves coming from the central BH and accretion disk are the only local measurements that can be used as standard distance candles. Any measurement of the Hubble constant must calibrate to these local phase probabilities.

References:

*(1) **Thurston, William** "The geometry and topology of three-manifolds" American Mathematical Society (2022). Our use of Bill Thurston's images has been granted limited permissions by Julian Thurston for our distribution to the scientific community. All other uses are protected by the AMS copyrights and prohibited.*

*[2] **Freedman, Madore** "Status Report on the Chicago-Carnegie Hubble Program (CCHP): Three Independent Astrophysical Determinations of the Hubble Constant Using the James Webb Space Telescope" arXiv: 2408.06153v1 [astro-ph. CO] 12 Aug 2024*

*[3] **Freedman Wendy L."**Measurements of the Hubble Constant: Tensions in Perspective (ApJ 919 16- 2021)*

*(4) **Freedman, Madore** "Progress in direct measurements of the Hubble constant." JCAP11(2023)050*

*[5] **Lee, Abigail** -"Carbon Stars as Standard Candles: An Empirical Test for the Reddening, Metallicity, and Age Sensitivity of the J-region Asymptotic Giant Branch (JAGB) Method" (2023) ApJ **956** 15**DOI** 10.3847/1538-4357/acee69*

*[6] **The Planck Collaboration** "Planck 2018 results. VI. Cosmological parameters "arXiv: 1807.06209v4 [astro-ph.CO] 9 Aug 2021*

*[7] **Snowmass 2021 Report** "Cosmology intertwined: A review of the particle physics, astrophysics, and cosmology associated with the cosmological tensions and anomalies Journal of High Energy Astrophysics", Volume 34, p. 49-211*

*[8] **The Event Horizon Collaboration** "First Sagittarius A* Event Horizon Telescope Results. VI. Testing the Black Hole Metric" (ApJL 930 L17 2022)*

*[9] **DESI Collaboration** "DESI 2024 VI: Cosmological Constraints from the Measurements of Baryon Acoustic Oscillations" arXiv:2404.03002v2 [astro-ph.CO] 24 Apr 2024*

*[10] **Bogdan et al** "Detection of an X-ray quasar in a gravitationally-lensed z = 10.3 galaxy suggests that early supermassive black holes originate from heavy seeds" arXiv:2305.15458 v2 [astro-ph.GA] 25 Sep 2023*

*[11] **Finkelstein et al-"**The Complete CEERS Early Universe Galaxy Sample: A Surprisingly Slow Evolution of the Space Density of Bright Galaxies at z ~ 8.5–14.5" arXiv:2311.04279v1 [astro-ph.GA] 7 Nov 2023*

*[12] **Blackwood, CJ** "Implementing rules for the measurement of Markovian and Bayesian time operations, establishes the measurement of charged and uncharged boundary conditions – without the need for observers." mtdi.org (May, 2018)*

*[13] **Blackwood, CJ** "Time symmetry and measurement at the event horizon of a black hole." mtdi.org (Dec., 2018)*

*[14] **Blackwood, CJ** "Establishing a minimum measurement boundary for the coupling of charged potentials eliminates the need for gluon fields." mtdi.org (Feb., 2019)*

*[15] **Blackwood, CJ** "Viewing paradox through the lens of general relativity" mtdi.org (Sept. 2019)*

*[16] **Blackwood, CJ** "Resolving the apparent paradox between Hubble and Planck measurements of H_0" mtdi.org (Oct, 2019, Revise March 2022)*

*[17] **Blackwood, CJ** "A black hole as an ideal spin capacitor" mtdi.org (Nov, 2019)*

*[18] **Blackwood, CJ** "Establishing geometric boundaries for the fundamental constants and dark energy." Mtdi.org (March, 2020)*

*[19] **Blackwood, CJ** "Three Paths for Fermat" mtdi.org (Sept 2020)*

*[20] **Blackwood, CJ** "The Geometric Theorem of Completeness." Mtdi.org (Feb, 2021)*

*[21] **Blackwood, CJ** "Measuring the Universe Part I" mtdi.org (May 2022)*

*[22] **Blackwood, CJ** "Measuring the Universe Part II"mtdi.og (Dec, 2023)*

Addendum A*:* Local calibration of global phase probabilities with DESI measurements

Like the Planck measurements, DESI measures BAO in the CMB as a global phase probability. DESI also captures the relative motions of galaxies in a single, hyperbolic, measurement. Because DESI uses a unique design that allows for the, simultaneous, tracking of the relative motions of galaxies, we can use these measurements to demonstrate the calibration of a global phase probability with a local phase mode. We are going to skip a lot of math here because DESI has already done the calibration for us:

"Since BAO distance measurements alone are sensitive to the combination $H_0 r_d$ an external calibration of the sound horizon r_d is required in order to break the $H_0 - r_d$ degeneracy and obtain a constraint on the Hubble constant H_0. This method of calibrating the BAO distance scales using the sound horizon at early times is known as the "inverse distance ladder" approach. Directly calibrating the BAO standard ruler using the value r_d = 147.09 ± 0.26 Mpc obtained from using all CMB and CMB lensing information gives H_0 = (69.29 ± 0.87) km s−1 Mpc−1 (DESI BAO + r_d from CMB)."

DESI 2024 VI: Cosmological Constraints from the Measurements of Baryon Acoustic Oscillations

Calibrating DESI measurements to the sound horizon, effectively, calibrates all the global phase requirements of Lorentz invariance to a local phase probability. Their inclusion of the sound horizon has established a hyperbolic, *and relative*, measurement frame of reference for all, Euclidean, phase probabilities. In this set of measurement parameters, DESI has calibrated a Euclidean global phase measurement, (CMB, BAO), with the hyperbolic local measurement of the speed of sound, established by Baryonic Acoustic Oscillations in the local CMB. If we set the "BAO standard ruler", referenced in the DESI paper, using the vectored fine structure constant, we can create an equivalency to the local, topological, phase mode and mean:

$$H_0 = \frac{2\pi i^2}{c^2} = .699i^2 = TRGB\ local\ phase\ mean = DESI\ BAO + \ r_d$$

$$H_0 = \frac{2\pi i^2}{c^2} = .699i^2 = TRGB\ local\ phase\ mean = DESI\ BAO + \ \frac{\vec{k}\pi i^2}{2\varepsilon_0 hc}$$

The result establishes equivalencies between the local phase calibration of DESI global probabilities, the local Fermi-Dirac phase mean, the fine-structure phase mode and our topological equivalent to the Hubble constant.