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COSMOLOGICAL REDSHIFT AS A FUNCTION OF RELATIVE COSMIC TIME: INTRODUCING A STATIONARY LIGHT MODEL

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ABSTRACT

This paper evaluates cosmological redshift as a function of the relative cosmic age of the emitter and observer of light, suggesting a model of spatial expansion that radically differs from the present interpretation. This Stationary Light model suggests that the propagation of light and expansion of space are synonymous. We can yield close numerical agreement of the distance/redshift relation to λCDM without the consideration of any conventional or theoretical forces, and thus no consideration of density (Ω).

$$H_o = \ddot{\tau} = 1/t_o \tag{1}$$

$$z = \frac{-ln(1-t)}{\sqrt{1-t^2}} \tag{2}$$

$$X = ct_o(1 + \frac{\int_0^t (z)dt}{t}) \tag{3}$$

$$r = ct_o(3.9207) \tag{4}$$

$(\mathrm{H}_o) = Hubble\ Parameter, (\tau) = proper\ time, (t_o) = time\ of\ the\ observer, (z) = cosmological\ redshift, (t) = lookback\ time/time\ of\ the\ observer, (X) = Coordinate\ distance, (c) = speed\ of\ light, (r) = radius\ ofthe\ universe$

1. INTRODUCTION

This paper presents a radical reinterpretation of the metric expansion of the universe. Since the turn of the last century, mathematical models have suggested that space itself could expand or contract. When Edwin Hubble and Milton Humason observed that the redshift of light from distant galaxies appeared to be proportional to their distance from Earth, this was taken as an observational proof that space is expanding in our universe and light from distant galaxies has been stretched and reddened as it traveled across expanding space Thompson, L.A. (2013). Until the late 1990s, cosmologists assumed that this roughly constant rate of expansion should be gradually decreasing due to the influence of gravity. Detailed studies of extremely distant supernovas produced a strange challenge to the model; instead of gradually slowing as was expected, it appeared that the expansion has been positively accelerating in more recent cosmic history Perlmutter, S et al (1999). To explain this observation, a force of unknown origin must act repulsively, while being evenly distributed through space, and not decreasing in density as volume increases. The value of this repulsive force would need to be precisely fine-tuned in the early history of the universe in order to arrive at a value so close to the force of gravity in the present era. The addition of this Dark Energy or Lambda parameter to the model yielded the present cosmology, the λCDM model.

This paper posits that spatial expansion is much more fundamental to our universe than is supposed in λCDM. Spatial expansion is present in all locations, and has a fixed value that is not acted on by any force. While objects with mass may maintain static distances between them, the relationship to the global metric is fundamental. Every point in space expands its radius by c, growing by 300,000 kilometers per second. To observe spatial expansion does not require giant telescopes and careful spectroscopy. We all see evidence of this expansion from the moment we open our eyes as babies, because it is responsible for the propagation of light. *This is to say, light is stationary with respect to expanding space.* Light brings the the present in contact with the past. In this model, light is not a mere emissary from a past moment in space, but a point in space itself, that has expanded its dimensions to come in contact with the present observer. Since the propagation of light is intrinsically related to the flow of time through special relativity, this paper is also establishing an equivalence of spatial expansion and the forward arrow of time. By measuring time against ever-expanding space, all clocks will accelerate over time; every second will tick by faster than the one that preceded it. This paper explores this mathematical consequences of these equivalences, and demonstrates that this model naturally yields the specific redshift that we observe from distant galaxies– as a distortion in the flow of time or an acceleration of clocks– without the need to invoke Dark Energy or a Cosmological Constant. This paper derives this new equation, and show its agreement with type 1a supernova data, as well as it's general compatibility with big bang cosmologies, with a similar

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evolution of scale and temperature to those implicated in our explanation of the Cosmic Microwave Background and the formation of light elements in Big Bang nucleosynthesis. A critical departure of this model from the present cosmology is that the clock acceleration should be observable on the scale of the solar system. Evidence for this clock drift may have been found in the Pioneer Anomaly, discussed here in section 4.1.

2. DERIVATION

2.1. *Stationary Light Equations*

In this section we will derive this equation which is at the heart of the Stationary Light model. The redshift (z) is redefined as a dilation of time between an observer and emitter of light. This dilation is a function of the relative cosmic age of the emitter versus the observer, and is given by the novel equation:

$$z = \frac{-ln(t_e/t_o)}{\sqrt{1-(t_o - t_e/t_o)^2}} \tag{5}$$

The numerator of equation (5) represents the geometrical distortion of space, and consequently time, as a logical consequence of constant expansion. If we begin with the assumption that the expansion of space is constant, and the flow of time is dependent on the expansion of space, it can be shown that the instantaneous acceleration of a clock is always $1/t_0$. That is, any interval of time comprises a correspondingly smaller portion of cosmic time after it has elapsed. When the universe was one second old, the passage of an additional second doubled its age. At a cosmic age of 2 seconds, the instantaneous acceleration of time was 1/2 seconds/seconds^2, and so on. This acceleration of proper time (τ) is in fact what we are measuring when we attempt to measure the Hubble parameter (H_o), which is not just close to, but exactly $1/t_o$ at all moments in cosmic history.

$$H_o = \ddot{\tau} = 1/t_o \tag{6}$$

To define the relative 'speed' of time between an observer and emitter based on this spatial stretching, we simply integrate the acceleration 1/t between t_e and t_o.

$$\dot{\tau} = \int_{t_e}^{t_o} (1/t)dt = -ln\,|t_e/t_o| \tag{7}$$

Since the time (t) is always positive, we can disregard the absolute value, giving:

$$-ln(t_e/t_o) \tag{8}$$

The numerator value is not a complete description of redshift versus relative cosmic time, however. The denominator of the equation accounts for a special relativistic dilation, and is derived from the Lorentz equations. Any cosmological object will have a recessional velocity that is some fraction of the spatial expansion rate. This velocity will have an attendant time dilation, equivalent to moving at that fraction of the speed of light in an inertial frame. Like the numerator acceleration, the recessional velocity is proportional to the relative elapsed time between the emitter and observer. Thus we can substitute the relative age for the fractional speed of light in the Lorentz dilation (γ):

$$\gamma = \frac{1}{\sqrt{(1 - c^2/(c((t_o - t_e)/t_o))^2)}} \tag{9}$$

this equation reduces to:

$$\frac{1}{\sqrt{1-((t_o - t_e)/t_o)^2}} \tag{10}$$

Multiplying these 2 sources of time dilation together, (8) and (10), we arrive at the Stationary Light equation for redshift,

$$z = \frac{-ln(t_e/t_o)}{\sqrt{1-(t_o - t_e/t_o)^2}} \tag{11}$$

Converting the absolute age of the emitter and the observer to units of natural time, where the observer's age is equal to one yields:

$$z = \frac{-ln(t_e)}{\sqrt{1-(1 - t_e)^2}} \tag{12}$$

For many purposes it is more useful to define the relative lookback time, where the observer's time is equal to 0 and the origin is equal to 1, giving:

$$z = \frac{-ln(1 - t_{lb})}{\sqrt{1 - t_{lb}^2}} \tag{13}$$

We can construct an analogy for this innate time distortion using audiotape as a metaphor. Audiotape represents sound waves as alternating bands of charge printed onto magnetic tape. The tape is pulled across the read head of an audio-player to reproduce the waveform in the speakers. Imagine that lightwaves are printed onto space itself, like the bands of alternating charge. Instead of moving the tape (space) across the read head (the observer) the universe stretches space. This causes the recording (light) to play, but more slowly than it was recorded, because the tape is physically stretching. For audiowaves, a slower playback lowers the pitch of the sound; the analogy in light is a reddening, i.e. redshift. This analogy thus far describes the numerator of equations (5) and (13). To describe the denominator using the tape analogy, we must think about the write head (a distant emitter) and well as the read head (an observer). The recording is additionally distorted by the fact that most emitters are moving away from most observers, since the they are suspended in non-static space, unconstrained by gravity or other forces.

We can return to the assertion that the clock acceleration is exactly equal to $1/t_o$ for any observer, by taking the time derivative of the z equation in natural units of lookback time, yielding:

$$\dot{z} = -\frac{(ln(1-t)-1)t-1)}{(1-t^2)^{3/2}} \tag{14}$$

When solved for t=0 (the present in lookback time for any observer) this equation yields 1, and can be converted to any unit of time by dividing the function by the age of the universe in that unit, giving $1/t_o$, or the Hubble parameter (H_o).

We have now defined the instantaneous acceleration of time (H_o) at a particular instant, as well as the relative change in the speed of time (z) between two instances, and thus it follows that we can define the length of time (X) between those two instances. The length of time between the observer and emitter is analogous to the spatial separation between them, corresponding to the co-moving or coordinate distance scale in λCDM. A second integration, this time of (z) with respect to time, will give us this distance:

$$X = ct_o(1 + \frac{\int_0^t (z)dt}{t}) \quad (15)$$

This distance scale divided by c can also be thought of as the age of the universe if it were measured by a present clock, or the age in proper seconds τ.This equation has a finite value at t= 1, which indicates that the radial spatial extent (r) of the universe in this model is finite. Integrating numerically, we arrive at:

$$r \approx ct_o(3.9207) \quad (16)$$

Using an age of the universe of 13.721E9 years, we can compute that the present finite radius of the universe is 53.796E9 lightyears. This number is larger than the observable horizon, which is limited by the opacity of the Cosmic Microwave Background, and thus does encompass all observations made up to this point. However the present cosmology assumes a much larger, potentially infinite universe in disagreement with this relatively small radius. The problem of spatial flatness, in which all observations suggest flat Euclidean space with non-converging parallel lines, is one reason the universe is believed to be much larger than the observable horizon. However in this new model, light is not considered something that travels across space; rather light is a feature of expanding space itself. Thus we cannot observe global curvature through observations of light. This conceptual shift alleviates the constraint of spatial flatness and a precise critical density. It is important to address the absence of General Relativity in the model at this point, since the effect of mass on the global spacetime geodesic is not considered, similar to the 'empty universe' model of Milne. Perlmutter, S et al (1999) The local effects of mass on spacetime as described by the field equations of General Relativity are well established at this point in history. The precession of Mercury's orbit, the Pound-Rebka experiment, observations of gravitational lensing, and even the practical application of adjusting GPS satellite clocks all establish a relationship between mass and the spacetime geodesic. Turyshev, S. (2008) However the extrapolation of General Relativity to a global solution demands an onerous initial fine-tuning of density to achieve our present spatial flatness. As has been stated, spatial flatness could alternatively be explained by the equivalence of spatial expansion and light propagation. In this situation there would be no way to measure the effect of mass density on the global metric, since we measure time itself by the expansion of space. General Relativity then, is a local rather than global solution. It should also be noted that in this new model, the relative flow of time (z), does diverge to infinity at the bounded spatial edge, meaning that time is infinitely dilated there from any observer's perspective. In this sense the universe is spatially finite but thermodynamically infinite. It is not possible for any observer to travel to the spatial boundary, or indeed have any interactions with it at all. From the observer's perspective, time is stopped at the horizon. Thus the edge of space is the beginning of time, frozen forever beyond reach.

3. COMPATIBILITY WITH OBSERVATION

3.1. *Supernova distance observations*

From this point onwards in cosmological distance calculations, there is no mathematical distinction between the Stationary Light Model and conventional cosmology. To determine the distance to an astronomical object, so as to compare its apparent (m) and absolute (M) visual magnitudes, we employ the standard luminosity distance (Dl), as given by:

$$D_l = X(1 + z) \quad (17)$$

This is followed by the standard distance Modulus:

$$M = m - 5(log_{10}(D_l) - 5) \quad (18)$$

(M) is the absolute magnitude of the object as viewed from 10 parsecs, and (m) is the apparent magnitude corrected for extinction. The supernova studies of the late 90s rely on type 1a supernovas as standard candles, when standardized by various corrections including the Phillips relationship, to establish a relationship of redshift to distance. Observational astronomers measure the apparent magnitude of the peak brightness of the supernova, and it's redshift, and then using an estimate of its absolute magnitude, we estimate its distance. When The SCP and high Z studies where performed in the 1990s, the distances to the highest redshift supernovas appeared to be around 15% higher than predictions, suggesting that spatial expansion was actually accelerating in the recent past, not decelerating as would be expected due to the influence of gravity. Perlmutter, S et al (1999) The Dark Energy parameter functions primarily to explain this acceleration. However the observed evolution of redshift versus distance emerges naturally from the Stationary Light model. No densities or forces need to be accounted for in order to explain this relationship– it is a change in the relative flow of time given entirely by simple geometry and the SL equation for (z). Redshift is only secondarily related to distance, as the relationship is fundamentally governed by relative cosmic age.

References. — table 1

For this sampling of the supernova data from the Supernova Cosmology Project, with redshift (z) values between .172 and .083, the mean disagreement between the λCDM and SL predictions of coordinate distance (X) is 0.7%. For lower and higher values of z, the disagreement increases somewhat, however the agreement remains safely within present observational certainty.

3.2. *The Cosmic Microwave Background*

It can be shown that, with a similar evolution of scale to that of λCDM, the Stationary Light model is a Big Bang cosmology. As in conventional cosmology, (z) relates to the dimensionless scaling of space (a) as:

$$a = \frac{1}{1+z} \tag{19}$$

Consequently redshift and background temperature (K) are related linearly, since the expansion of the universe is a process of adiabatic cooling:

$$K_e = (z+1)K_o \tag{20}$$

Moving on to another pillar of any Big Bang cosmology, we can evaluate the Cosmic Microwave Background in a SL framework. Using the well established present temperature of the CMB of 2.73 K, and extrapolating back to time when the background temperature lowered to the threshold of around 3000 k, allowing the the bulk of electrons and protons to combine and become transparent, gives a redshift of about 1090. Kinney (2003) To use the Stationary Light equation to find the time when z was 1090,

$$1090 = -\frac{ln(1-t)}{\sqrt{1-t^2}} \tag{21}$$

and so 1-t= 4.3E-05 in units of natural time, or 590,003 years with a t_o of 13.721 gigayears. This age is within an appropriate magnitude of the moment of recombination in the present theory, frequently quoted as 380,000 years. Faessler et al (2013)

3.3. *Primordial Nucleosynthesis*

The relationship of temperature to time continues to broadly agree with the magnitudes predicted by λCDM as we approach t= 0, and so evidence of primordial nucleosynthesis is not explicitly challenged by the Stationary Light model. Evaluating the era of light element formation, beginning around 1 second after the Big Bang, λCDM predicts a temperature 1 Mev, or 11.6E9 kelvins. K.A. Olive et al (2014)

$$2.73\frac{-ln(1/4.327E17)}{\sqrt{1-((4.327E17-1)/4.327E17)^2)}} = 51.56E9 \tag{22}$$

Again this predicted temperature is within the order of magnitude predicted by λCDM, and implicated in the abundance of light elements we have observed.

Thus we can continue to describe a universe beginning in a hot dense state, which created the initial abundances of light elements and has left a background glow of light expanding adiabatically over history. In other words this is a Big Bang cosmology, unlike the similar Milne universe, which supposes a steady state.

4. PREDICTIONS

This paper has posited that that the expansion of space is present locally in our universe, as evidenced by the phenomenon of light itself. Objects in the solar system are decoupled from the expansion of space, and have essentially stable distances from one another on the time scales we have observed them. However, time dilation as a function of relative age, and consequently distance, should also be present locally, and confirmable by experiment.

4.1. *the Pioneer Anomaly*

An accidental experiment has already been conducted detecting what could be a second time derivative in our solar system. After the twin Pioneer spacecraft completed their missions within the solar system, they were left on ballistic trajectories. Being spin-stabilized, the probes fired no thrusters during this time period. Telemetry data, describing velocity, range and rough position, continued to be tracked for as long as was possible through Doppler analysis of signals sent and returned to spacecraft. After all known effects of solar system gravitational forces, pressure from solar wind, relativistic effects etc were accounted for, each probe independently demonstrated a small, very constant sun-ward deceleration of 8.74E-10 m/s^2 $\pm$1.33 in excess of prediction. Anderson, John et al (2002)

Several exhaustive studies were conducted to identify a mundane explanation for this Pioneer Anomaly; eventually the case was considered closed and the anomaly was explained as due to the recoil force associated with an anisotropic emission of thermal radiation off the vehicles. Turyshev, S. et al (2012) However, early on it was observed that this deceleration was very close to the speed of light multiplied by the Hubble parameter, suggesting a mysterious cosmological origin for the acceleration. The original team lead by Slava Turyshev and John Anderson hypothesized that the drifting Doppler data from the Pioneers could also be interpreted as an acceleration of Earth-based clocks, instead of a real change in motion caused by an unidentified force. Several phenomenological models for the clock acceleration were proposed, but a simple constant clock acceleration, of 2.8E-18 sec/sec^2 Turyshev, S. (2004) worked well to explain the anomaly on Pioneer 10 and 11. This change in station time (ST) was given by:

$$\Delta ST = STreceived - STsent \rightarrow \Delta ST + 1/2(a)clocks * \Delta ST^2 \tag{23}$$

Anderson, John et al (2002)

Because of the very small light travel delay between us and the Pioneers relative to the age of the universe, $\ddot{\tau}$ is an essentially constant acceleration. Thus we can approximate:

$$\Delta ST \approx 1/2 H_o(t_o - t_e)^2 for(t) \ll .1 \tag{24}$$

However the correct equation to yield the accumulated discrepancy in station time is given by the equation for coordinate distance, omitting the distance multiplication of $(t_o c)$:

$$\Delta ST = 1 + \frac{\int_0^t (z)dt}{t} \tag{25}$$

Since Pioneer is merely functioning as a mirror of Earth time, reflecting back a phase-locked signal of an Earth-based clock, the lookback time (t_{lb}) is the round-trip light delay for the signal, or twice the distance.

This model does not indicate a true change in Pioneers position or speed, but is an artifact of the intrinsic drift in frequency of the Earth-based hydrogen maser which is used to determine the Doppler phase, to create the illusion of the measured acceleration. This value is very similar to the Hubble parameter written in sec/sec^2. The

Doppler records leading to this value are digital measurements of Doppler phase difference rather than a frequency measurement. Anderson, John et al (2002) As such, this reading is analogous to the second derivative of proper time that causes us to observe cosmological redshift, even though it is sometimes referenced incorrectly as a blueshift in the case of the Pioneer data. The time dilation interpretation unifies these observations.

Among the new physics options to explain the anomaly, the clock acceleration has the feature that since no real force is involved, the motions of the planets do not need to account for it. A modified gravity explanation for the Pioneer anomaly is unlikely because of the well-known agreement of the outer planets motions with Newtonian/ Einstein gravity. Another way that the clock acceleration model can be distinguished from a gravitational force model is the direction of the effect; a clock acceleration would exist along the line of sight to Earth, as opposed to towards the sun. This would introduce a sinusoidal variation in the effect based on the Earth's annual motion, and this annual variation is present in the data. Anderson, John et al (2002)

References. — figures 1 and 2

This annual variation favors the clock acceleration model, over a true acceleration or mundane explanations such as thermal recoil. The original team suggested a general relativistic explanation for a clock acceleration- a decreasing gravitational potential in the universe at large due to the expansion of space. Further papers by other authors went on to elaborate this explanation, yielding a lower value for the clock acceleration of $2/3H_o$ through a general relativistic analysis. Rananda, Antonio F (2005) The constant acceleration value suggested by Turyshev and Anderson, however, fits the new equation explanation. The presence of a clock acceleration that precisely correlates to H_o can be seen as a very natural manifestation of the Stationary Light model on the scale of the solar system.

4.2. *further investigation*

Should this theory be recognized as self-consistent and compatible with existing observations, a good future test of the SL model could be held by duplicating the conditions of the Pioneers with a pair of ballistic probes. This may also be one of the best ways to derive the present age of the universe (t_o) via an accurate Hubble parameter, since the probes can be exactly duplicated and sent in different directions. They can be completely free of unknown peculiar velocity and relatively free of obscuring dust or gas. An experiment could be conducted using spin-stabilized, symmetrically thermally radiating and identical ballistic time probes to search for a local time derivative ($\ddot{\tau}$) of value (H_o). Even without a new experiment, a clock drift could become apparent by revisiting many of the precise telemetry protocols already in use in the solar system, since this effect is only dependent on distance separating the repeater and the originator of the clock signal. The 2017 launching of the Deep Space Atomic Clock may also prove of interest, as space-based time-keeping increases in accuracy, this small clock acceleration could become more apparent.

Another categorical difference between the present cosmology and a Stationary Light model regards the long-term evolution of redshift of specific astronomical targets, namely whether their redshift will increase or decrease to an observer. The Stationary Light predictions for the quantitative change in redshift are well below the current margin of error in our determinations of redshift, but the predictions made by SL and ΛCDM are of an opposite sign, and logically incompatible. In ΛCDM, the present dominance of Dark Energy has resulted in an accelerating expansion of space, such that any particular object should exhibit increasing redshift if observed at a later date. It's spatial separation is increasing at an increasing rate. In this model it is implied that we will eventually lose sight of any given cosmological, non-bound object due to ever-increasing redshift. In the Stationary Light model, redshift is treated as a difference in the flow of time between the emitter and the observer, as a function of the relative age of the two objects. While any distant co-moving object continues to fall behind us in objective cosmic age due to its time dilation, it is catching up to us as a function of relative age. Therefore the observed redshift will decrease over time. A horizon of redshift is receding, and more and more distant objects will come into observable wavelengths over time, as their redshift decreases. A notable exception to this is the case of the CMB– since the CMB represents not a particular object, but rather a particular moment in time, it's relative age and consequently redshift will always increase, albeit at a lower rate over time.

5. CONCLUSIONS

The authors of the firmest proof of dark energy themselves express great skepticism at the necessary cosmic coincidences in that paradigm, perhaps Dark Energy should be remembered as a prudent placeholder concept for a subtle but very important data set. Obviously the revisions to the concepts of space-time and light in the Stationary Light model would have far-reaching implications, in relativity, quantum mechanics and beyond, the discussion of which is well beyond the scope of this paper. For instance, contemplation of this model yields an inherently probabilistic and non-local model of light interactions: point phenomena physically expand in all directions to come in contact with many possible future paths. An interaction with a photon is an interaction with the actual past moment in which the photon was created, and so can create the illusion of action at a distance in the present. This is in accordance with what we observe on the quantum scale. The effectiveness of the Stationary Light Model in simply describing astronomical observations with a minimum of parameters warrants further investigation into this model. There is a beauty to this new image: when we feel the warmth of the sun on our cheek, it is not because a particle has streamed across the vacuum for 8 minutes to land on our face, but because we are standing where the Sun was eight minutes ago. Light is not merely an emissary from the past, but the past itself, unfurling our entire grand universe from within the head of a pin.

Table 1

Comparision of λCDM to SL for supernova distance scales. name is SCP type 1a supernova designation, (z) is measured redshift (m_p) is corrected peak magnitude, (t) is lookback time in gyrs (X)SL is coordinate distance computed with Stationary Light, (X)λCDM is coordinate distance computed with λCDM, disagreement is ratio of (X)SL to λCDM, D_l SL is luminosity distance computed with Stationary Light, (M) SL is absolute magnitude computed with Stationary Light

name	(z)	(m_p)	(t)	(X) SL	$(X)\lambda$CDM	disagreement	(D_l) SL	(M)SL
1992bi	0.458	22.12	4.788	5.765	5.774	0.002	8.418	-19.937
1994F	0.354	22.08	3.946	4.575	4.591	0.003	6.216	-19.310
1994G	0.425	21.52	4.534	5.395	5.409	0.003	7.708	-20.346
1994H	0.374	21.28	4.117	4.809	4.824	0.003	6.628	-20.258
1996cf	0.570	22.70	5.571	6.969	6.958	0.002	10.924	-19.923
1997G	0.763	23.56	6.676	8.869	8.795	0.008	15.505	-19.824
1997I	0.172	20.04	2.144	2.376	2.322	0.023	2.721	-19.565
1997ap	0.830	23.20	7.001	9.481	9.379	0.010	17.164	-20.404
					mean	0.007		

Note. — To compute Coordinate distances (X) using λCDM,Ned Wright's cosmology calculator was input with best fit values of Ω_m= .286, Ω_l= .714 for a total Ω of 1, an H_o of 69.6 km/s/mpsc. and t_o of 13.721e9 years. The only input necessary for the SL calculations is the present age of the universe, at 13.721 e9 years.

Perlmutter, S et al (1999); Wright, Ned (2006)

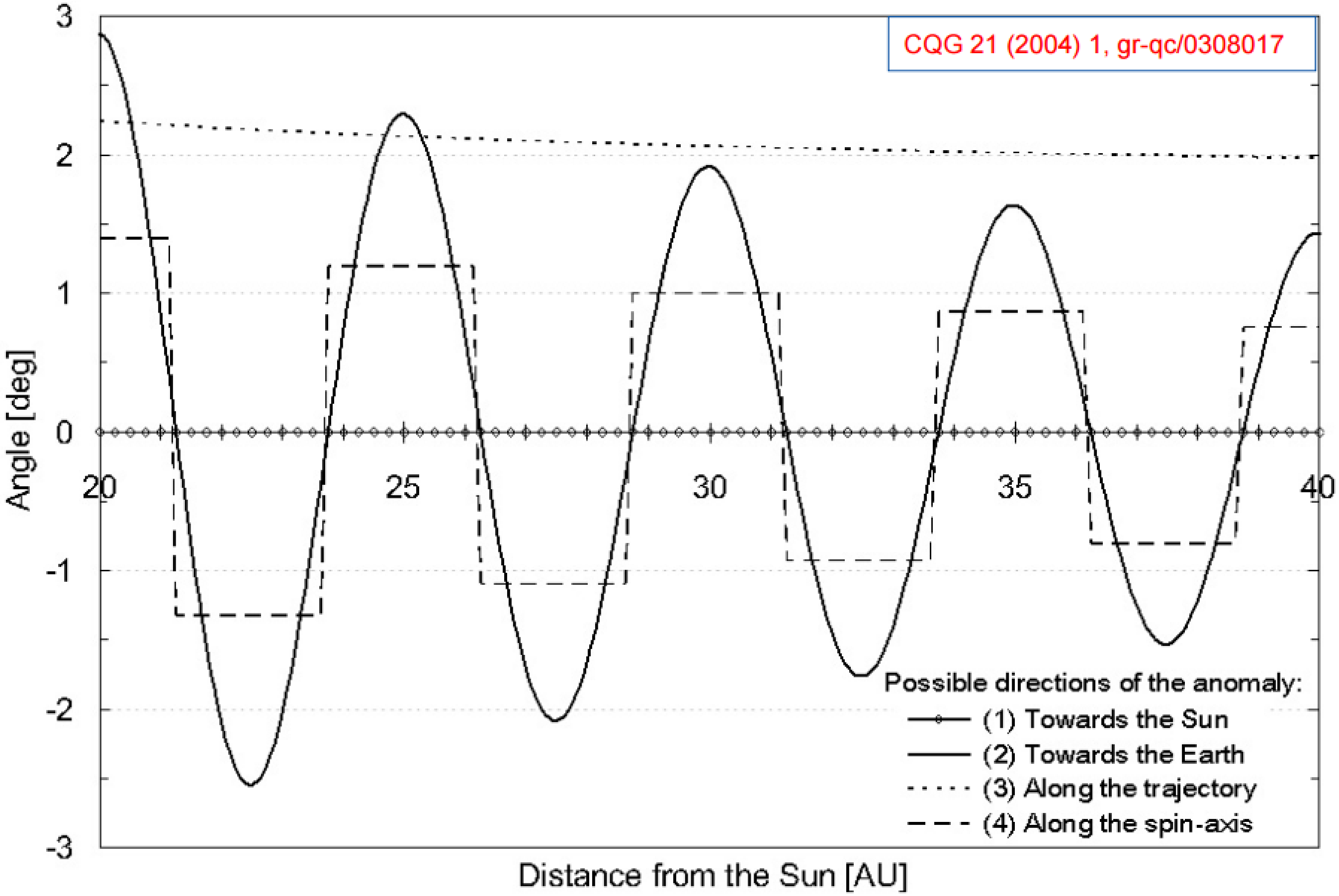

Figure 1. Theoretical Directional Modulations of Pioneer Anomaly
Turyshev, S. et al (2012).

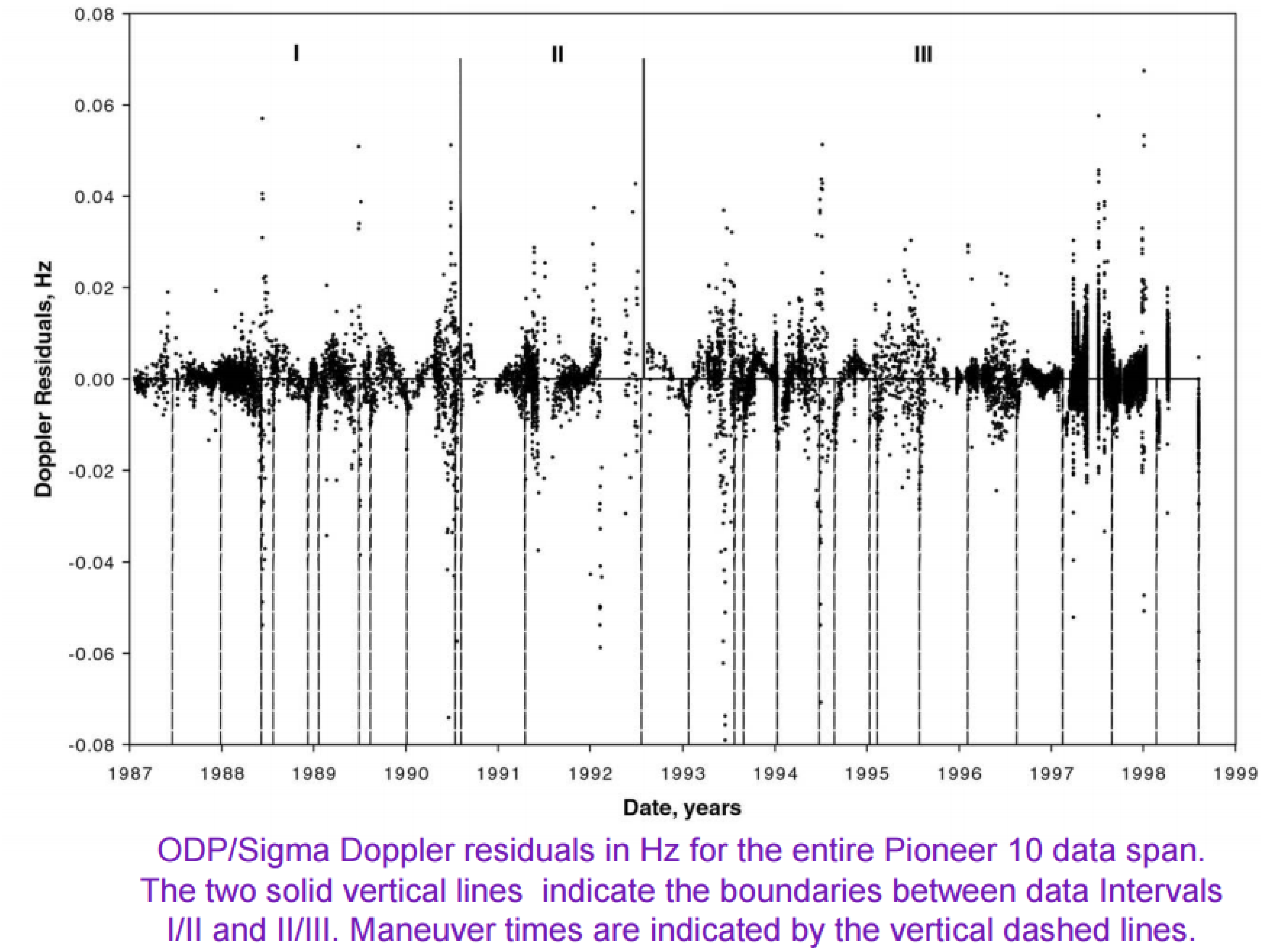

Figure 2. Actual Doppler residuals showing annual sinusoidal variation in pioneer anomaly, suggesting Earth based direction, and consequently temporal explanation.
Turyshev, S. et al (2012)

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