# Photonic Temperature & Realistic Non-Singular Cosmology

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**Abstract**

***In our framework for 'realistic non-singular cosmology' we consider a more radical situation where the present photonic temperature of the universe is higher (for instance ∼16 K) than that suggested by the microwave background. This leads to a minimal scale of ∼0.08, and a maximum temperature of ∼192 K, for an oscillating cosmology whose main protagonists are whole galaxies rather that stars, with an age of the current expansion of ∼8.9 Gyr. We show that this scheme is quite compatible with the supernovae data for magnitudes and redshifts, provided that the Hubble fraction is ∼0.55.***

## 1 Introduction

What we call *realistic non-singular cosmology* is based on the idea[1] that the expanding (and subsequently contracting) universe is an oscillating system with two turning points. The lower turning point (that of minimal scale) is determined by the (negative) pressure of electromagnetic radiation (photons) that is produced by stellar matter, while the upper turning point is determined by the (positive) pressure of gravitational radiation (gravitons, or curvature). In our initial proposal[1],[2],[3], we have regarded the cosmic microwave background[4]-[8] as a possible description of the average photonic density of the universe, and used the measured temperature ($T \sim 2.726$ K) to determine the minimal cosmic scale $a$ when the photonic density (scaling like $1/a^4$) equates matter density (scaling like $1/a^3$). The measured temperature of the microwave background implies a photonic density of $\rho_r \sim 4.7\times10^{-31}$ kg/m$^3$. Comparing this with the present value of matter density ($\rho_m \sim 5.2\times10^{-27}$ kg/m$^3$), we obtain the value of $a \approx 0.00009$ (notice that the cosmic scale $a$ is normalized to be equal to 1 at the present state of the universe). Consequently, the matter density at minimal scale ($\rho_m/a^3 \sim 7.1\times10^{-15}$ kg/m$^3$), and the temperature ($T/a \sim 3\times10^4$ K $\sim 2.6$ eV) would imply that the universe was in *a state consisting of whole and active stars*, the latter (rather than highly energetic particles) being the main constituents that are essential to cosmology, whose global motion is governed by their radiational emissions as well as their gravitational attraction.

The fate of galaxies in the ensuing picture is that they would merge together as we go back in time to the contracted state, loosing their identity, and leaving the stage for the stellar bodies as the main protagonists. However, when we realize that the whole scheme is *very sensitive to the present value of the photonic density*, we cannot but contemplate the idea that if the present value of photonic temperature could be higher than that suggested by the microwave background then the scenario for galaxies could be altered. In fact, if the universe is expanding at all, the balance between photonic density and matter density must have occurred in the past. Hence from the fact that the present value of photonic density must be less than the density of matter, we can estimate an *upper bound* for the corresponding temperature to be $\sim 30$ K (see later). Our purpose in this article is to reconsider our scheme for realistic non-singular cosmology, and to show that an acceptable scheme could be proposed whose implications would lead to a universe with *an initial state consisting of whole galaxies*, with a very low background temperature. Such a scenario depends on a *higher* value of the present-time background photonic temperature, somewhere between 3 K and 30 K.

At this point, we should remark that the value to be chosen for the background photonic temperature would correspond in Friedmann's equation[9],[10],[11] to a photonic density fraction that yields a higher value for the minimal cosmic scale. Now noting, from the relation $(1 + z) = 1/a$ that such a *higher* value for the minimal scale $a$ would imply a *lower* upper bound for any observable redshift $z$. Of course, we must choose a value of the photonic density fraction whose $z$ upper bound does not conflict with already observed redshifts. We shall make our choice compatible, as well, with the supernovae data for magnitudes and redshifts[12]-[17], and an acceptable value for the Hubble constant.

In the following sections, we shall begin by reviewing the Friedmann equation pertaining to our scheme of realistic non-singular cosmology. We shall then make appropriate choices for the density fraction terms, and show how they can be made compatible with the supernovae data for magnitudes and redshifts, demonstrating agreeable graphics. We shall compute the age of the expansion since minimal scale, as well as the tentative remaining time before the return to contraction. Subsequently, we shall assess and discuss the state of the universe at minimal scale.

## 2 The Friedmann Equation for Realistic Non-Singular Cosmology

Our scheme for realistic non-singular cosmology is based on Friedmann's equation taking the following form:

$$\left(\frac{\dot{a}}{a}\right)^2 = H^2\left\{-\frac{r}{a^4} + \frac{(1+r+g)}{a^3} - \frac{g}{a^2}\right\} \tag{1}$$

Here $a(t)$ is the cosmic scale as a function of cosmic time, the dot represents the time derivative, and $H$ is the Hubble constant. The parameters $r, g$ are both positive. Hence, we have introduced a *negative* photonic density term with fractional coefficient $-r$ and a *negative* gravitonic (or curvature) density term with fractional coefficient $-g$, leaving the *positive* matter density term with a coefficient $(1+r+g)$. Notice that when $a = 1$, corresponding to the present state of the universe, the RHS of the above equation reduces to $H^2$.

According to the above equation, the expansion and the contraction of the universe is governed by two turning points, making the RHS vanish, and corresponding to the roots of the quadratic equation

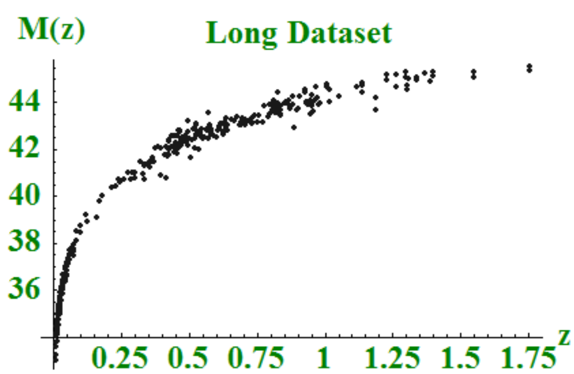
$$-r + (1 + r + g)a - ga^2 = 0 \tag{2}$$

In earlier works[1]-[3], we have taken $r$ to be a very small fraction ($\sim 9 \times 10^{-5}$) that corresponds to the ratio of the mass density of the photonic background (as suggested by the microwave radiation with temperature $\sim 2.726$ K) to the total mass density, while $g \approx 0.1$ was taken tentatively. In this work, we shall take the *illustrative and tentative* values of $r \approx 0.1$ and $g \approx 0.1$. Notice that the maximal value (upper bound) of observable redshifts corresponds to the equation $(1 + z) = 1/a$ with $a$ the lower solution of the above equation. With our prescription for $r$ and $g$, we obtain $z \approx 11$ as the *highest value of redshift that can be observed*! As far as we know, all observed redshifts are confortably below this value.

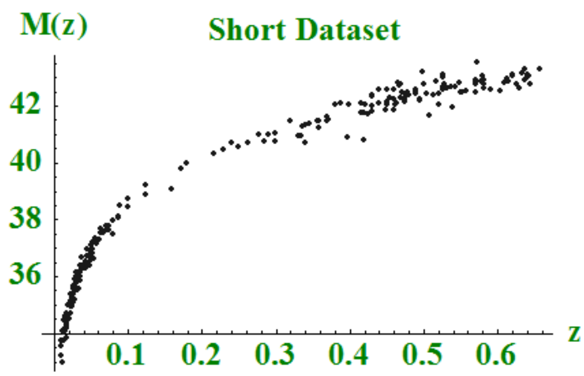
Before discussing the state of the universe at its lower turning point, we shall confront the implications of our scheme with the supernovae data for magnitudes and redshifts.

## 3 Supernovae Data & the Hubble Constant

A large list giving supernovae magnitudes against redshifts is given in the appendix (this was used in our last work on the subject[3]). The corresponding graphic (magnitude against redshift) is given below:




This is another graphic with a better resolution for the points with lower redhifts:



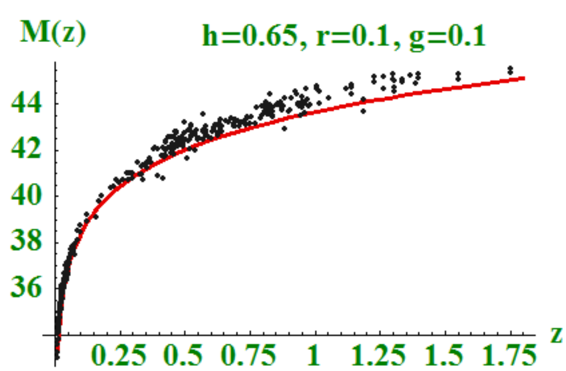

Now in order to relate our Friedmann equation (1) to the above supernovae data, we recall that stellar magnitudes are given by the expression[10],[11]

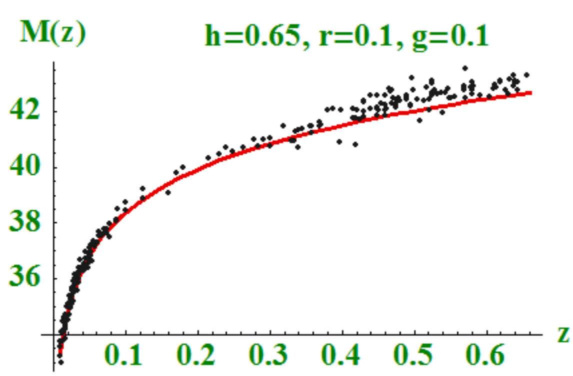
$$\mathcal{M} = 25 + 5\log_{10}(d_L) \tag{3}$$

where $d_L$ is the luminosity distance in Mpc, or mega parsec ($\approx 3.08568 \times 10^{22}$ m). With the scale parameter $a$ related to the redshift $z$ by the expression $a = 1/(1+z)$, we obtain from the foregoing Friedmann equation,

$$d_L = \frac{c}{H}(1+z)\int_0^z \frac{\mathrm{d}\xi}{\sqrt{-r(1+\xi)^4 + (1+r+g)(1+\xi)^3 - g(1+\xi)^2}} \tag{4}$$

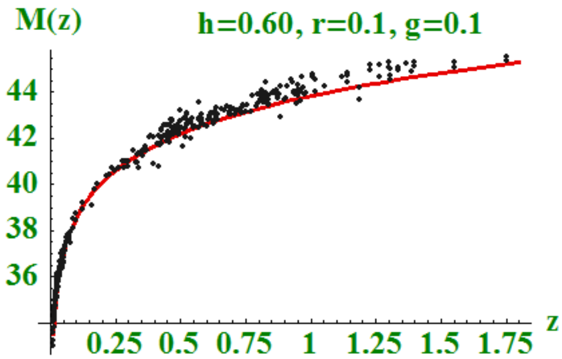
with $c$ being the speed of light, using $r = 0.1$ and $g = 0.1$, and a Hubble fraction of $h = 0.65$. Using the foregoing two formulas, we can plot the curve of magnitude against redshift on the same graphic, given before, for supernovae data (showing graphics for long range and short range side by side):

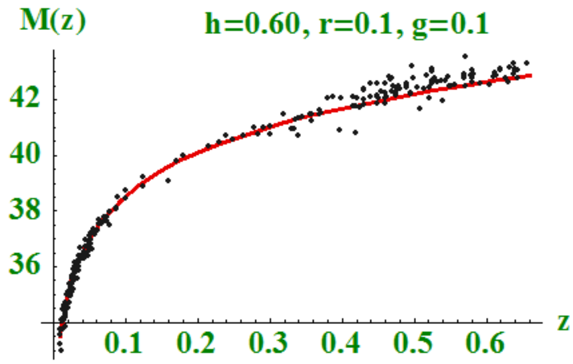


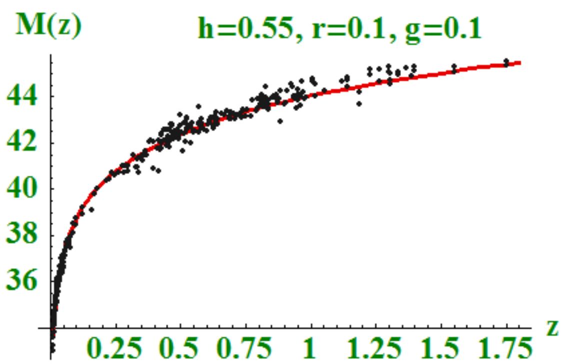

It is clear that the curve goes much below the data points.

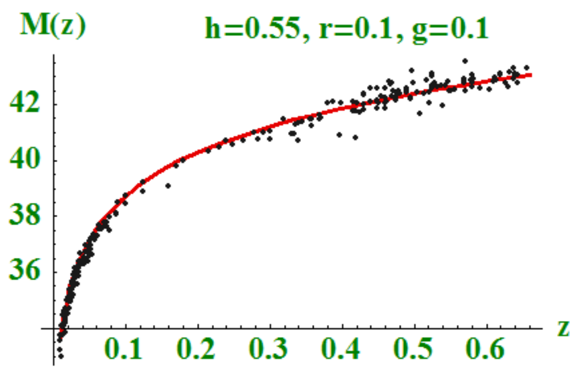
Lowering the value of the Hubble fraction to $h = 0.60$, we obtain:



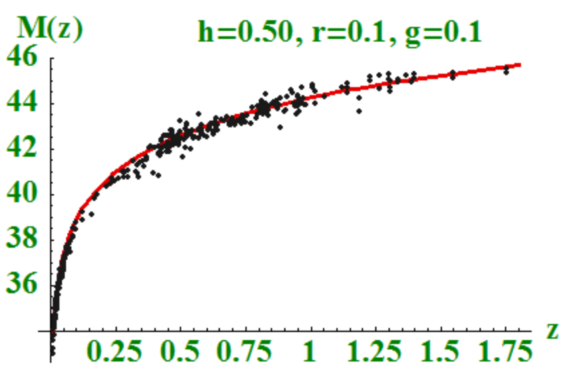



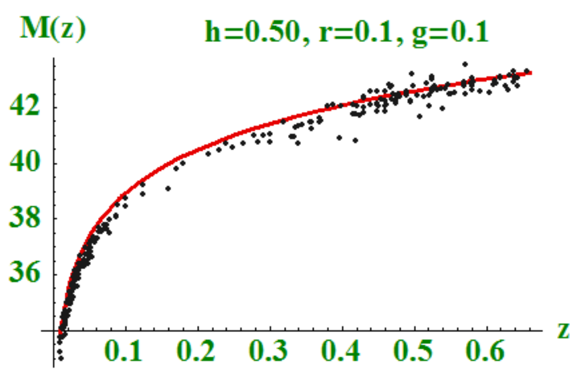

Lowering further to $h = 0.55$, we obtain




And further to $h = 0.50$,




It is clear from the above graphics that a value of $h \approx 0.55$ provides the *best fit*, and that with such a value, which corresponds to a Hubble constant of 55 km/sec/Mega parsec, our scheme for the Friedmann equation is compatible with supernovae data for magnitudes and redshifts.

## 4 Times, Densities, & Temperatures

With the choice of $r = 0.1$ and $g = 0.1$, the turning points of cosmic oscillation are given by the solution of the equation $-0.1 + 1.2a - 0.1a^2 = 0$, and we obtain $a = 0.0839202$

for the lower turning point (minimal scale) and $a = 11.9161$ for the upper turning point (maximal scale). The *age of the current expansion* since minimal scale is obtained from the following integral (using the appropriate H with $h = 0.55$):

$$\frac{1}{H} \int_{a=0.0839202}^{1} \frac{a \; \mathrm{d}a}{\sqrt{-0.1 + 1.2a - 0.1a^2}} \approx 8.93154 \, \mathrm{Gyr} \tag{5}$$

On the other hand, the *remaining time before returning to contraction* is obtained from:

$$\frac{1}{H} \int_{a=1}^{11.9161} \frac{a \; \mathrm{d}a}{\sqrt{-0.1 + 1.2a - 0.1a^2}} \approx 751.557 \, \mathrm{Gyr} \tag{6}$$

Moving to questions of matter density and temperature, recall that the *total mass density* on the RHS of our Friedmann equation is given by $3H^2/8\pi G$. With our choice of the Hubble constant, this gives a total density of $\sim 5.68344 \times 10^{-27}$ kg/m$^3$. Multiplying this by $r = 0.1$ we obtain the *photonic mass density*, while multiplying by $(1 + r + g) = 1.2$ we obtain the *matter mass density*. Now the photonic mass density as a function of temperature is given by:

$$\rho_r = \frac{\pi^2}{15} \frac{k^2 T^4}{\hbar^3 c^5} \approx 8.41821 \times 10^{-33} T^4 \tag{7}$$

where we have used $k = 1.38066 \times 10^{-23}$ joule/K for the Boltzmann constant, $c = 2.99792458 \times 10^8$ for the speed of light constant, and $\hbar = 1.05457 \times 10^{-34}$ joule·sec for the reduced Planck constant. Equating the above to the matter density implemented in our equation, we obtain $T \approx 30$ K as an *upper bound* on the *present* photonic temperature if the universe is to be expanding at all. On the other hand, dividing the above by the total mass density and equating to $r = 0.1$, we obtain $T \approx 16.1194$ K as the *actual value* of the implemented temperature for the present-time photonic background. This should be contrasted with $T = 2.726$ K associated with the microwave background. The temperature of photonic radiation at minimal scale ($a \approx 0.0839202$) is given by $T/a$ or $\sim 192.08$ K. This value should be contrasted with $\sim 30,298$ K obtained in our earlier work[1] associated with the microwave background, and with *infinity* in the conventional singular cosmology.

Whereas the density of matter at present is given by $(1 + r + g) = 1.2$ times the total mass density, or $\rho_m \approx 6.82013 \times 10^{-27}$ kg/m$^3$, the value at minimal scale is $\rho = \rho_m/a \approx 1.15397 \times 10^{-23}$ kg/m$^3$. Notice that if a typical galaxy like ours (consisting of about $10^{11}$ stars like our sun) were to distribute its mass over a certain radius, and have the latter density, its radius $(3M/4\pi\rho)^{1/3}$ would be about 3.34 the size of our galaxy.

## 5 Discussion

In our earlier work[1]-[3] regarding realistic non-singular cosmology, and viewing the microwave background (whose temperature is 2.726 K) as a true measure of the photonic background of the universe, a general picture had emerged depicting the state of the universe at minimal scale as that of *space packed with stars, that may have been whole and active* with a background temperature of $\sim 30,298$ K. The stars were considered as the main protagonists in an oscillating universe whose turning points are determined by the photonic and the gravitonic densities. However, in this article we have been able to show that *the main protagonists in such an oscillating universe would rather be the galaxies*, and the state of the universe at minimal scale would be very cold, with a background temperature of $\sim 192$ K only!

Recall that our basic starting point depends on the *assumption* the the present average temperature of cosmic photons is $\sim 16$ K, an *illustrative* value higher that the that associated with the microwave background, but still lower than $\sim 30$ K, the upper bound for an expanding scenario in our scheme for realistic non-singular cosmology based on a Friedmann equation. We have shown that our choice for the photonic and the gravitonic densities yield *remarkable agreement* with the supernovae data for magnitudes and redshifts provided a Hubble fraction of $\sim 0.55$ is adopted. We have also remarked that our implemented minimal scale yields an *upper bound* on observable redshifts $z \sim 11$. The latter fact could and should be a decisive observational constraint in any future scrutinizing of our theory.

Whether the main protagonists of a realistic non-singular cosmology are the stars or the galaxies is a question that may demand further investigation, although we tend towards adopting the *more realistic colder scenario* introduced in the present work. This means that the global motion of the universe (expanding and contracting) is just a very cold *superficial* phenomenon engaging the galaxies. Whatever will be the final form of a realistic non-singular cosmology, it would always provide *a more acceptable alternative than the conventional singular cosmology and the outrageous ever-accelerating counterparts.*

## A Appendix: Supernovae Magnitudes Data List

The following is a collected list[15], [16], [17] of items of the form $\{z, M\}$, where $z$ is the redshift and $M$ is the corresponding supernova magnitude:

```
{{0.0104,33.21},{0.0104,33.56},{0.0104,33.73},{0.0116,32.96},{0.0121,34.05},
{0.0132,34.02},{0.0136,33.73},{0.0141,34.12},{0.0141,34.13},{0.0141,34.43},
{0.015,34.118},{0.0152,34.11},{0.0157,34.58},{0.016,34.071},{0.016,34.083},
{0.016,34.129},{0.016,34.405},{0.0161,34.5},{0.0162,34.13},{0.0164,34.41},
{0.0164,34.47},{0.0165,33.82},{0.0166,34.54},{0.0167,34.21},{0.017,34.162},
{0.017,34.216},{0.017,34.319},{0.017,34.452},{0.017,34.18},{0.017,34.47},
{0.0171,34.68},{0.0175,34.52},{0.0178,34.7},{0.018,34.489},{0.018,34.576},
{0.018,34.29},{0.0186,34.96},{0.0193,34.59},{0.02,34.494},{0.0218,35.06},
{0.0219,34.7},{0.022,34.941},{0.023,35.146},{0.0233,35.14},{0.0234,35.36},
{0.024,35.228},{0.024,35.25},{0.0244,35.09},{0.0247,35.33},{0.025,34.931},
{0.025,35.192},{0.0251,35.09},{0.0257,35.41},{0.026,35.342},{0.026,35.353},
{0.026,35.565},{0.026,35.62},{0.0262,35.06},{0.0265,35.64},{0.0266,35.36},
{0.0276,35.9},{0.028,35.15},{0.0286,35.53},{0.029,35.7},{0.0297,36.12},
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{0.03,35.822},{0.03,35.994},{0.0307,35.9},{0.031,35.532},{0.031,35.558},
{0.0316,35.85},{0.032,35.789},{0.0327,36.08},{0.0331,35.54},{0.0348,36.17},
{0.035,35.837},{0.036,36.113},{0.036,36.17},{0.036,36.01},{0.036,36.39},
{0.038,36.67},{0.039,36.284},{0.04,36.38},{0.043,36.276},{0.043,36.53},
{0.045,36.728},{0.045,36.97},{0.046,36.35},{0.049,36.383},{0.049,36.52},
{0.049,36.9},{0.05,36.632},{0.05,36.827},{0.05,36.84},{0.05,37.08},
{0.051,36.67},{0.052,37.16},{0.053,36.794},{0.053,36.97},{0.053,37.17},
{0.054,36.606},{0.056,37.31},{0.058,37.13},{0.061,37.3},{0.063,37.54},
{0.063,37.67},{0.067,37.54},{0.071,37.604},{0.071,37.78},{0.075,37.642},
{0.075,37.77},{0.079,37.465},{0.079,37.94},{0.088,38.07},{0.088,38.121},
{0.089,38.5},{0.101,38.437},{0.101,38.73},{0.124,39.2},{0.125,38.885},
{0.16,39.08},{0.172,39.79},{0.18,39.98},{0.216,40.33},{0.216,40.33},
{0.23,40.44},{0.24,40.68},{0.249,40.571},{0.263,40.682},{0.278,41.},
{0.285,40.731},{0.291,40.999},{0.3,40.76},{0.3,41.01},{0.32,41.45},
{0.331,40.946},{0.334,40.92},{0.337,41.259},{0.34,40.71},{0.34,41.323},
{0.346,41.367},{0.357,41.441},{0.358,41.474},{0.359,41.23},{0.369,41.485},
{0.369,41.62},{0.371,41.488},{0.38,42.02},{0.388,42.07},{0.397,40.89},
{0.4,42.04},{0.415,41.772},{0.416,42.1},{0.42,40.79},{0.42,41.76},
{0.422,42.02},{0.425,41.7},{0.43,41.776},{0.43,41.99},{0.43,42.33},
{0.43,42.36},{0.44,42.08},{0.44,42.57},{0.449,41.866},{0.45,42.1},
{0.45,42.13},{0.45,42.58},{0.451,42.038},{0.455,42.29},{0.46,41.83},
{0.46,42.23},{0.46,42.56},{0.461,42.031},{0.463,42.089},{0.465,42.81},
{0.468,42.708},{0.47,42.268},{0.47,42.74},{0.47,42.77},{0.472,42.46},
{0.475,42.14},{0.475,42.24},{0.477,42.38},{0.478,42.48},{0.48,42.37},
{0.49,42.41},{0.49,42.54},{0.49,42.58},{0.495,42.25},{0.496,42.18},
{0.498,43.21},{0.5,42.74},{0.5,42.75},{0.5,42.75},{0.504,42.429},
{0.508,41.64},{0.514,42.39},{0.518,42.83},{0.521,42.05},{0.521,42.439},
{0.526,42.56},{0.526,42.644},{0.526,43.01},{0.526,43.08},{0.528,42.77},
{0.532,42.592},{0.538,42.66},{0.54,41.96},{0.543,42.68},{0.548,42.825},
{0.55,42.487},{0.552,42.461},{0.557,42.511},{0.57,42.77},{0.57,42.81},
{0.57,42.88},{0.571,42.465},{0.572,43.521},{0.579,42.86},{0.58,43.04},
{0.581,42.63},{0.581,42.761},{0.582,42.881},{0.592,42.562},{0.604,42.515},
{0.61,42.796},{0.613,42.961},{0.615,42.85},{0.62,43.03},{0.62,43.11},
{0.627,42.746},{0.63,42.62},{0.633,43.133},{0.638,42.89},{0.638,43.3},
{0.64,43.07},{0.64,43.01},{0.643,43.023},{0.644,42.78},{0.657,43.27},
{0.67,43.19},{0.67,43.19},{0.679,43.398},{0.688,43.046},{0.691,43.144},
{0.695,43.023},{0.698,43.33},{0.707,43.237},{0.71,43.05},{0.71,43.176},
{0.719,43.22},{0.721,43.209},{0.73,43.287},{0.735,43.09},{0.735,43.14},
{0.74,43.35},{0.74,43.38},{0.741,43.427},{0.752,43.17},{0.756,43.453},
{0.771,43.12},{0.778,43.81},{0.791,43.353},{0.798,43.88},{0.8,43.49},
{0.81,43.691},{0.811,43.95},{0.811,43.97},{0.815,43.76},{0.815,44.09},
{0.817,43.652},{0.818,43.532},{0.822,43.544},{0.828,43.61},{0.828,43.96},
{0.83,43.85},{0.83,44.414},{0.832,43.55},{0.839,43.45},{0.839,43.86},
{0.84,43.475},{0.84,43.67},{0.854,43.96},{0.86,44.03},{0.868,43.871},
{0.87,44.095},{0.873,43.75},{0.882,43.9},{0.884,44.23},{0.886,42.91},
{0.899,43.64},{0.9,43.64},{0.905,43.708},{0.91,44.259},{0.927,44.553},
{0.93,44.43},{0.935,43.97},{0.935,43.99},{0.94,43.87},{0.949,43.507},
{0.949,43.99},{0.95,44.06},{0.95,43.954},{0.95,43.98},{0.954,43.85},
{0.954,44.28},{0.954,44.3},{0.96,43.622},{0.961,44.},{0.97,44.13},
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{1.34,45.05},{1.37,45.23},{1.39,44.9},{1.4,45.09},{1.4,45.28},
{1.551,45.07},{1.551,45.3},{1.755,45.35},{1.755,45.53}}

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ANNOUNCEMENT

## *PhysXp* for *Windows*

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