

Approaching the Cosmos from a Quantum Point of View

“Who cares what happens to light when traveling from A to B?” - A friend

Classical Electromagnetic Dirac's Equation

$$i\hbar \frac{\partial \psi}{\partial t} = \left[c \vec{\alpha} \cdot (\vec{p} - e \vec{A}) - e\varphi + \beta mc^2 \right] \psi$$

c : speed of light

(φ , A): electromagnetic potentials

e: electrical charge

Gravitational Dirac's Equation

$$i\hbar \frac{\partial \psi}{\partial t} = \left[C \vec{\alpha} \cdot (\vec{p} - m \vec{A}) - m\varphi + \beta mC^2 \right] \psi$$

C : speed limit in nature

(φ , A): gravitational potentials

m: gravitational charge (mass)

Following Bethe, H. and Salpeter, E., (1957) Quantum Mechanics of One – and Two – Electron Atoms.
Ed. Academic Press Inc., New York, 63-71.

Long Close Trip Solution ($\ell \gg 1$)

$$u_1 = -iU_0 \exp\left[\frac{i}{\hbar}(2E + 2m\varphi - mC^2)\tau\right]$$

$$u_2 = -iU_0 \exp\left[\frac{i}{\hbar}(2E + 2m\varphi - mC^2)\tau\right]$$

$$u_3 = U_0 \exp\left[\frac{i}{\hbar}(2E + 2m\varphi - mC^2)\tau\right]$$

$$u_4 = U_0 \exp\left[\frac{i}{\hbar}(2E + 2m\varphi - mC^2)\tau\right]$$

$$\frac{\partial u_1}{C\partial\tau} = \frac{i}{\hbar C}\left[E + m(-C^2 + \varphi)\right]u_1 - \frac{\partial u_3}{c\partial\tau}$$

$$\frac{\partial u_2}{C\partial\tau} = \frac{i}{\hbar C}\left[E + m(-C^2 + \varphi)\right]u_2 + \frac{\partial u_4}{c\partial\tau}$$

$$\frac{\partial u_3}{C\partial\tau} = \frac{i}{\hbar C}\left[E + m(C^2 + \varphi)\right]u_3 - \frac{\partial u_1}{c\partial\tau}$$

$$\frac{\partial u_4}{C\partial\tau} = \frac{i}{\hbar C}\left[E + m(C^2 + \varphi)\right]u_4 + \frac{\partial u_2}{c\partial\tau}$$

$$E + mC^2 + m\varphi \approx \frac{E_{star} + mC^2 + m\varphi}{\sqrt{1 + \frac{d}{c\tau_0}}}$$

$$\tau_0 = \frac{h}{mC^2}$$

RedShift

$$z = \frac{E_0}{E} - 1$$

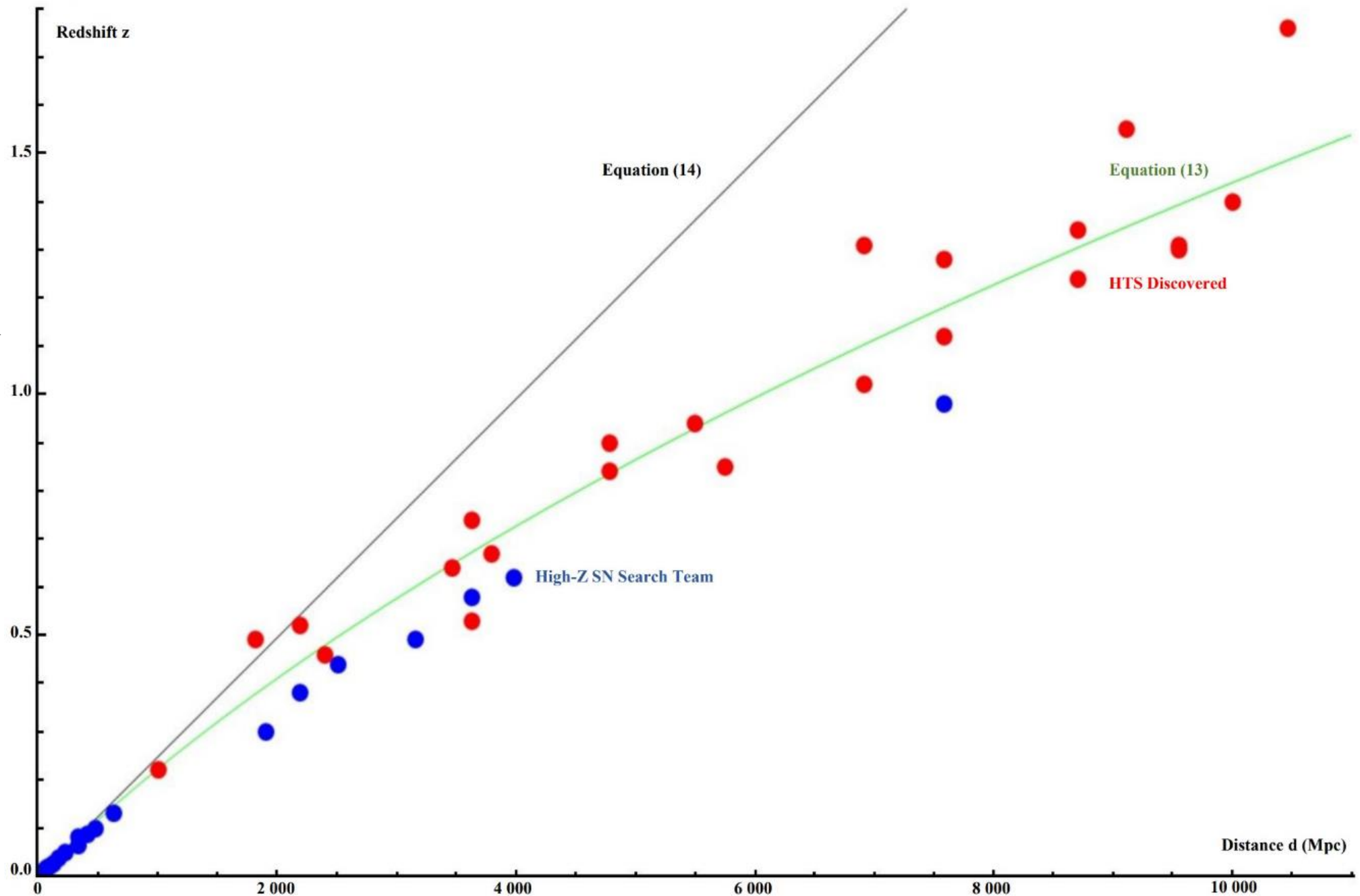
$$z_{13} = \sqrt{1 + \frac{mC^2}{hc}d} - 1$$

$$z \approx \frac{mC^2}{2hc}d$$

$$z_{14} \approx \frac{H_s}{c}d$$

$$H_s \approx \frac{mC^2}{2h}$$

$$m_\gamma \approx \frac{2hH_s}{C^2}$$



Origin of the Cosmic Microwave Background Radiation.

It appears were the redshift skyrocket

$$E \approx \frac{E_{star} + m(C^2 + \varphi)}{\sqrt{1 + \frac{d}{c\tau_0}}} - m(C^2 + \varphi)$$

$$\frac{E_{star}}{E} \approx \frac{1}{1 + \frac{m(C^2 + \varphi)}{\frac{E_{star}}{\sqrt{1 + \frac{d}{c\tau_0}}}} - \frac{m(C^2 + \varphi)}{E_{star}}}$$

$$z \approx \frac{1}{1 + \frac{m(C^2 + \varphi)}{\frac{E_{star}}{\sqrt{1 + \frac{mC^2}{\hbar c}d}} - \frac{m(C^2 + \varphi)}{E_{star}}}} - 1$$

$$z_1 = \frac{1.0631 \text{ mm}}{580 \text{ nm}} - 1 = 1,831.93$$

$$z_2 = \frac{1.0639 \text{ mm}}{580 \text{ nm}} - 1 = 1,833.31$$

$$\text{with: } \frac{m(C^2 + \varphi)}{E_{star}} \approx 0.005,945$$

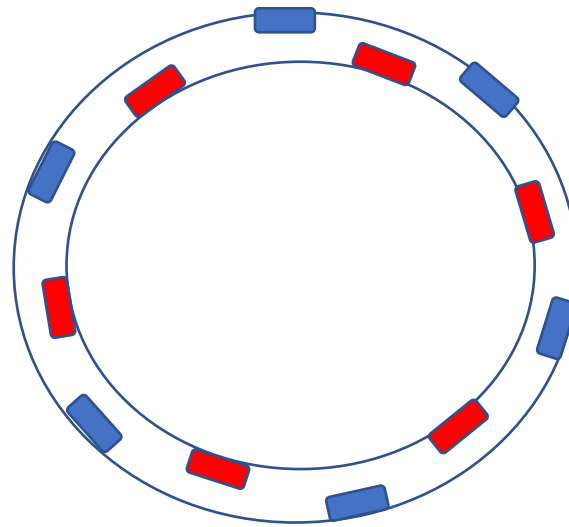
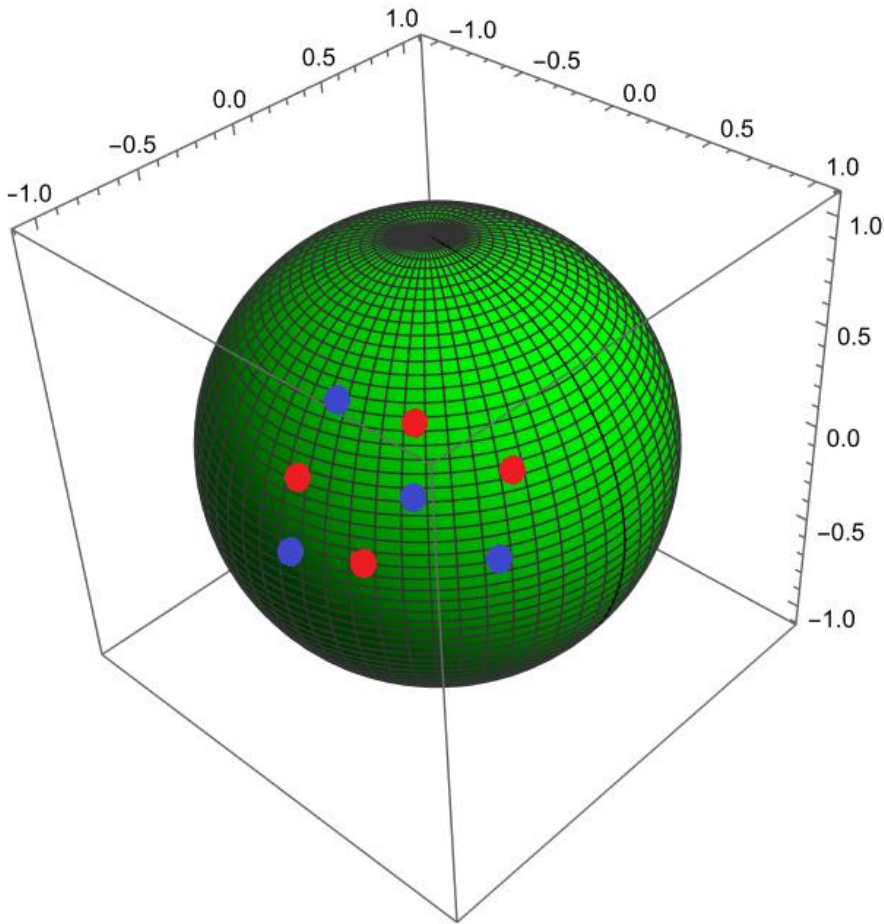
$$d_1 = 48,557,000 \text{ Mpc}$$

$$d_2 = 48,563,100 \text{ Mpc}$$

$$\Delta d = 6,142 \text{ Mpc}$$

$$H_s = \frac{z_2 - z_1}{d_2 - d_1} = 67.4 \text{ km s}^{-1} \text{ Mpc}^{-1}$$

We are living in a Cosmic Atom limited by a shell of galaxies



Spots

Radius ~ $R \sim 400,000$ Mpc

Height ~ $H \sim 3,000$ Mpc

Number + $N \sim 6,000 \ll N$ available $\sim 42,000$

The Photon Mass: Chibisov, G. V. (1976)

Astrophysical Upper Limits on the Photon Rest Mass, Sov. Phys. Usp. 19, 624-626., by modeling the cosmic magnetic field, shows the most experimental demanding 3×10^{-63} kg photon mass upper limit.

$$m_{\gamma} = \frac{2hH_0}{C^2} = \frac{2 \times 6.626 \times 10^{-34} \text{ kg m s}^{-2} \text{ m s} \times 74.2 \text{ km s}^{-1} \text{ Mpc}^{-1}}{9 \times 10^{10} \text{ km}^2 \text{ s}^{-2}} = 3.5 \times 10^{-68} \text{ kg}$$