

# The Constancy of the Laws of Nature - Variation of the Fine Structure Constant

The Value of the Fine Structure Constant Over Cosmological Times, C M Gutierrez and M. L'opez-Corredoira, The Astrophysical Journal , 713:46–51, 2010 April 10 doi:10.1088/0004-637X/713/1/46

In Jeremiah 33:25, God declares, “I have established...the fixed laws of heaven and earth.”

This is just one of several Scripture passages demonstrating that for thousands of years the Bible has been on record as stating that the laws of physics do not vary.

The one constant of physics most amenable to this testing technique is the fine structure constant, which characterizes the strength of the electromagnetic interaction. The fine structure constant has the additional advantage of being directly related to several other physical constants. For example, it is the ratio of the elementary electron charge to the Planck charge; the ratio of the velocity of the electron in the Bohr model of the atom to the velocity of light; the ratio of the energy needed to overcome the electrostatic repulsion between two electrons separated by distance D to the energy of a single photon at wavelength,  $\lambda = 2\pi D$ . It is the dimensionless coupling constant for electromagnetism,  $\alpha \sim 1/137$ .

Consequently, testing the constancy of the fine structure constant also test the constancy of several other physical constants. The principal assumption made in this work is that the difference in wavelengths divided by their sum is proportional to the fine-structure constant squared. The analysis is done by measuring the position of the fine structure lines of the [Oiii] doublet ( $\lambda\lambda 4959$  and  $\lambda\lambda 5008$ ) in QSO (Quasistellar Object, Quasar) nebular emission.

This method is based on fine structure splitting. The splitting ratio  $(\lambda_2 - \lambda_1)/(\lambda_2 + \lambda_1)$  at two different epochs gives the relative difference in the relative difference in  $\alpha$  between these two epochs. It is shown (Uzan 2003) that

$$\frac{\Delta\alpha}{\alpha}(z) = \frac{1}{2} \left\{ \frac{[(\lambda_2 - \lambda_1)/(\lambda_2 + \lambda_1)]_z}{[(\lambda_2 - \lambda_1)/(\lambda_2 + \lambda_1)]_0} - 1 \right\}$$

where  $\lambda_2$  and  $\lambda_1$  are the wavelengths of the pairs of the doublet, and the subscripts z and 0 refer to the values at redshift z and locally, respectively. Analyzed a sample of 1,568 quasars in the Sloan Digital Sky Survey Data Release 6.

## Results of Analysis Matrix $\alpha_z$ : Redshift Min, Max, $\Delta\alpha/\alpha \cdot 10^{-5}$ , $1\sigma$ Errors

$$z_{avg_{za}} := \text{mean}(\alpha_{z_{za,0}}, \alpha_{z_{za,1}}) \quad \alpha_z := \text{READPRN}(\text{"Fine Structure Constant vs Redshift.txt"}) \quad z_a := 0..8 \quad \text{cols}(\alpha_z) = 4$$

$$\Delta\alpha_{\alpha_{max}} := \alpha_z^{(2)} + \alpha_z^{(3)} \quad \Delta\alpha_{\alpha_{min}} := \alpha_z^{(2)} - \alpha_z^{(3)} \quad \Delta\alpha_{\alpha_{mean}} := \alpha_z^{(2)}$$

$$\Delta\alpha_{\alpha_{avg}} := \text{mean}(\alpha_z^{(2)}) \quad \chi := \text{line}(z_{avg}, \Delta\alpha_{\alpha_{mean}})$$

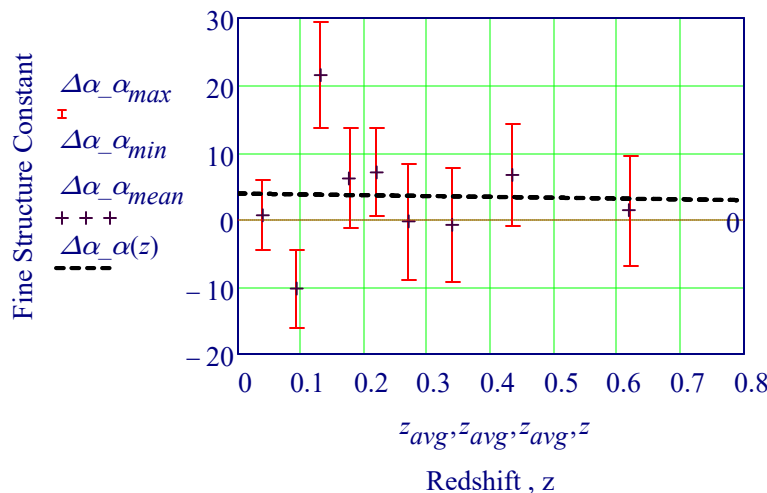
$$\Delta\alpha_{\alpha(z)} := \chi_0 + \chi_1 \cdot z$$

$$\Delta\alpha_{\alpha_{avg}} = 3.533 \quad \chi_0 = 3.852$$

$$\chi_1 = -1.235$$

### Change in the Fine Structure Constant Over Cosmological Times

$\Delta\alpha/\alpha \cdot 10^{-5}$  vs Redshift, z



$$\Delta\alpha/\alpha = (+2.4 \pm 2.5) \times 10^{-5}$$

in the range of redshifts  
z ~ 0 to 0.8

The range in redshift is a maximum look-back time of 6.6 Gyr, and a mean of 3.0 Gyr. See XXIV.

$$\frac{2.4 \cdot 10^{-5}}{3.3 \text{ Gyr}} = 0.7 \cdot 10^{-14} \cdot \text{yr}^{-1}$$

The mean variation compatible with our results is:  $1/t \Delta\alpha/\alpha = (0.7 \pm 0.7) \times 10^{-14} \text{ yr}^{-1}$

This gives at a confidence level of better than 99 percent that the value of the Fine Structure Constant has Not Changed over the past seven billion years by any more than three parts per hundred trillion per year.