
A Shift of Nucleon Mass Could Substitute the Idea of an Accelerated Expansion

Johann Michael Köhler

Department of Physical Chemistry and Microreaction Technology, Institute for Micro and Nano Technologies, Technical University Ilmenau, Ilmenau, Germany

Email address:

michael.koehler@tu-ilmenau.de

To cite this article:

Johann Michael Köhler. A Shift of Nucleon Mass Could Substitute the Idea of an Accelerated Expansion. *International Journal of High Energy Physics*. Vol. 4, No. 2, 2017, pp. 19-22. doi: 10.11648/j.ijhep.20170402.11

Received: July 5, 2017; **Accepted:** July 19, 2017; **Published:** August 4, 2017

Abstract: A considering of a very slow shift in the nucleon rest mass is proposed in order to avoid the assumption of acceleration in the expansion of the universe. A recent yearly change in the order of magnitude of $5 \cdot 10^{-11}$ is sufficient for an alternative approach, which interprets the discrepancy between the low intensity of far-distance supernovae Ia and their red-shift by a reduction of supernovae energy. Such a reduction of intensity could be explained by a lowered critical mass of the white dwarf due to higher nucleon masses and lower required particle numbers in the critical state.

Keywords: Accelerated Expansion, White Dwarfs, Supernovae Ia, Nucleon Mass, Chandrasekhar Limit

1. Introduction

Electromagnetic waves are the single sources for getting detailed information from the depth of universe. The fascinating progress of observation methods in astrophysics supplied a lot of data from different parts of the electromagnetic spectrum and lead to an enormous increase of knowledge and understanding of processes in far-distant stars, gas and dust clouds, galaxies and larger cosmic structures [1].

The identification of stellar objects with a strong standardized behaviour was one of the most important insights for the development of methods in cosmology. Beside the cosmological red-shift, the detection and characterization of such comparable objects in different directions allowed to calibrate cosmic distances and to draw a picture of the spatial structure of the galaxy and for the observable universe as whole. The combination of this data with the model of cosmological expansion, which is reflected by the red-shift, allowed to concluding on the dynamics in cosmic evolution.

The use of supernovae of the type Ia became particular interesting, because they are very bright objects with a high dynamics, they are very regular in character and are marked by a very good observability in different parts of the spectrum. In addition, their originating mechanism is well understood and confirmed by all spectral investigations. Despite this regularity, it was found that far-distant supernovae Ia appear

less bright as expected if their distance was determined by the red-shift of all electromagnetic waves coming from these objects. This discrepancy was confirmed by many measurements during the last decades. The only possible interpretation of this effect seemed to be the assumption of a change in the rate of cosmological expansion during the evolution of our universe. This conclusion led to the model of an accelerating expanding universe [2, 3].

Up to now, there is no convincing reason for the origin of the acceleration. “Negative gravitation effects”, a “cosmological constant” and “dark energy” are typical terms in this discussion. But, it has to be aware that these terms are not objects for an empirical research but have a speculative character. In alternative to the assumption of dark energy, modified gravity [4], a cosmological time contraction [5] entropic [6] and viscosity effects [7] are discussed, for example. The interpretation of the observation data from far-distant supernovae Ia and the conclusion of an accelerating universe are based on physical constants obtained from measurements on experiments on earth. Meanwhile, the deciding fundamental constants have been determined with very high accuracy [8-10]. But despite the fact, that a clear hint on a temporal shift of fundamental constants was neither reliably recognized in measurements on earth nor in astrophysical observations [11], it has to be taken in mind that deviations for large distances and times cannot be excluded completely. In the following, it is

proposed to discuss a slow variation of nucleon mass [12] as the reason for the observed discrepancy between red-shift and absolute magnitude of the far-distant supernovae Ia, in alternative to the assumption of an accelerated expansion.

2. Interpretation of “Large Numbers” as a Mirror of Long-Term Cosmological Evolution

Jacque Dirac already recognized a relation between cosmological data and data from the microcosm of elementary particles [13]. The ratio of extension of observable universe (about 10^{26} m) and the size of a proton (about 10^{-15} m) is roughly in the order of magnitude of 10^{40} . The square root of this value corresponds approximately to the ratio of the size of proton and Plancks length. The cubic of the last mentioned ratio (about 10^{61}) corresponds roughly to the order of magnitude of the ratio between the age of universe and Plancks time [14].

The following discussion is based on the assumption that the universe has to be seen as a space in evolution. All essential parameters of universe are changing: its size, its mean temperature, its structure and the age and character of the contained objects. Thus, it seems that the evolutionary change, the time arrow is the key feature in the character of the universe.

The age of universe can be described by a dimensionless “time-counter”, if Plancks time t_p (about $5.4 \cdot 10^{-44}$ s) is interpreted as the elementary time step. This counter z is in the order of magnitude of 10^{61} ($8 \cdot 10^{60}$, if a cosmic age of about 14 Ga is assumed or would be about $4 \cdot 10^{60}$, in case of an assumed age of about 7 Ga or by taking twice the Planck time value as counting basis). If, in addition, a continuous evolution of elementary masses from the fundamental Planck mass m_p (about $2.2 \cdot 10^{-8}$ kg) is assumed, the proton mass can approximately be expressed by Plancks mass and the cubic root function of z :

$$m_{pr} \approx 4 * \pi * \frac{m_p}{\sqrt[3]{z}} \quad (1)$$

This approximation suggests a decrease of relative proton mass by about $5 \cdot 10^{-11}$ per year (Figure 1). This value is in the order of magnitude of the most accurate methods of determination of proton size. And this shift is much smaller than the difference between the experimentally determined proton size and the Compton radius of protons.

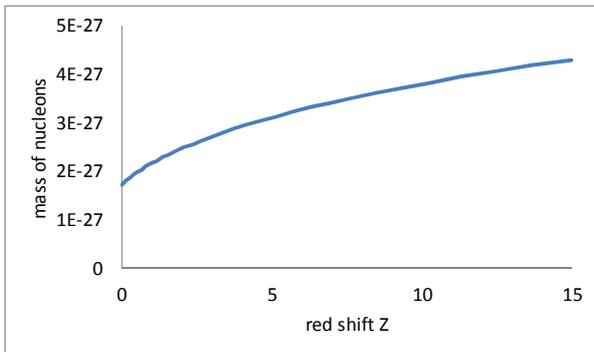


Figure 1. Assumption of a slow shifting mass of nucleons.

But, the postulated shift in proton mass would become significant if the distances become larger and the temporal distance increases. For a red-shift of $Z=1$, a proton mass of about $2.12 \cdot 10^{-27}$ kg would result, corresponding to a difference of 27% compared with its recent mass.

It is to assume that in an evolving universe, a parameter exists which describes the universal aging. In principle, this parameter could be identified with the above mentioned counter z or with a parameter deviated from this value by the natural logarithm:

$$\beta = \ln \left[\frac{z}{4 * \pi} \right] \quad (2)$$

Under assumption of the above assumed recent counter value of $4.1 \cdot 10^{60}$ results:

$$\beta_{\text{recently}} = 137 \quad (3)$$

This value corresponds to the reciprocal value of the fine structure constant (FSK) α . In case of an assumed counter z of $8 \cdot 10^{60}$, the parameter β' could be interpreted as the reciprocal of α , if it is approximated by:

$$\beta' = \ln \left[\frac{z}{8 * \pi} \right] \quad (4)$$

Following this equation, a significant enhanced FSK could be assumed for a cosmological red-shift of $Z=1$. The value ($1/136.3$) is about 0.5% higher than the recently observed value ($1/137.04$). But, this enhancement is considerably smaller than the effect of the above discussed assumption of a shift in the nucleon mass.

3. Supernovae Ia Signals in Case of Variability of Proton Mass and Fine Structure Constant

The character of supernovae Ia as a standard candle is due to reaching the limit of stability of a growing white dwarf, which sucks material from a star in its close neighbourhood. The effect of crossing a critical mass limit was discussed already by W. Anderson [15] and E. C. Stoner [16] and investigated further by S. Chandrasekhar [17].

A simple approximation is used, in the following, for a rough estimation of the Chandrasekhar limit. Therefore, it is assumed, that the total energy of electrons E_{el} of a white dwarf is just compensated by the gravitational energy E_g at the limit:

$$E_{el} = E_g \quad (5)$$

For the approximation of the total energy of electrons a Compton-length related expression is used:

$$E_{el} \approx \frac{N * h * c}{\pi * \lambda_e} \quad (6)$$

N is the number of protons (equal of the number of electrons) in the white dwarf, and λ_e is the energy-related Compton wave length of electrons.

The gravitational energy is approximated by:

$$E_g = \frac{G * (A * m_n)^2}{d} \quad (7)$$

$$R \sim \sqrt[3]{\frac{M_c}{m_n^4}} \quad (17)$$

G is the gravitational constant, d the diameter of the white dwarf, A the number and m_n the mass of nucleons.

The diameter can be estimated by the number of electrons N and their space requirement λ_e :

$$d \approx \lambda_e * \sqrt[3]{3 * N * \frac{\sqrt{2}}{\pi}} \quad (8)$$

and

$$E_g \approx \frac{G * (A * m_n)^2}{\lambda_e * \sqrt[3]{3 * N * \frac{\sqrt{2}}{\pi}}} \quad (9)$$

This leads with eq. (5) to:

$$\frac{N * h * c}{\pi * \lambda_e} \approx \frac{G * (A * m_n)^2}{\lambda_e * \sqrt[3]{3 * N * \frac{\sqrt{2}}{\pi}}} \quad (10)$$

which can be transformed into an expression for the critical number of nucleons A:

$$\sqrt[3]{A^2} \approx \sqrt[3]{\left(\frac{N}{A}\right)^4} * \sqrt[3]{3 * \frac{\sqrt{2}}{\pi}} * \frac{h * c}{\pi * G * m_n^2} \quad (11)$$

The critical mass can be approximated from this equation by:

$$M_c \approx m_n * A \approx m_n * \left(\sqrt[3]{\left(\frac{N}{A}\right)^4} * \sqrt[3]{3 * \frac{\sqrt{2}}{\pi}} * \frac{h * c}{\pi * G * m_n^2} \right)^{\frac{3}{2}} \quad (12)$$

$$M_c \approx \frac{1}{m_n^2} * \frac{N^2}{A^2} * \sqrt[3]{3 * \frac{\sqrt{2}}{\pi}} * \left(\frac{h * c}{\pi * G} \right)^{\frac{3}{2}} \quad (13)$$

This approximation supplies a reasonable value in comparison with the well-known critical mass of about 1.4 sun masses $m_{(sol)}$ if a N/A ratio of 0.5 is assumed:

$$M_c \approx 3 * 10^{30} \text{ kg} \approx 1.5 m_{(sol)} \quad (14)$$

The expression shows that the critical mass is approximately only dependent on the fundamental constants h, c and G, the ratio of protons and nucleons (N/A) and the nucleon mass m_n .

The energy of a supernova is mainly given by the gravitational energy of the collapse E_c , which is dominated by the final characteristic Radius of the resulting neutron star:

$$E_c \approx M_c^2 * \frac{G}{R} \quad (15)$$

The radius can be approximated by the volume of the star and an approximation for the space requirement of nucleons ($h/(m_n * c)$):

$$R \approx \sqrt[3]{\frac{3}{4 * \pi} * A * \left(\frac{\sqrt{2}}{2}\right)^2} * \frac{h}{m_n * c} \quad (16)$$

With $A \approx M_c/m_n$ the following approximation results:

And

$$E_c \sim \frac{M_c^2}{\sqrt[3]{\frac{M_c}{m_n^4}}} \approx M_c^{\frac{5}{3}} * m_n^{\frac{4}{3}} \quad (18)$$

This leads to an approximated proportionality of supernova energy to the inverse square of the nucleon mass:

$$E_c \sim m_n^{-\frac{10}{3}} * m_n^{\frac{4}{3}} = m_n^{-2} \quad (19)$$

For a redshift of $Z=1$, the nucleon mass is to assume to be 126% of the recent nucleon mass if a continuous mass reduction of nucleons by a cubic root function is postulated:

$$m_{n(Z=1)} = m_{n(Z=0)} * \sqrt[3]{2} = 1.26 * m_{n(Z=0)} \quad (20)$$

The corresponding energy for $Z=1$ is lowered by 37% in comparison with the recent supernovae energy down to 0.63 E_c . For $Z=3$, the energy is lowered down to 40% (Figure 2).

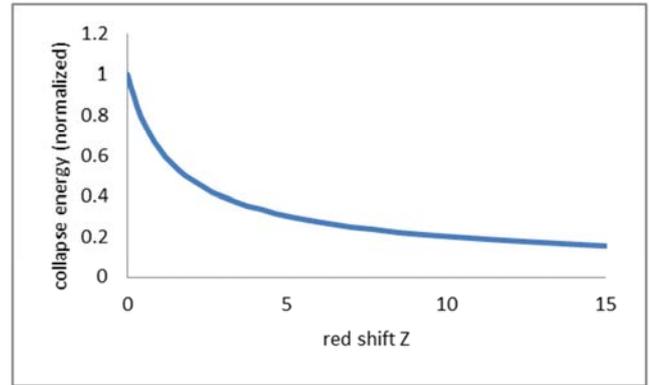


Figure 2. Approximation of the energy of gravitational collapse of a white dwarf in dependence on red-shift Z under assumption of a slow shifting mass of nucleons.

A supernova with an emission energy lowered to 63% ($Z=1$) seems to be in a distance of 126%, for an energy lowered to 40% ($Z=3$) it seems to be in a distance of 158% of the real distance, if constant nucleon masses are assumed. The assumption of a variable particle mass would avoid the postulation of this acceleration in the expansion of the universe.

4. Conclusions

The assumption of a slow decrease in the rest masses of nucleons would allow to give an alternative interpretation of the discrepancy between the intensity and the red-shift of far-distance supernovae Ia without the postulation of an acceleration in the cosmological expansion. A cubic root decrease in rest masses corresponds roughly with the observation data.

The effect of particle mass shift on the emitted energy of supernovae can be estimated by a simple approach for the Chandrasekhar limit derived from a balance between gravitational and electron energy and which formulates the

critical mass as a function of the proton-to-nucleon ratio, c , G , h and the nucleon mass, only. In result, distance-related reduced absolute supernovae intensities can be approximated. This proposed distance-dependent shift in the absolute values of supernovae signals does not contradict their use as standard candles for distance measurements in deep-field astronomy, but suggest to reconsidering the reduced intensities of early supernovae by a suited calibration function.

References

- [1] Bartelmann M. The dark universe. *Rev. Mod. Phys.* 2010; 82: 331-382.
- [2] Perlmutter, S. et al: Discovery of a supernova explosion at half age of the universe, *Nature* 391 (1998), 51-54.
- [3] Perlmutter, S: Turner, M. S., White, M: Constraining dark energy with type Ia supernovae and large scale structure, *Phys. Rev. Lett.* 83 (1999), 670-673.
- [4] Joyce, A, Lombriser, L, Schmidt, F: Dark energy versus modified gravity, *Ann. Rev. Nucl. Part. Sci.* 66 (2016), 95-122.
- [5] Kipreos, E. T.: Implications of an absolute simultaneity theory for cosmology and universe acceleration, *Plos One* 9 (2014), e115550.
- [6] Easson, D. A, Frampton, P. H, Smoot, G. F: Entropic accelerating universe, *Phys. Lett. B* 696 (2011), 273-277.
- [7] Floerchinger, S, Tetradis, N, Wiedemann, U. A: Accelerating cosmological expansion from shear and bulk viscosity, *Phys. Rev. Lett.* 114 (2015), 091301.
- [8] Webb, J. K, Flambaum, V. V, Churchill, C. W, Drinkwater, M. J, Barrow, J. D: Search for time variation of the fine-structure constant. *Phys. Rev. Lett.* 82, 884 (1999).
- [9] Bekenstein, J. D: Fine-structure constant variability, equivalency principle, and cosmology. *Phys. Rev. D* 66, 123514 (2002).
- [10] Fritzsche, H: Fundamental constants and their time variation. *Progress Part. Nucl. Phys.* 66, 193-196 (2011).
- [11] Murphy MT, Flambaum VV, Muller S, Henkel C. Strong limit on a variable proton-to-electron mass ratio from molecules in the distant universe. *Science* 2008; 320: 1611-1613.
- [12] Carvalho, J. C: Time variation of cosmic and quantum masses in Dirac's cosmology. *Astrophys. Space Sci.* 306, 5-9 (2006).
- [13] Dirac, P. A. M: A new basis for cosmology, *Proc. Royal Soc. London A* 165, 199-208 (1938).
- [14] Alfonso-Faus, A: Zel'dovich and Weinberg's relation: an explanation for the cosmological coincidences. *Astrophys. Space Sci.* 318, 117-123 (2008).
- [15] Stoner, E. C: *Philosophical Magazine* 7, 1929, 63.
- [16] Anderson, W: Über die Grenzdichte der Materie und der Energie. In: *Zeitschrift für Physik* 56, 1929, S. 851–856.
- [17] Chandrasekhar, S: The Maximum Mass of Ideal White Dwarfs, *Astrophysical Journal*, 74, 1931, 81.