H. Weyl. How far can one get with a linear field theory of gravitation in flat space-time? *Amer. J. Math.* 66 (1944), 591 – 604.

M. SERDYUKOVA
A. SERDYUKOV

M. A. Serdyukova, A. N. Serdyukov

Frantsysk Skaryna State University, Gomel, Belarus

# How Far Can One Get with a Linear Field Theory of Gravitation in Flat Space-Time?

M. SERDYUKOVA
A. SERDYUKOV

# 1 GRAVITATION IN FLAT SPACE-TIME: MOTIVATIONS

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

The Einstein's idea of a dynamic generalization of Newtonian law of gravitation on the base of strong principle of equivalence lead to the metric approach in gravity [1].

Its persistent success contributed to the common certainty that Riemannian geometry is the best language that enables us to adequately describe and truly interpret the relativistic dynamics of the gravitational field.


[1] A. Einstein. Die Feldgleichungen der Gravitation. *Sitzungsber. preuss. Akad. Wiss.* 48 (1915), 2, 844–

847.

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

Several generations of scientists who contributed to the development or popularization of general relativity, like the first of them, David Hilbert [2], Wolfgang Pauli [3], and Arthur Eddington [4], noted the heuristic power of the Einstein's version of equivalence principle and admired the beauty inherent in general relativity. Almost all of them did not doubt, like Vladimir Fock, that Einstein's field equations "represent one of the greatest achievements of human genius" [5] (p. 396).


[2] D. Hilbert. Die Grundlagen der Physik (Erste Mitteilung). *Gott. Nachr.* 1915 (1915), 395 – 407.

[3] W. Pauli. *Relativitätstheorie*. Encyklopiidie der mathematjschen Wissenschaften, Vol. V19. Leipzig, B. G. Teubner (1921).

[4] A. S. Eddington. *The Theory of Relativity and its Influence on Scientific Thought. The Romanes Lecture. 1922.* Oxford: Clarendon Press (1922).

[5] V. Fock. *The Theory of Space, Time, and Gravitation.* London: Pergamon (1964).

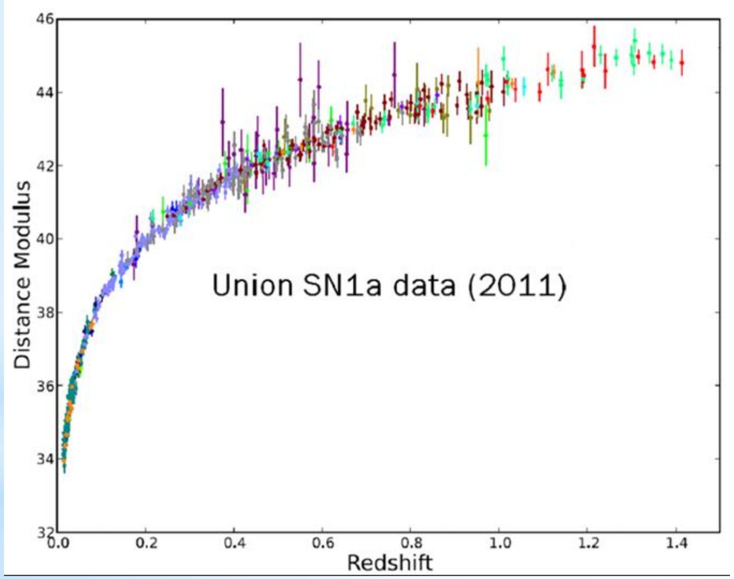
# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

"...a theory with beauty and elegance of Einstein's theory *has* to be substantially correct."

P. A. M. Dirac. The excellence of Einste1n's theory of gravitation. In: *Einstein: the First Hundred Years.* Eds. M. Goldsmith, A. Mackay, & J. Woudhuysen. Pergamon Press (1980). Pp. 41 – 46.

# 1.1 Unanswered cosmological challenge to general relativity

A. Sandage. The change of redshift and apparent luminosity of galaxies due to the deceleration of selected expanding universes. *Ap. J.* 136 (1962), 319 – 333.




A. G. Riess, A. V. Filippenko, P. Challis, *et al.* Observational evidence from supernovae for an accelerating universe and a cosmological constant. *Astron. J.* 116 (1998), 1009 – 1038.

S. Perlmutter, G. Aldering, G. Goldhaber, *et al.* Measurements of $\Omega$ and $\Lambda$ from 42 high-redshift supernovae. *Ap. J.* 517 (1999), 565 – 586.

B. P. Schmidt, N. B. Suntzeff, M. M. Phillips, *et al.* The high-z supernova search: Measuring cosmic deceleration and global curvature of the universe using Type IA supernovae. *Ap. J.* 507 (1998), 46 – 63.

## 1.2 Unresolved problems of general relativity: Troubles with conservation laws

The principal impossibility of a mathematically rigorous formulation of the energy conservation law in general relativity was first noted by David Hilbert as a characteristic feature of this theory right after its advent [29] (pp. 16-17). The proof of Hilbert's conjecture about the failure of this law in the newfound theory was immediately obtained by Emmy Noether in her famous article [30] as a special case along with the loss of other conservation laws in this theory of gravitation.

[29] D. Hilbert. In: *David Hilbert's Lectures on the Foundations of Physics, 1915 – 1927: Relativity, Quantum Theory and Epistemology*. Eds. T. Sauer and U. Majer. Heidelberg, Germany: Springer (2009).

[30] E. Noether. Invariante Variationsprobleme. *Gott. Nachr.* 1918 (1918), 235 – 257; E. Noether. Invariant Variation Problems. *Transp. Theory Statist. Phys.* 1 (1971), 186 – 207.

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

Initially Einstein [1] and then his numerous followers, in particular, [31], [32], [33], [34], [35], [36], based on the derived in [1] field equations of gravitation and using a technique similar to the one developed in electrodynamics, attempted to construct the local form of the equation of conservation of energy-momentum for the gravitational field. But this program proved to be impracticable, as it should be by virtue of the Noether's theorem, so that the solutions to the raised problem that were offered at different times have turned out to be illusory. All these unavoidable failures simply led in another way to a clear understanding of the absence in general relativity of a whole series of fundamental conservation laws, which form an integral part of the special theory of relativity.


[31] L. D. Landau & E. M. Lifshitz. *The Classical theory of fields*. Volume 2 of *Course of Theoretical Physics*. Oxford: Butterworth–Heinemann (1987).

[32] R. C. Tolman. *Relativity, Thermodynamics, and Cosmology*. Oxford: Clarendon Press (1934).

[33] A. Papapetrou. Einstein's theory of gravitation and flat space. *Proc. Roy. Irish. Acad.* 52A (1948), 11–23.

[34] C. Møller.On the localization of the energy of a physical system in general theory of relativity. *Annals of Physics*. 4 (1958), 347 – 371.

[35] C. Møller. Further remarks on the localization of the energy in the general theory of relativity. *Annals of Physics*. 12 (1961), 118 – 133.

[36] A. Trautman. Conservation laws in general relativity. In: *Gravitation: an Introduction to Current Research*. Ed. L.Witten. New York: Wiley (1962). Pp. 169 – 198.

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

We believe unacceptable the erosion of these clear physical concepts even for the sake of the exciting idea that the geometry of space-time in general relativity is not given a priori, but is determined by the distribution of matter, and this fact is considered as a remarkable achievement of this theory in a philosophical sense (for example, see [53] or [3] (p. 149)). We must not forget that on the other side of the scales lies the outstanding achievement of a higher philosophical resonance - this is the emergence of conservation laws from the undistorted symmetry of Minkowskian space-time that is established by Noether's theorem. For this reason we cannot agree with the obviously physically unacceptable assertion that "the conservation of energy and momentum is only approximate" [54] (p. 45) and " "total mass-energy" is a limited concept, useful only when one adopts a limited viewpoint that ignores cosmology" [42] (p. 463).

[42] C. Misner, K. Thorne & J. A. Wheeler. *Gravitation*. San Francisco: Freeman & Co. (1973).
[54] P. A. M Dirac. *General theory of relativity*. New York: Wiley (1975).

Fortunately, the quoted statement, as we shall see, is not a proven scientific truth, but only a point of view of the authors of the book in question, who themselves developed the theory of gravitation very actively. Of course, it was also the point of view of a whole generation of physicists who were quite satisfied with the status quo of energy in the theory of the gravitational field in the happy 1970s-1980s, not yet overshadowed by the upcoming discoveries in astronomy that would be called "dark".

M. SERDYUKOVA
A. SERDYUKOV

In summary, we must recognize that Einstein's generalization of the empirical law of the proportionality of inertial and gravitational masses in the form of strong principle of equivalence is fatal for fundamental special-relativistic laws of conservation for energy, momentum, angular momentum, and center-of-mass motion. Of course, the most appreciable unwanted circumstances for the cosmology based on general relativity arise in connection with the loss of the law of energy conservation. A lot of time and effort, expended by researchers in numerous but invariably unconvincing attempts to solve the problem of the nature of dark energy, convinces us that an understanding of the essence of gravity, where "Anybody who looks for a magic formula for "local gravitational energy-momentum" is looking for the right answer to the wrong question" [42] (p. 467), is a useless toy for repelling the present challenges of observational cosmology.

M. SERDYUKOVA
A. SERDYUKOV

# UNSOLVED PROBLEMS OF GRAVITY:
# POSITIVITY OF ENERGY DENSITY

When searching, instead of a metric one, the really field approach to the problem of gravity, a direct electromagnetic analogy may seem promising for constructing a dynamic theory of the gravitational field, taking into account the obvious similarity between the Coulomb and Newtonian static fields. James Clerk Maxwell was the first to try to construct such a theory, taking advantage of this circumstance.

M. SERDYUKOVA
A. SERDYUKOV

## 1.2 Unsolved problem with gravity: Maxwell principle

Faced with the challenge of negative field energy in his theory adapted to gravity, Maxwell postulates, as an universal physical principle, the positive definiteness of the energy density in general, regardless of its nature: "it is impossible for any part of space to have negative intrinsic energy" (see the end of Part IV in [62]). Maxwell reasoned that one can get rid of troubles by proving that the free space or medium in themselves have a positive energy density, which is able to compensate for the negative energy of any possible gravitational field. But here he is disappointed and forced to retreat, abandoning the attempt to create dynamic theory of gravitational field based on electromagnetic analogy: "As I am unable to understand in what way a medium can posses such properties, I cannot go any further in this direction in searching for the cause of gravitation" [62].

[62] J. C. Maxwell. A dynamical theory of the electromagnetic field. *Phil. Trans. Roy. Soc. Lond.* 155 (1865), 459 – 512 [pp. 492-493]. Reprinted by Vipf and Stock Publishers (1996), Eugene, Oregon [pp. 76-77].

M. SERDYUKOVA
A. SERDYUKOV

## Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

The negative expression

$$W_{\mathrm{f}}^{\mathrm{pseudo}} = -\frac{g^2}{8\pi G_N}$$

is widely known in general relativity as the energy density of static gravitational field in Newtonian approximation. It can de found, for example, in books (list is very far of completeness)


[31] L. D. Landau & E. M. Lifshitz. *The Classical theory of fields*. Volume 2 of *Course of Theoretical Physics*. Oxford: Butterworth–Heinemann (1987).

[43] H. Weyl. *Space, Time and Matter*. New York: Dover (1951). H. Weyl. *Raum - Zeit - Materie. Vorlesungen uber allgemeine Relativitatstheorie*. Berlin: Springer (1970).

[76] N. V. Mitskevich. *The Physical Fields in General Relativity* (in Russian). Moskow: Nauka (1969).

[98] L. Brillouin. *Relativity Reexavined*. New York: Academic Press (1970).

[99] G. ’t Hooft. *Introduction to General Relativity*. Utrecht, Netherlands: Utrecht University (2012).



M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

It should not be inferred from our discussion that the violation of the principle of positive definiteness of the energy density is a sign only of the vector model of gravity. Actually, this is a well-known conceptual challenge of the gravitational interaction facing theoretical physics in general. This unsolved problem has a long history, but it seems that its existence in limbo does not bother anyone today. Having penetrated into cosmology along with gravity, the negative energy density is now not considered as something that can cause a protest, but this illegal phenomenon is even deliberately introduced, for example, together with hypothetical fields with the negative density of the kinetic energy, creating wrong scenarios of the universe evolution and problem of its instability. The absolute profanation of the science of the universe, resulting from the negative energy density of the gravitational field, are, of course, the zero-energy universe and the miracle of the multiple creation of universes from nothing in grandiose vacuum fluctuations [72].

[72] E. P. Tryon. Is the Universe a vacuum fluctuation? *Nature*. 246 (1973), 396–397.

M. SERDYUKOVA
A. SERDYUKOV

# 2 MINIMAL RELATIVISTIC EXTENSION OF NEWTONIAN GRAVITY

## 2.1 Scale-invariance one of the forms of gauge invariance

$$\mathscr{L} = -\frac{c^4}{2\pi G_N}\left(\eta^{\mu\nu}\,\partial_\mu\phi\,\partial_\nu\phi + \varkappa^2\phi^2\right) + \mathscr{L}_{\mathrm{p}}$$

$$\mathscr{L}_{\mathrm{p}} = -c^2\sum_a m_a\sqrt{1-\frac{v_a^2}{c^2}}\,\phi^2\,\delta^{(3)}(\mathbf{r}-\mathbf{r}_a)$$

M. SERDYUKOVA
A. SERDYUKOV

## 2.2 Nordstroem mechanics and spin-0 field equations

$$c^2 \frac{d\left(m\,\phi^2 u^\mu\right)}{ds} = m\,\phi^2 g^\mu$$

$$\left(\Box - \varkappa^2 - \frac{2\pi G_N}{c^2}\vartheta\right)\phi = 0$$

$$c^2 m \frac{du^\mu}{ds} = m\left(g^\mu + u^\mu u_\nu g^\nu\right)$$

$$\vartheta = \sum_a m_a \sqrt{1 - \frac{v_a^2}{c^2}}\;\delta^{(3)}(\mathbf{r} - \mathbf{r}_a)$$

$$g_\mu = -2c^2 \frac{1}{\phi}\partial_\mu \phi$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$g^{\mu} = (Q,\ \mathbf{g})$$

$$\mathbf{g} = -2c^2 \frac{1}{\phi} \nabla \phi$$

$$Q = 2c \frac{1}{\phi} \frac{\partial \phi}{\partial t}$$

$$\frac{d}{dt}\left( \frac{\mathscr{M}\mathbf{v}}{\sqrt{1 - \dfrac{v^2}{c^2}}} \right) = \mathscr{M}\sqrt{1 - \frac{v^2}{c^2}} \cdot \mathbf{g},$$

$$\frac{d}{dt}\left( \frac{\mathscr{M}c^2}{\sqrt{1 - \dfrac{v^2}{c^2}}} \right) = c\mathscr{M}\sqrt{1 - \frac{v^2}{c^2}} \cdot Q,$$

$$\mathscr{M} = m\,\phi^2$$

$$\frac{d}{dt}\left( \frac{m\mathbf{v}}{\sqrt{1 - \dfrac{v^2}{c^2}}} \right) = \frac{m}{\sqrt{1 - \dfrac{v^2}{c^2}}} \left( \mathbf{g} + \frac{1}{c^2}\mathbf{v} \times \mathbf{v} \times \mathbf{g} - \frac{1}{c}\,\mathbf{v}Q \right)$$

$$\frac{d\mathbf{v}}{dt} = \left( 1 - \frac{v^2}{c^2} \right) \left( \mathbf{g} - \frac{1}{c}\mathbf{v}Q \right)$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\left(\Box - \varkappa^2 - \frac{2\pi G_N}{c^2}\vartheta\right)\phi = 0$$

$$\partial_\mu g^\mu = \frac{1}{2c^2} g_\mu g^\mu - 2c^2\varkappa^2 - 4\pi G_N \vartheta$$

$$\partial_\mu g_\nu - \partial_\nu g_\mu = 0$$

$$\nabla \cdot \mathbf{g} = \frac{1}{2c^2}\mathbf{g}^2 - 4\pi G_N \varrho$$

$$\nabla \times \mathbf{g} = 0$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Energy-momentum conservation

$$T^{\mu}_{\ \nu} = \mathscr{L}\delta^{\mu}_{\ \nu} - \frac{\partial \mathscr{L}}{\partial_{\mu}\phi}\partial_{\nu}\phi$$

$$T_{\mu\nu} = \frac{c^4}{\pi G_N}\left(\partial_{\mu}\phi\partial_{\nu}\phi - \frac{1}{2}\left(\partial_{\sigma}\phi\partial^{\sigma}\phi + \varkappa^2\phi^2\right)\eta_{\mu\nu}\right)$$

$$T_{\mu\nu} = \frac{\phi^2}{4\pi G_N}\left(g_{\mu}g_{\nu} - \frac{1}{2}\left(g_{\sigma}g^{\sigma} + 4c^4\varkappa^2\right)\eta_{\mu\nu}\right)$$

$$W = T_{00} = T^{00}$$

$$S_i = -cT_{0i} = cT^{0i}$$

$$G_i = -c^{-1}T_{i0} = c^{-1}T^{i0}$$

$$\sigma_{ij} = T_{ij} = T^{ij}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Energy-momentum conservation

$$W = \frac{\phi^2}{8\pi G_N}\left(\mathbf{g}^2 + Q^2 + 4c^4\varkappa^2\right),$$

$$\mathbf{S} = \frac{c\phi^2}{4\pi G_N} Q\mathbf{g},$$

$$\mathbf{G} = \frac{\phi^2}{4\pi G_N c} Q\mathbf{g},$$

$$\sigma_{ij} = \frac{\phi^2}{4\pi G_N}\left(g_i g_j + Q^2\delta_{ij}\right) - W\delta_{ij}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Energy-momentum conservation

$$\frac{d}{dt}\left(\sum_{(V)} p^{\mu} + \frac{1}{c}\int\limits_{V} T^{\mu 0} dV\right) = -\oint\limits_{\Sigma} T^{\mu i} df_i$$

$$p^{\mu} = cm\phi^2 u^{\mu} = \left(\frac{1}{c}\mathscr{E}, \quad \mathbf{p}\right)$$

$$\mathscr{E} = \frac{c^2 m\phi^2}{\sqrt{1 - \dfrac{v^2}{c^2}}}$$

$$\mathbf{p} = \frac{m\phi^2 \mathbf{v}}{\sqrt{1 - \dfrac{v^2}{c^2}}}$$

$$\mathscr{E} \approx mc^2 + \frac{mv^2}{2} + m\Phi$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Energy-momentum conservation

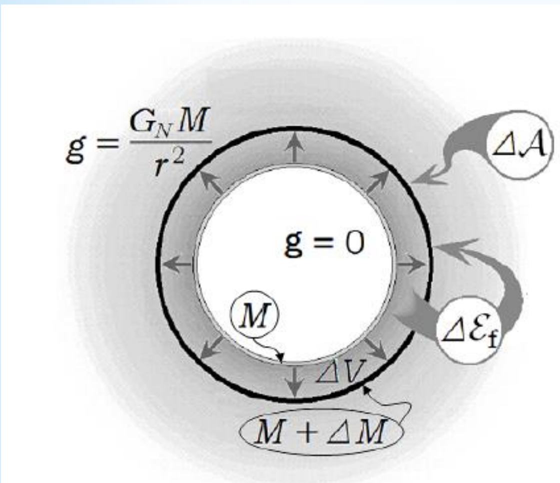
$$\frac{d}{dt}\left[\sum_{(V)}\frac{c^2 m\phi^2}{\sqrt{1-\dfrac{v^2}{c^2}}}+\int_V\frac{\phi^2}{8\pi G_N}\left(\mathbf{g}^2+Q^2+4c^4\varkappa^2\right)dV\right] = -\oint_\Sigma\frac{c\phi^2}{4\pi G_N}Q\mathbf{g}\cdot d\mathbf{f}\,. \qquad (65)$$

$$\mathbf{S}=\frac{c\phi^2}{4\pi G_N}Q\mathbf{g}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Positive energy density of Newtonian field




$$\mathbf{g}(\mathbf{r}) = \begin{cases} 0 & \text{for } 0 \leqslant r < R, \\ -\dfrac{G_N M}{2R^2}\,\hat{\mathbf{r}} & \text{for } r = R, \\ -\dfrac{G_N M}{r^2}\,\hat{\mathbf{r}} & \text{for } r > R, \end{cases}$$

$$\Delta\mathcal{A} + \Delta\mathcal{E}_\mathrm{f} = \Delta\mathcal{E}_\mathrm{p}$$

$$\frac{g^2}{8\pi G_N}\Delta V + W_\mathrm{f} 4\pi R^2 \Delta r = \frac{g^2}{4\pi G_N}\Delta V.$$

$$\boxed{W_\mathrm{f} = \frac{g^2}{8\pi G_N}}$$

$$W_\mathrm{f}^\mathrm{pseudo} = -\frac{g^2}{8\pi G_N}$$

M. SERDYUKOVA
A. SERDYUKOV

M. A. Serdyukova, A. N. Serdyukov

Frantsysk Skaryna State University, Gomel, Belarus

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

M. SERDYUKOVA
A. SERDYUKOV

М. А. Сердюкова, А.Н. Сердюков

Гомельский госуниверситет им. Ф. Скорины, Гомель, Беларусь

# Хаббловский гравитационный фон и циклическая динамика спокойной Вселенной

# 3 CYCLIC DYNAMICS OF GRAVITATING UNIVERSE

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\left( \Box - \varkappa^2 - \frac{2\pi G_N}{c^2} \vartheta \right) \phi = 0$$

$$\vartheta = \sum_a m_a \sqrt{1 - \frac{v_a^2}{c^2}}\, \delta^{(3)}(\mathbf{r} - \mathbf{r}_a) \longrightarrow \Theta = \frac{1}{\mathscr{V}} \sum_{(\mathscr{V})} m \sqrt{1 - \frac{v^2}{c^2}}$$

$$\phi(x) = \psi(t)$$

$$\frac{d^2\psi}{dt^2} + c^2 \varkappa^2 \psi + 2\pi G_N\, \frac{1}{\mathscr{V}} \sum_{(\mathscr{V})} \frac{m}{\sqrt{1 + \dfrac{p^2}{c^2 m^2 \psi^4}}} \psi = 0$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\frac{d^2\psi}{dt^2} + c^2\varkappa^2\psi + 2\pi G_N \,\frac{1}{\mathcal{V}}\sum_{(\mathcal{V})} \frac{m}{\sqrt{1+\dfrac{p^2}{c^2m^2\psi^4}}}\psi = 0$$

$$W_M = \frac{1}{\mathcal{V}}\sum_{(\mathcal{V})} \frac{c^2 m\psi^2}{\sqrt{1-\dfrac{v^2}{c^2}}}$$

$$W_Q = \frac{c^4}{2\pi G_N}\left[\frac{1}{c^2}\left(\frac{d\psi}{dt}\right)^2 + \varkappa^2\psi^2\right]$$

$$\frac{d}{dt}\left(W_M + W_Q\right) = 0$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\Theta = \frac{1}{\mathscr{V}} \sum_{(\mathscr{V})} m \sqrt{1 - \frac{v^2}{c^2}}$$

$$p \ll cm$$

$$\Theta(t) \approx \mu = \mathrm{const}$$

$$\mu = \frac{1}{\mathscr{V}} \sum_{(\mathscr{V})} m$$

$$\left(\Box - \frac{\Omega^2}{c^2}\right)\psi = 0$$

$$\Omega = \sqrt{2\pi G_N \mu + c^2 \varkappa^2}$$

$$T \approx \frac{\pi}{\sqrt{2\pi G_N \mu + \varkappa^2 c^2}}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\left(\Box - \frac{\Omega^2}{c^2}\right)\psi = 0$$

$$\phi(x) = \psi(t)$$

$$g^{\mu} = -2c^2 \frac{1}{\psi} \partial^{\mu} \psi$$

$$\frac{d^2\psi}{dt^2} + \Omega^2 \psi = 0$$

$$\psi(t) = \mathscr{A} \sin \Omega t$$

$$g^{\mu} = (Q, 0, 0, 0)$$

$$Q = 2c \frac{1}{\psi} \frac{d\psi}{dt}$$

$$Q = 2c\Omega \cot \Omega t$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

# Cyclic gravitational background in a quiet universe

$$Q = 2c\Omega \cot \Omega t$$

$$\psi(t) = \mathscr{A} \sin \Omega t$$

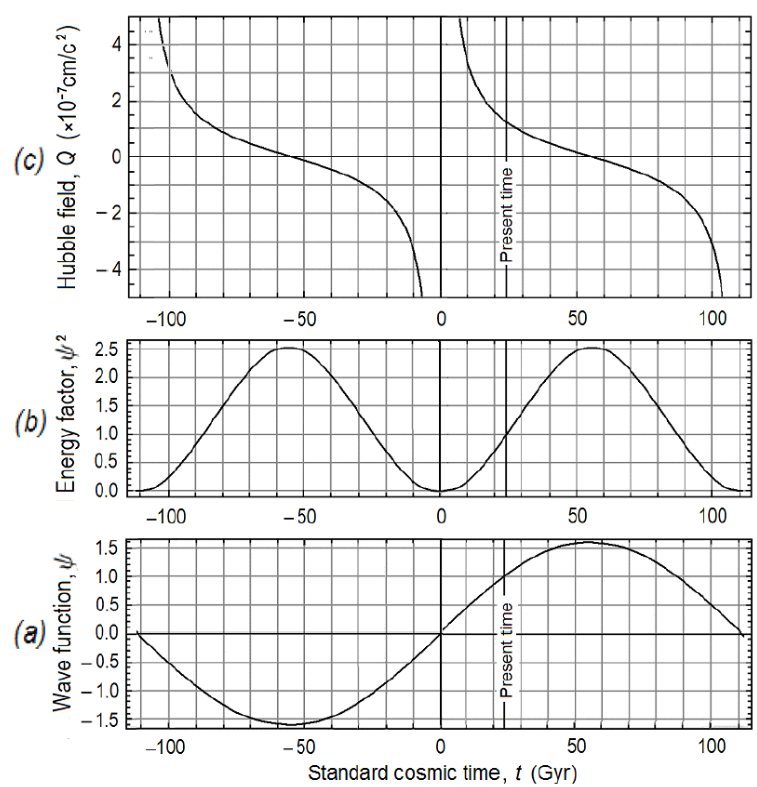
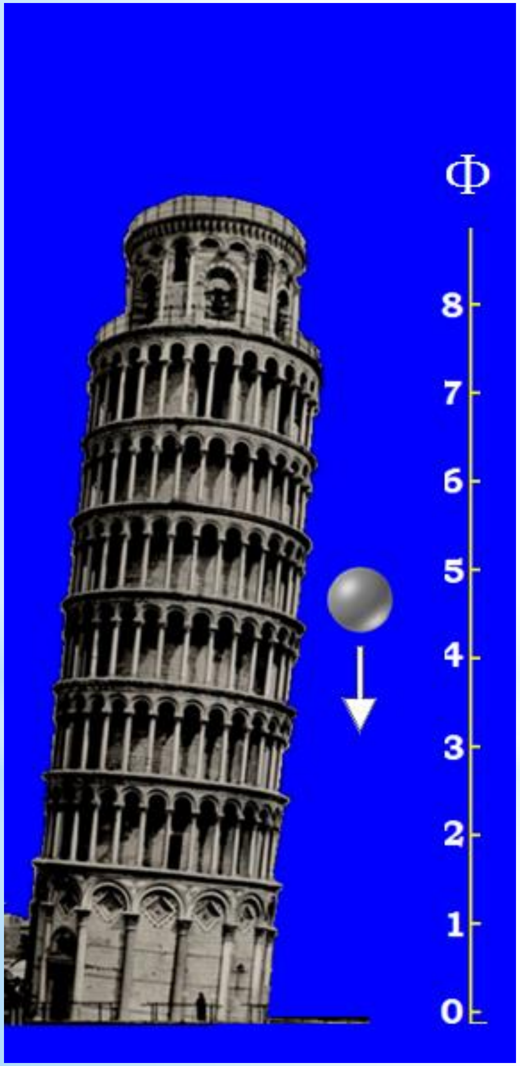



Figure 2: Cyclic evolution of the background gravitational field in the quiet universe: $(a)$ – the logarithmic potential $\psi(t)$, $(b)$ – the energy content factor $\psi^2(t)$, $(c)$ – the scalar strength $Q(t)$.


M. SERDYUKOVA
A. SERDYUKOV

# Gravitational origin of inertial mass

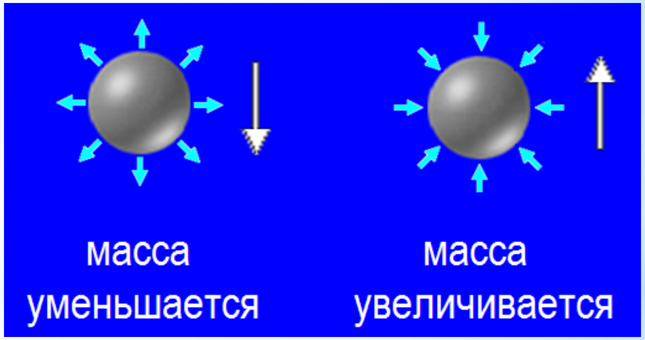



$$g^{\mu}_{\text{ext}} = (0,\ \mathbf{g}_{\text{ext}}) = (0,\ 0,\ 0, -g_{\text{ext}})$$

$$g'^{\mu}_{\text{ext}} = (Q'_{\text{ext}},\ \mathbf{g}'_{\text{ext}}) = \left( \frac{(v/c)g_{\text{ext}}}{\sqrt{1-(v/c)^2}}, 0, 0, \frac{-\,g_{\text{ext}}}{\sqrt{1-(v/c)^2}} \right)$$

$$Q'_{\text{ext}} = \frac{(v/c)g_{\text{ext}}}{\sqrt{1-(v/c)^2}}$$

$$\mathbf{S} = \frac{c\phi'^2_{\text{ext}}}{4\pi G_N} Q'_{\text{ext}} \mathbf{g}$$




$$\mathscr{M} = m\,\phi^2$$

M. SERDYUKOVA
A. SERDYUKOV

## Gravitational origin of inertial mass

## Mach's principle

$$\mathscr{M} = m\,\phi^2$$

$$\phi(x) = \psi(t)$$

$$\psi(t) = \mathscr{A}\,\sin \Omega t$$

$$\mathscr{M} = m\,\mathscr{A}^2 \sin^2 \Omega t$$

$$\psi(t_0) = \mathscr{A}\,\sin \Omega t_0 = 1$$

$$\psi(t) = \frac{\sin \Omega t}{\sin \Omega t_0}$$

$$\mathscr{M}(t) = m\frac{\sin^2 \Omega t}{\sin^2 \Omega t_0}$$

M. SERDYUKOVA
A. SERDYUKOV

## Entropy in cyclic universe

$$\sigma \propto W_M^{3/4}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Gravitational nature of cosmological red-shift

$$\mathscr{E}_n(t) = \mathscr{E}_n^0 \frac{\sin^2 \Omega t}{\sin^2 \Omega t_0}$$

$$\omega_{nm}(t) = \frac{\mathscr{E}_n^0 - \mathscr{E}_m^0}{\hbar} \frac{\sin^2 \Omega t}{\sin^2 \Omega t_0}$$

$$t = t_0 - t_{\mathrm{ret}}$$

$$z = \frac{\omega_{nm}(t_0) - \omega_{nm}(t_0 - t_{\mathrm{ret}})}{\omega_{nm}(t_0 - t_{\mathrm{ret}})}$$

$$1 + z = \frac{\sin^2 \Omega t_0}{\sin^2 \Omega (t_0 - t_{\mathrm{ret}})}$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### 3.1 Gravitational nature of cosmological red-shift

$$1 + z = \frac{\sin^2 \Omega t_0}{\sin^2 \Omega (t_0 - t_{\rm ret})}$$

$z(t_0, t_{\rm ret})$

$t_{\rm ret} \ll t_0$

$$z = \frac{1}{c} H_0 d$$

$t_{\rm ret}/t_0$

$d = c t_{\rm ret}$

$$H(t) = \frac{1}{\psi^2(t)} \frac{d\psi^2(t)}{dt}$$

$$Q = cH$$

$$H_0 = 2\Omega \cot \Omega t_0$$

$$g_\mu = \left(\mathbf{g},\ cH_0\right)$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### The history of the cosmological shift of atomic spectra

$$H_0 = 2\Omega \cot \Omega t_0$$

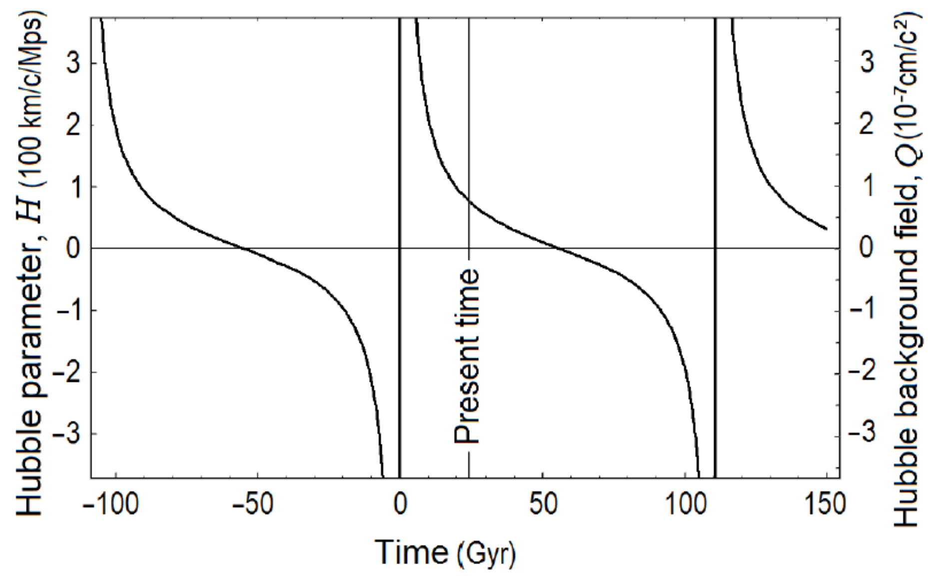



Figure 3: Cyclic evolution of background Hubble field


M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### The history of the cosmological shift of atomic spectra

$$z(t_{\text{obs}}, t_{\text{ret}}) = \frac{\sin^2 \Omega t_{\text{obs}}}{\sin^2 \Omega\big(t_{\text{obs}} - t_{\text{ret}}\big)} - 1$$

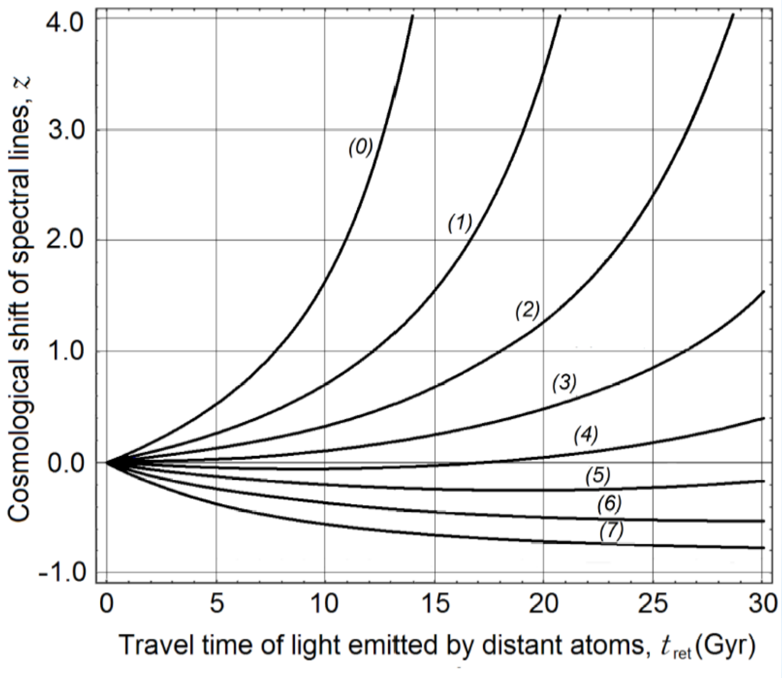



Figure 4: Parameter $z$ of cosmological shift of spectral lines versus light travel time $t_{\text{ret}}$ from distant motionless sources at different epochs of observation.


M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## The history of the cosmological shift of atomic spectra

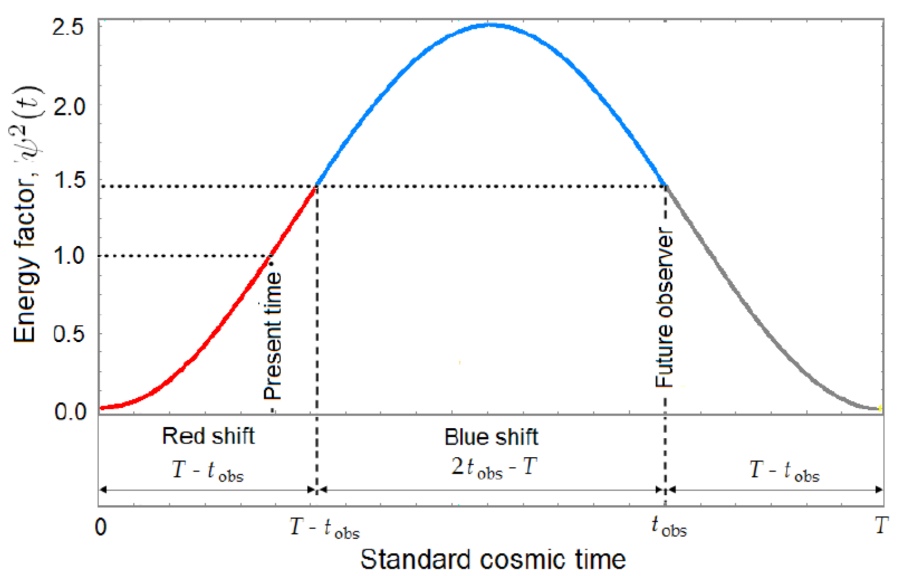



Figure 5: A schematic illustration of two time intervals $0 < t < T - t_{\rm obs}$ and $T - t_{\rm obs} < t < t_{\rm obs}$ in the evolutionary cycle that differ in the red and blue shifts of atomic spectra in comparison with the spectra of similar atoms at time of observation, $t_{\rm obs}$, in the second half of the cyclic epoch.


M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Massive long-range gravity

$$\left\{\Box - \varkappa^2 - \frac{2\pi G_N}{c^2}\left[\Theta(t) \; + \varrho(\mathbf{r})\right]\right\}\phi(\mathbf{r},t) = 0$$

$$\phi(\mathbf{r},t) = U(\mathbf{r})\,\psi(t)$$

$$\frac{c^2}{U}\nabla^2 U - 2\pi G_N\,\varrho = \frac{1}{\psi}\frac{d^2\psi}{dt^2} + \frac{2\pi G_N}{c^2}\Theta + c^2\varkappa^2$$

$$\lim_{r\to\infty} U(\mathbf{r}) = 1$$

$$U(r) = \frac{r - r_0}{r}$$

$$\mathbf{g}(\mathbf{r}) = -2c^2\frac{\nabla U}{U}$$

$$\mathbf{g}(\mathbf{r}) = -\frac{2c^2 r_0}{r\,(r - r_0)}\hat{\mathbf{r}}$$

$$r_0 = \frac{G_N}{2c^2}M_0$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Massive long-range gravity

$$\mathbf{g}(\mathbf{r}) = -\frac{G_N M_0}{r\left(r - \dfrac{G_N M_0}{2c^2}\right)}\hat{\mathbf{r}}$$

$$M_0 = \frac{1}{c^2}\int\left(\varrho c^2 + \frac{1}{8\pi G_N}\mathbf{g}^2\right)U^2\,dV$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Evolution of the gravitational constant

$$M = \frac{1}{c^2} \int \left( c^2 \varrho + \frac{1}{8\pi G_N} \mathbf{g}^2 \right) \phi^2 dV$$

$$\phi(\mathbf{r}, t) = U(\mathbf{r})\, \psi(t)$$

$$M_0 = \frac{1}{c^2} \int \left( \varrho c^2 + \frac{1}{8\pi G_N} \mathbf{g}^2 \right) U^2 dV.$$

$$M = \psi^2 M_0$$

$$M = \frac{1}{1+z} M_0$$

$$M(t) = M_0 \frac{\sin^2 \Omega t}{\sin^2 \Omega t_0}$$

$$G(t) M(t) = G_N M_0$$

$$G = (1+z)\, G_N$$

$$G(t) = G_N \frac{\sin^2 \Omega t_0}{\sin^2 \Omega t}$$

$$\mathbf{g}(\mathbf{r}) = - \frac{G_N M_0}{r \left( r - \frac{G_N M_0}{2c^2} \right)} \hat{\mathbf{r}}$$

$$\mathbf{g}(\mathbf{r}) = - \frac{GM}{r^2 \left( 1 - \frac{GM}{2c^2 r} \right)} \hat{\mathbf{r}}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Evolution of the gravitational constant

$$G(t_{\mathrm{ret}}) = G_N \frac{\sin^2 \Omega t_0}{\sin^2 \Omega (t_0 - t_{\mathrm{ret}})}$$

$$\frac{\dot{G}}{G} = -H$$

$$\left(\frac{\dot{G}}{G}\right)_0 = -7 \cdot 10^{-11} \mathrm{yr}^{-1}$$

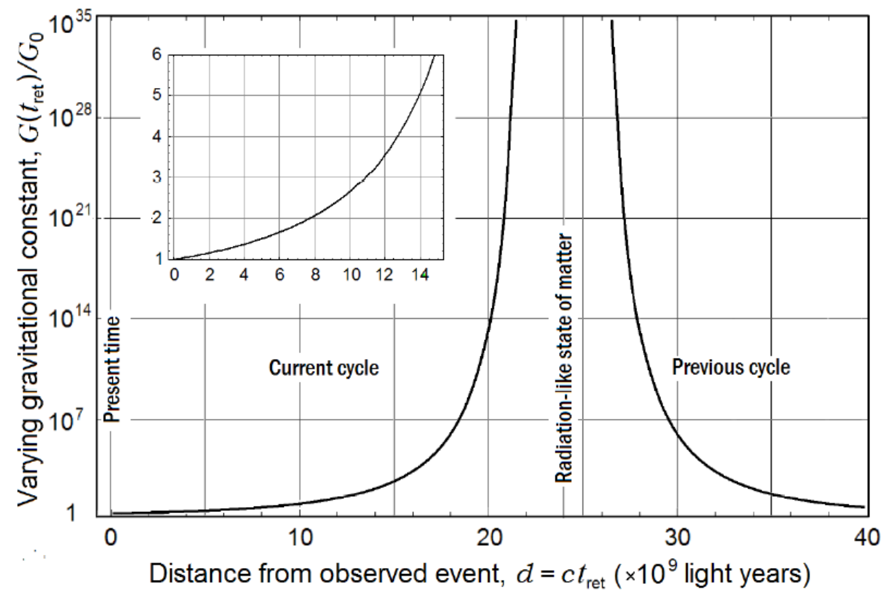



Figure 6: The history of variable gravitational constant in retrospect as we observe more and more distant objects in the universe.


M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### Evolution of the gravitational constant

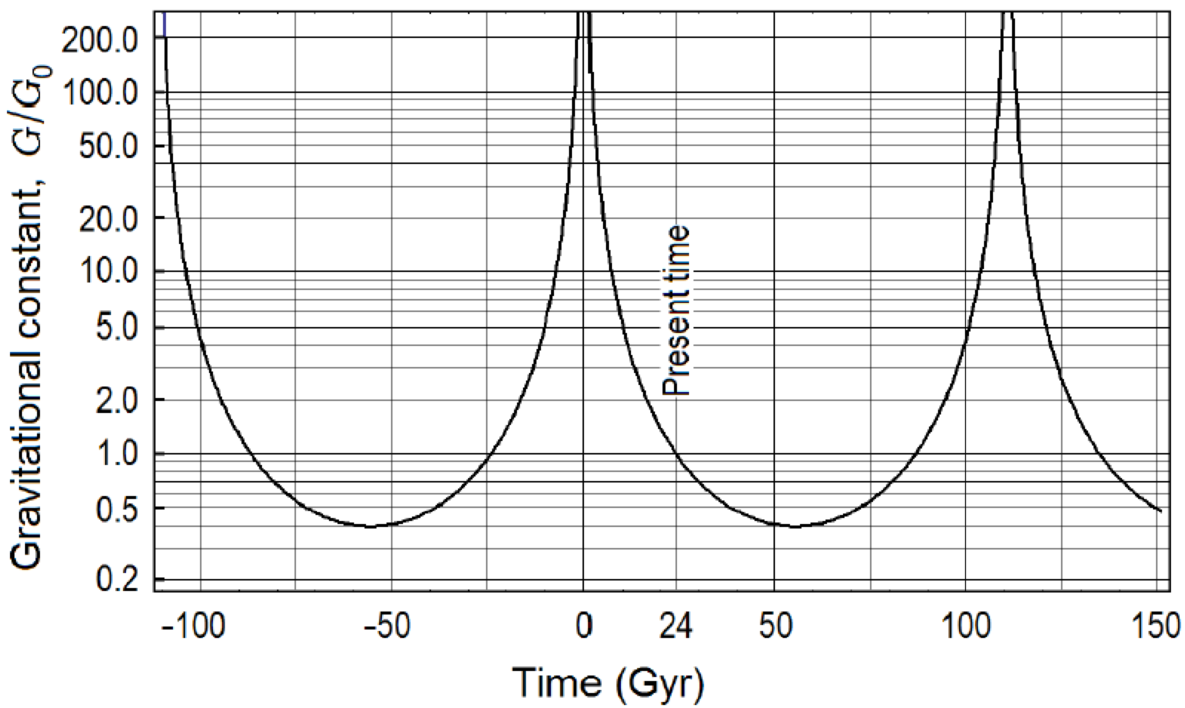



Figure 7: Cyclic evolution of the parameter of gravitational coupling $G(t)$.

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

**The evolution of Chandrasekhar's and Oppenheimer–Volkoff limiting masses**

$^{56}\mathrm{Ni}$ by fusion $^{12}\mathrm{C}$ and $^{16}\mathrm{O}$

$$^{56}\mathrm{Ni} \to {}^{56}\mathrm{Co} \to {}^{56}\mathrm{Fe}$$

$$\mathfrak{M}_0^{\mathrm{Ch}} = 1.43\, M_\odot = 2.84 \times 10^{30}\mathrm{kg}.$$

$$\mathfrak{M}^{\mathrm{Ch}}(t) = \frac{\sin^2 \Omega t}{\sin^2 \Omega t_0} \mathfrak{M}_0^{\mathrm{Ch}}$$

$$\mathfrak{M}^{\mathrm{Ch}}(z) = \frac{1}{1+z} \mathfrak{M}_0^{\mathrm{Ch}}$$

$$\mathfrak{N}^{\mathrm{Ch}} = \mathrm{const}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Cosmological law of radioactive decay

$$\Delta\tau \cdot \Delta\mathscr{E} \sim \hbar$$

$$\Delta\tau(t)\sin^2 \Omega t = \mathrm{const}$$

$$\lambda(t) = \Lambda \sin^2 \Omega t$$

$$\Lambda = \frac{\lambda_0}{\sin^2 \Omega t_0} = \frac{\ln 2}{T_0^{1/2} \sin^2 \Omega t_0}$$

$$T^{1/2}(t) = T_0^{1/2} \frac{\sin^2 \Omega t_0}{\sin^2 \Omega t}$$

$$\frac{\dot{T}^{1/2}}{T^{1/2}} = -H$$

$$\left(\frac{\dot{T}^{1/2}}{T^{1/2}}\right)_0 = -7 \cdot 10^{-11}\,\mathrm{yr}^{-1}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Cosmological law of radioactive decay

$$T^{1/2}(t_{ret}) = T_0^{1/2} \frac{\sin^2 \Omega t_0}{\sin^2 \Omega (t_0 - t_{ret})}$$

$$T^{1/2}(z) = (1+z)\, T_0^{1/2}$$

$$dN = -\Lambda \sin^2 \Omega t \, N(t)\, dt$$

$$\frac{N(t)}{N_{\mathrm{ref}}} = \exp\left\{ \frac{-\ln 2}{2\, T_0^{1/2} \sin^2 \Omega t_0} \left[ t - \frac{\sin 2\Omega(t_{\mathrm{ref}} + t) - \sin 2\Omega t_{\mathrm{ref}}}{2\Omega} \right] \right\}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Cosmological law of radioactive decay

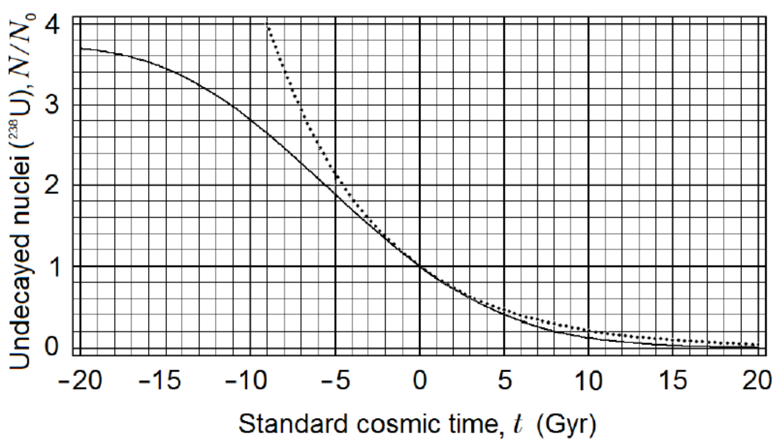



Figure 9: The expected accelerated decay of $^{238}$U in the first half of evolutionary cycle in relation to the current era ($t_{\rm ref} = t_0$) in comparison with that predicted by the customary decay law (176) (dotted line).

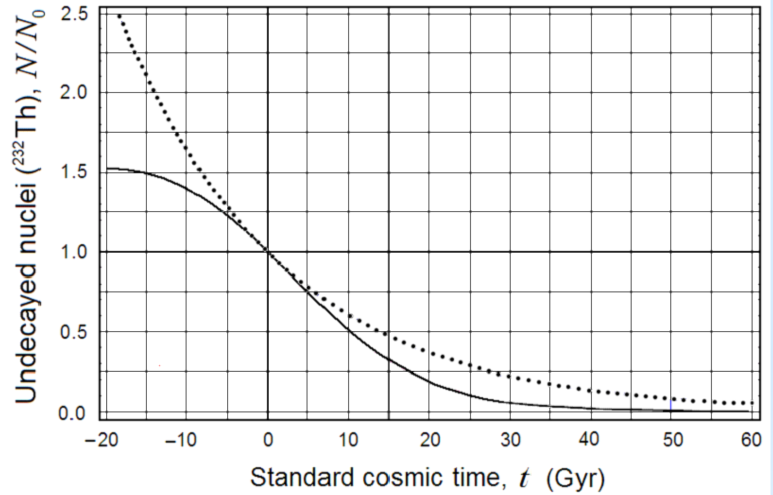



Figure 10: The decay of long-lived $^{232}$Th nuclei with time-dependent lifetime (solid curve) in comparison with the generally accepted decay law (dotted line).

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### Primary nucleosynthesis

$$\frac{N(t)}{N(0)} = \exp\left[\frac{-\ln 2}{2\,T_0^{1/2}\sin^2\Omega t_0}\left(t-\frac{\sin 2\Omega t}{2\Omega}\right)\right]$$

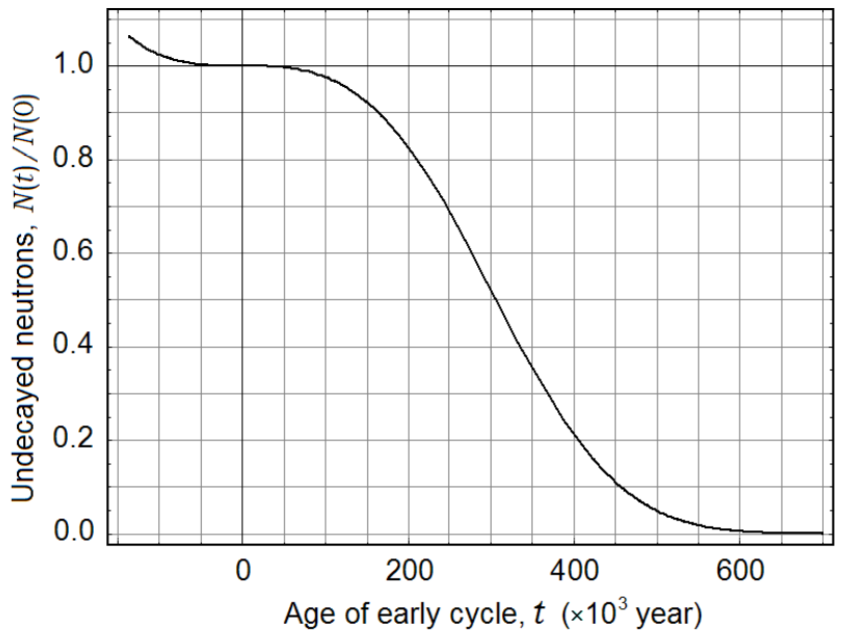



Figure 11: The decay of primordial neutrons at the junction of two cyclic epochs.


M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

### Absence of cosmological time dilation

| **Physical process** | **Rate** | |
|---|---|---|
| | First half-cycle | Second half-cycle |
| Free movement of massive particle | slowed from $c$ at $t=0$ | accelerated up to $c$ |
| Free rotation | slowed | accelerated |
| Orbital revolution | accelerated | slowed |
| Atomic clock | accelerated | slowed |
| Radioactive decay | accelerated | slowed |
| Light clock | synchronous | |
| Weight clock | synchronous | |
| Hourglass | synchronous | |

M. SERDYUKOVA
A. SERDYUKOV

# Cosmological testing the theory

## Redshift as a distance indicator

$$d(z) = \frac{2c\cot \Omega t_0}{H_0}\left(\Omega t_0 - \arcsin\frac{\sin \Omega t_0}{\sqrt{1+z}}\right)$$

$$d(z) = 35.27\left(0.68 - \arcsin\frac{\sin 0.68}{\sqrt{1+z}}\right)\cdot 10^9 \text{ light years}$$

$$d(z) = 35.27\left(0.68 + \arcsin\frac{\sin 0.68}{\sqrt{1+z}}\right)\cdot 10^9 \text{ light years.}$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$d(z) = \frac{2c\cot \Omega t_0}{H_0}\left(\Omega t_0 - \arcsin \frac{\sin \Omega t_0}{\sqrt{1+z}}\right)$$

$$T_1^{1/2} = (1+z)T_0^{1/2}$$

$$d_L(z) = \frac{2c(1+z)\cot \Omega t_0}{H_0}\left(\Omega t_0 - \arcsin \frac{\Omega t_0}{\sqrt{1+z}}\right)$$

M. SERDYUKOVA
A. SERDYUKOV

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

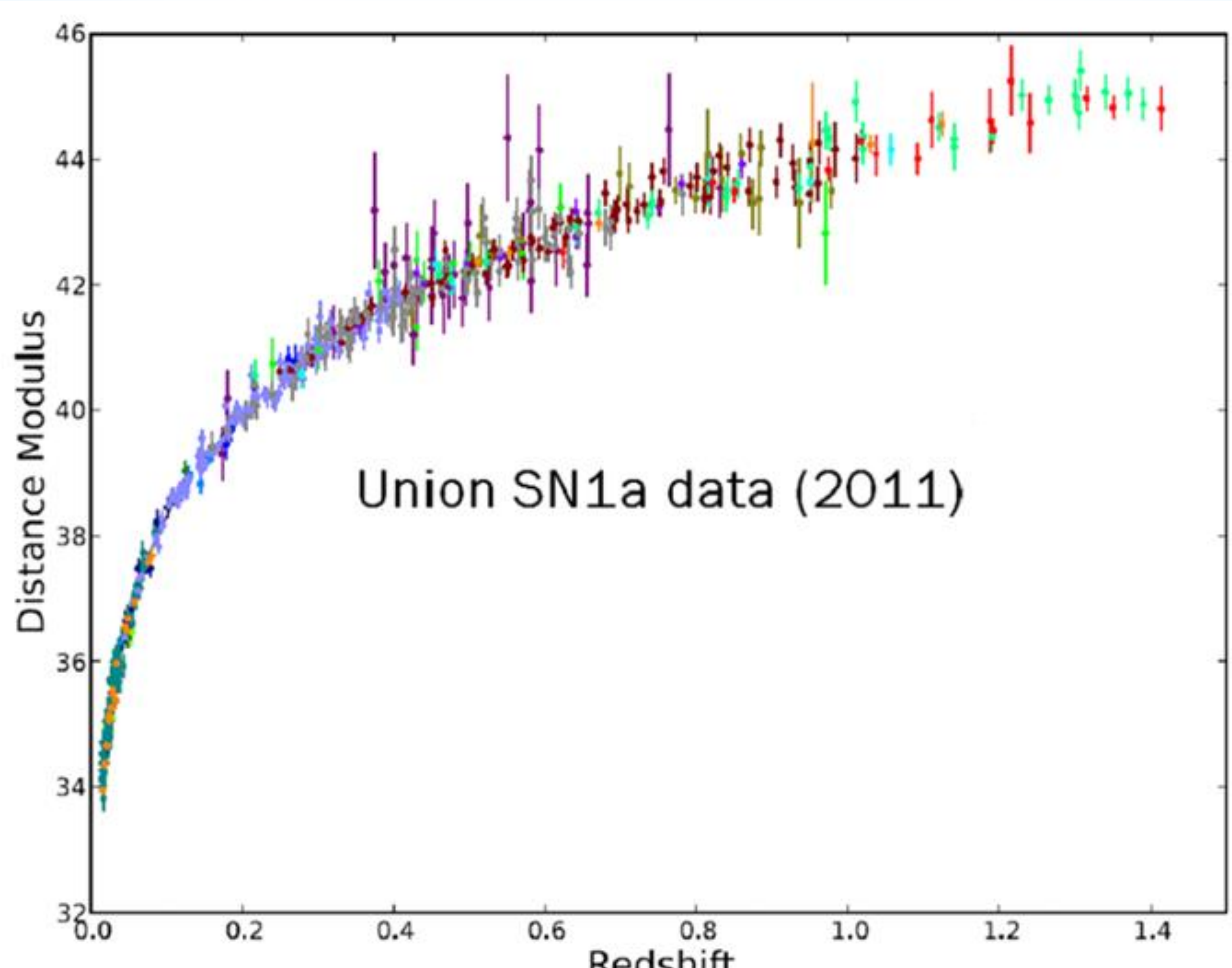
### Testing the model by SNe Ia data

$$\mu_{bol}(z) = 5\log_{10}\left[\frac{2c(1+z)\cot\Omega t_0}{10\text{pk}\cdot H_0}\left(\Omega t_0 - \arcsin\frac{\Omega t_0}{\sqrt{1+z}}\right)\right]$$

$$K = 2.5\log_{10}(1+z)$$

$$\mu_B(z) = 25 + 5\log_{10}\left[\frac{2c(1+z)^{\frac{3}{2}}\cot\Omega t_0}{\text{Mpk}\cdot H_0}\left(\Omega t_0 - \arcsin\frac{\Omega t_0}{\sqrt{1+z}}\right)\right]$$

M. SERDYUKOVA
A. SERDYUKOV




M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

$$\mu_B(z) = 25 + 5\log_{10}\left[\frac{2c(1+z)^{\frac{3}{2}}\cot \varOmega t_0}{\mathrm{Mpk}\cdot H_0}\left(\varOmega t_0 - \arcsin\frac{\varOmega t_0}{\sqrt{1+z}}\right)\right]$$

$$H_0 \simeq 68\,\mathrm{km\,s^{-1}Mps^{-1}}$$

$$\varOmega t_0 \simeq 0.68.$$

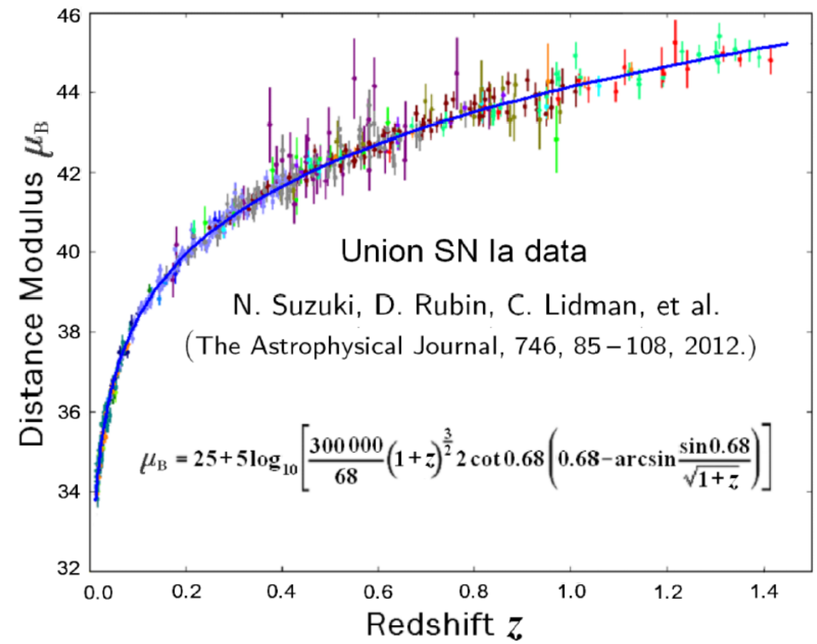
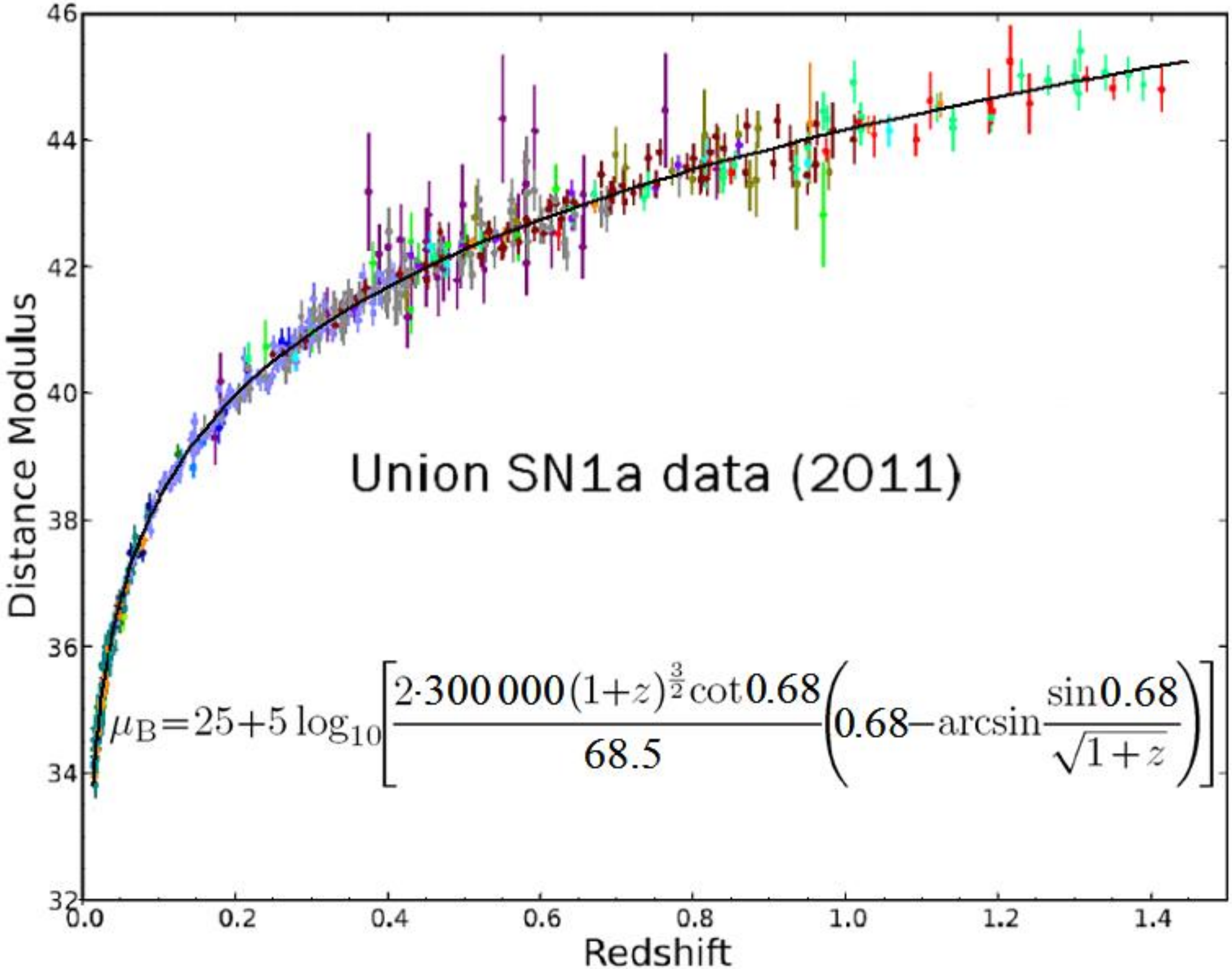



Figure 17: The curve represents the theoretical prediction of redshift-luminosity relation (206) for distant SNe Ia with Hubble parameter $H_0 = 68\ \mathrm{km\,s^{-1}Mpc^{-1}}$ and present value of the phase parameter $\varOmega t_0 = 0.68$.


M. SERDYUKOVA
A. SERDYUKOV

# The Hubble diagram




M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

## Basic parameters of the universe

*Table 3.* **The present values of basic cosmological parameters of cyclic non-expanding universe compatible with observational data from SNe Ia**

| Cosmological parameters | Present values |
|---|---|
| Hubble parameter, $H_0$ | $68\ \dfrac{\mathrm{km}}{\mathrm{s\,Mpc}}$ |
| Background Hubble field, $Q_0 = cH_0$ | $6.7 \cdot 10^{-8}\ \dfrac{\mathrm{cm}}{\mathrm{s}^2}$ |
| Total energy density | $5.0 \cdot 10^{-30}\ \dfrac{\mathrm{g}}{\mathrm{cm}^3}$ |
| Density of gravitating matter | $2.0 \cdot 10^{-30}\ \dfrac{\mathrm{g}}{\mathrm{cm}^3}$ |
| Density of Hubble field (dark) energy | $3.0 \cdot 10^{-30}\ \dfrac{\mathrm{g}}{\mathrm{cm}^3}$ |
| Nominal mass of graviton, $m_g$ | $\leqslant 1.5 \cdot 10^{-33}\ \mathrm{e\,V}$ |
| Cycle duration, $T$ | 110 Gyr |
| Age of present cycle, $t_0$ | 24 Gyr |
| Rate of $G$ decrease, $\dot{G}/G$ | $-7.1 \cdot 10^{-11}\ \mathrm{yr}^{-1}$ |
| Rate of growth of rest energy, $\dot{\mathscr{E}}/\mathscr{M}$ | $0.2\ \dfrac{\mathrm{W}}{\mathrm{kg}}$ |
| Dark energy flux to the earth | $2.35 \cdot 10^{9}\ \dfrac{\mathrm{W}}{\mathrm{m}^2}$ |

M. SERDYUKOVA
A. SERDYUKOV

**Drift in the atomic clocks and Pioneer 10/11, Galileo, and Ulysses anomaly.**

C. L¨ammerzahl, O. Preuss & H. Dittus. *Is the physics within the Solar system really understood? : Lasers, Clocks and Drag-Free Control: Exploration of Relativistic Gravity in Space.* Eds: H. Dittus

Cite from (Section 6.4.2): "A number of models were investigated and discarded for various reasons (see [18] for discussion), but there was one model that was especially interesting. This model adds a term that is quadratic in time to the light time, as seen by the DSN station as

$$t \to t + \frac{1}{2} a_t t^2 ."$$

## Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

**Drift in the atomic clocks and Pioneer 10/11, Galileo, and Ulysses anomaly.**

"A quadratic drift

$$t \to t + \frac{1}{2c} a_{\mathrm{P}} t^2$$

of the timekeeping of clocks on the Earth can simulate Pioneer anomaly."

"Though a drift of clocks by itself is a nonconventional physics"

$$a_{\mathrm{Pioneer}} \sim cH_0$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe

**Drift in the atomic clocks and Pioneer 10/11, Galileo, and Ulysses anomaly.**

$$d\tau = \frac{\sin^2 \Omega(t_0 + t)}{\sin^2 \Omega t_0}\, dt$$

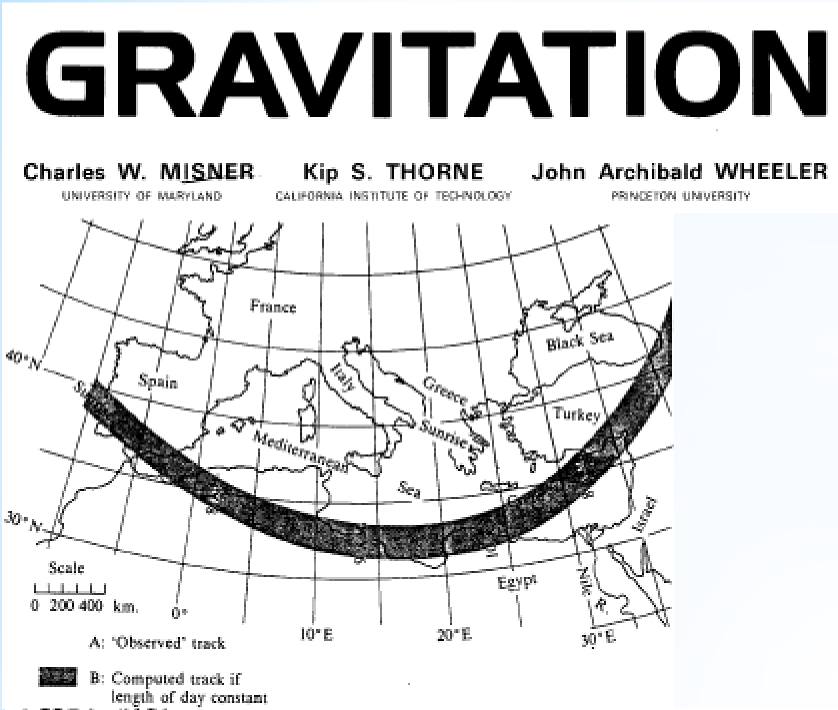
$$\tau = \frac{1}{2\sin^2 \Omega t_0}\left(t - \frac{\sin 2\Omega(t_0 + t) - \sin 2\Omega t_0}{2\Omega}\right)$$

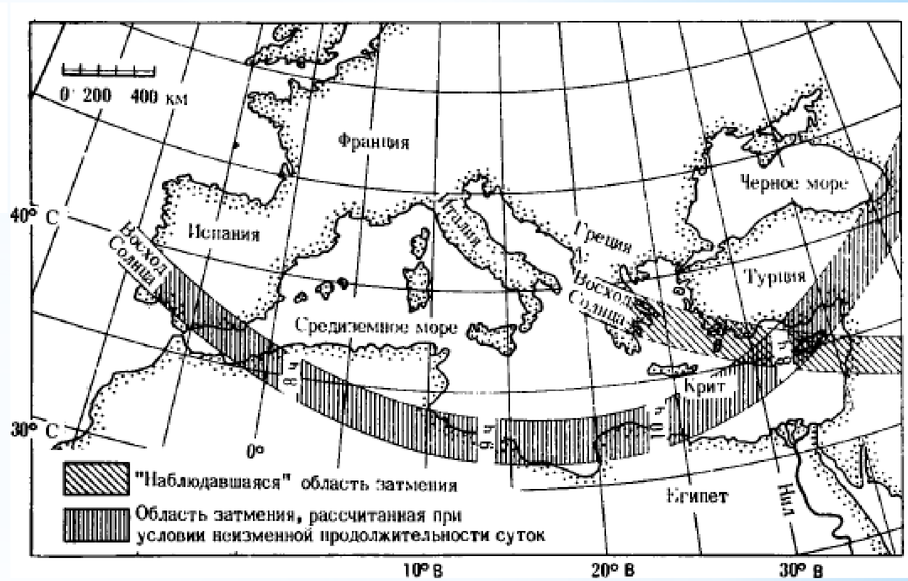
$$\tau = t + t^2 \Omega \cot \Omega t_0 + \ldots$$

$$\tau \approx t + \frac{1}{2} H_0 t^2$$

M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe



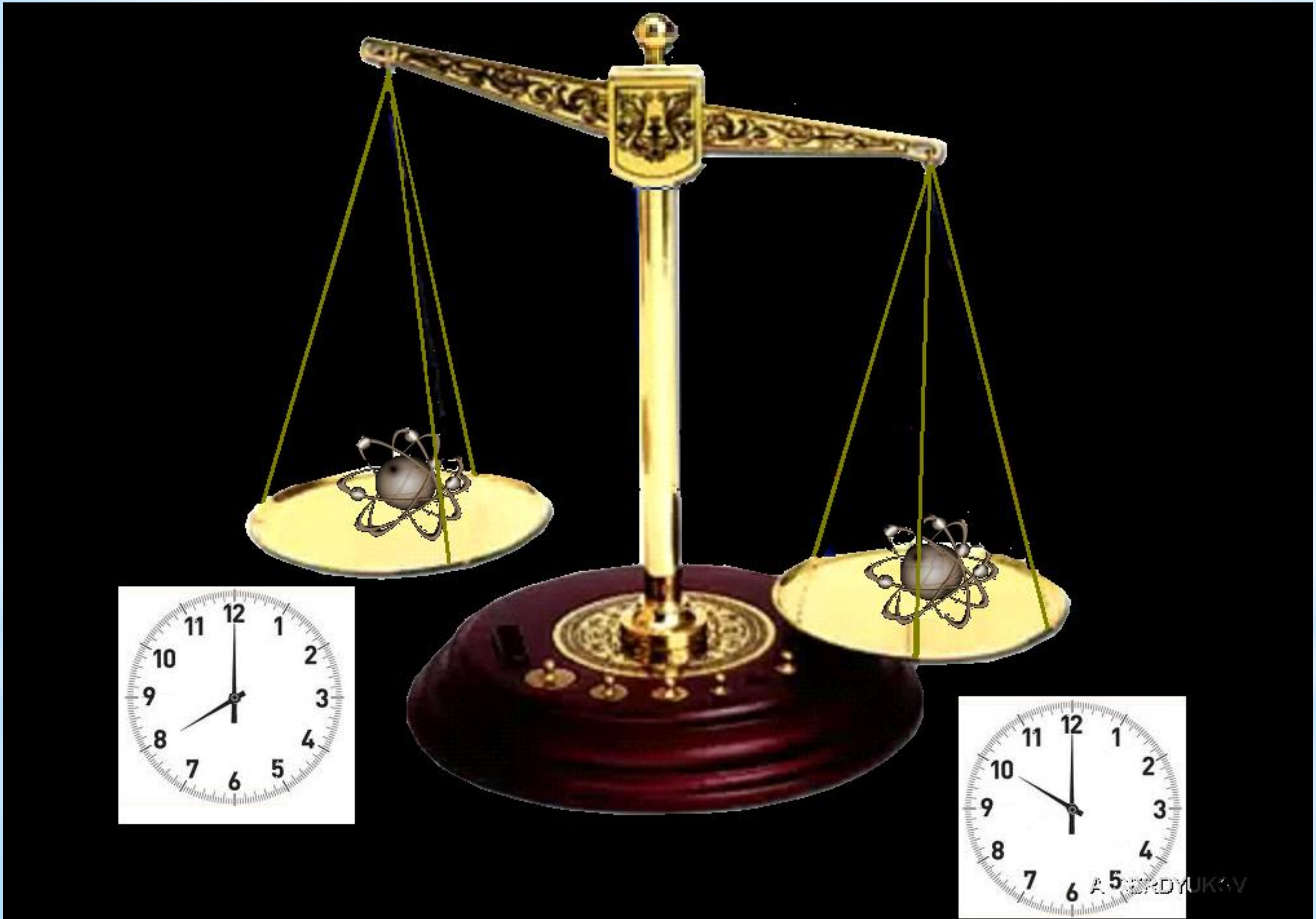

Рассчитанная область полного солнечного затмения 14 января 484 г. н. э. (слева; в расчетах не учтено замедление вращения Земли вокруг своей оси, угловая скорость вращения принята равной тому значению, которое она имела в 1900 г.) сравнивается с той же областью, смещенной настолько, чтобы Афины попали в центр затмения (при восходе Солнца) [величина смещения очень близка к 30°; при расчетах было принято, что скорость замедления составляет 32,75 угловой секунды/(столетие)$^2$]. Это «несомненно, наиболее достоверное из всех затмений в древности на территории Европы», согласно д-ру Стефенсону из Отделения геофизики и физики планет Университета в Ньюкасле-на-Тайне, любезно подготовившему этот рисунок специально для нашей книги. Он прислал также отрывок из первой греческой биографии Прокла из Афин (умер в Афинах в 485 г. н. э.), написанной Маринусом из Неаполя, в котором говорится: «Не обошлось и без предзнаменований в год, предшествовавший его смерти; например, наблюдалось такое сильное затмение Солнца, что казалось, будто ночь спустилась среди дня. Ибо наступила глубокая темнота и даже звезды появились на небе. Это случилось в восточной части неба, когда Солнце находилось в созвездии Козерога» (из книги [54]).

M. SERDYUKOVA
A. SERDYUKOV

# СПАСИБО
# ЗА
# ВНИМАНИЕ!

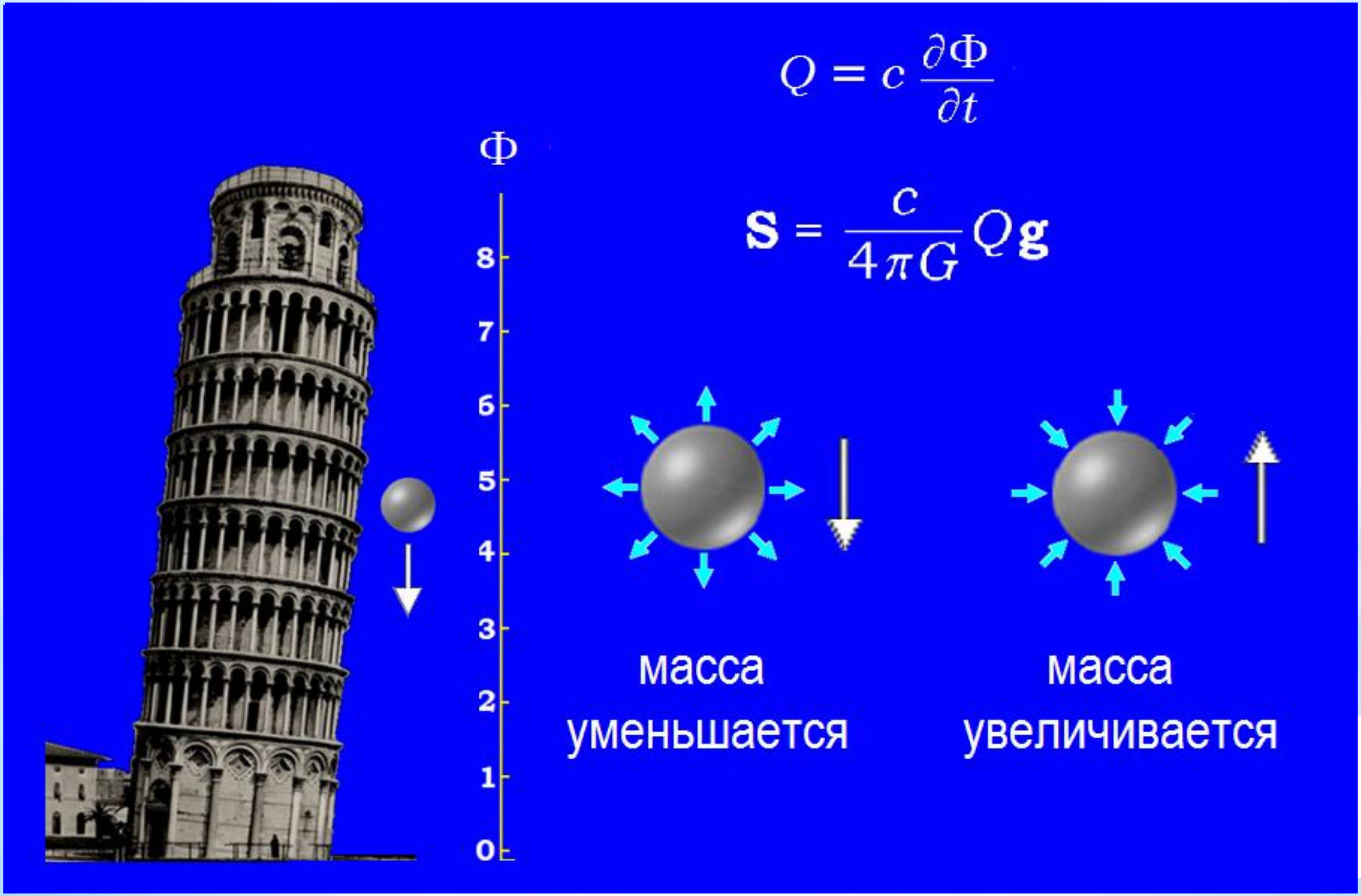
M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe




M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe




M. SERDYUKOVA
A. SERDYUKOV

# 4 Gravitational interaction in electrodynamics

Gravitational coupling to the charge

$$\mathscr{L}_M = -c^2 m \phi^2 \sqrt{1 - \frac{v^2}{c^2}}\, \delta\big(\mathbf{r} - \mathbf{r}(t)\big)$$

$$\mathscr{L}_{\mathrm{g}} = -\frac{c^4}{2\pi G_N} \left(\eta^{\mu\nu} \partial_\mu \phi \partial_\nu \phi + \varkappa^2 \phi^2\right)$$

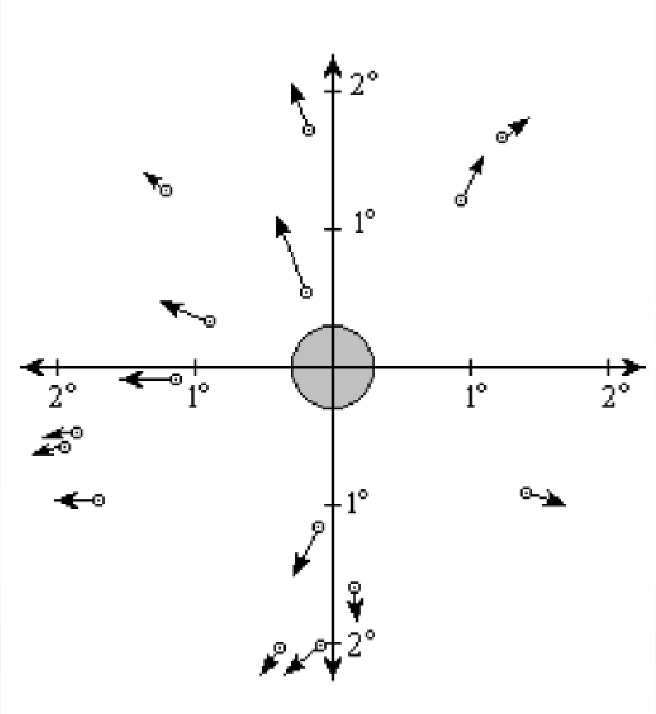
$$\mathscr{L}_{\mathrm{em}} = -\frac{1}{16\pi\epsilon} \left(\partial_\mu A_\nu - \partial_\nu A_\mu\right)^2$$

$$\mathscr{L}_{\mathrm{int}} = \frac{1}{c} \phi j_\mu A_\mu$$

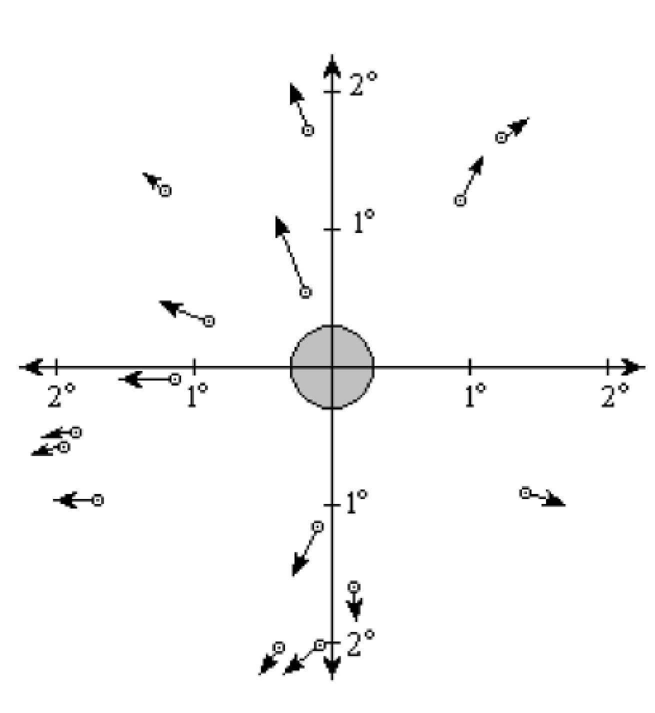
Cyclic particle–antiparticle symmetry

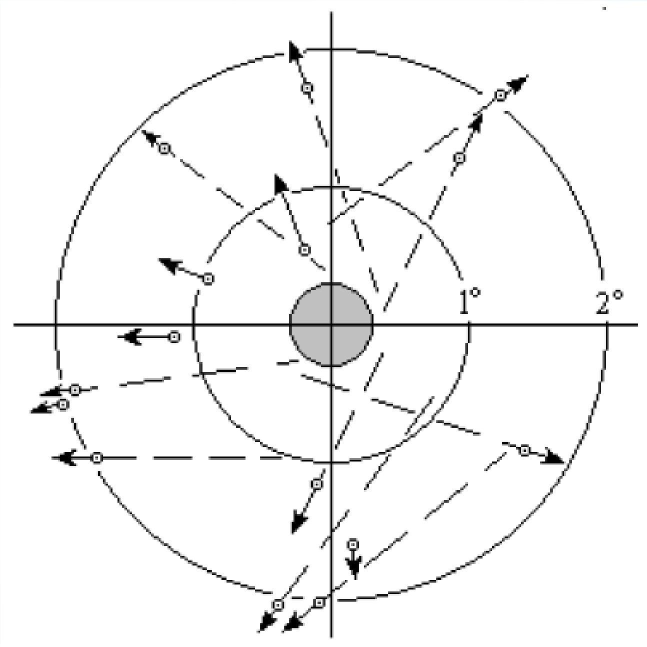
M. SERDYUKOVA
A. SERDYUKOV

# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe




# Hubble's Gravitational Background and the Cyclic Dynamics of a Quiet Universe




M. SERDYUKOVA
A. SERDYUKOV

# Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

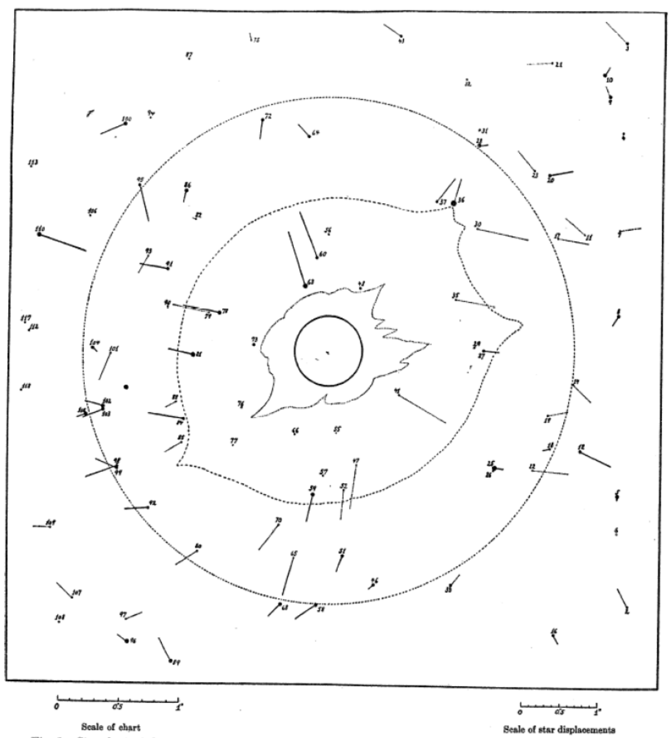
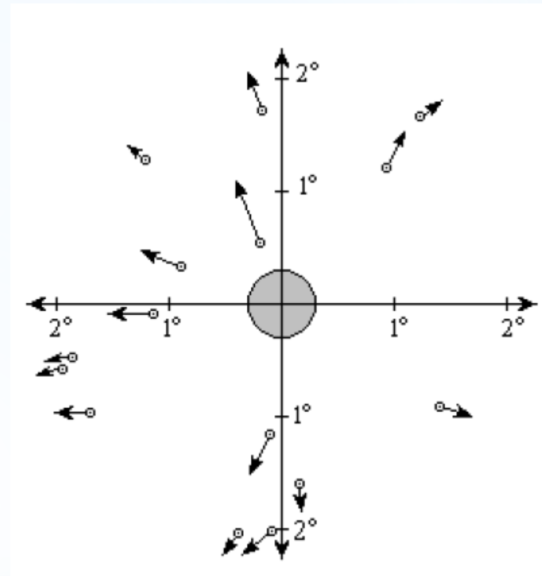



Fig. 1. Star chart of the total solar eclipse of Sept. 21, 1922, containing the 92 stars actually measured. The observed relative displacements are marked by a full line for weights 2.0 to 3.9, by a dotted line for weights 1.0 to 2.0, displacements of smaller weight are omitted. The dotted circle is of 2° radius and gives the inner limit of the reference stars, for which the average displacement has been made zero. The outline of the brighter parts of the corona as well as the limit of the faintest traces of coronal light is drawn in. The border line represents the edge of the plate.

Figure 13: The observed shifts in the arrangement of stars at the total solar eclipse in 1922, measured by astronomers of the Lick Observatory (according to [185]).





M. SERDYUKOVA
A. SERDYUKOV

# Hubble’s Gravitational Background and the Cyclic Dynamics of a Quiet Universe

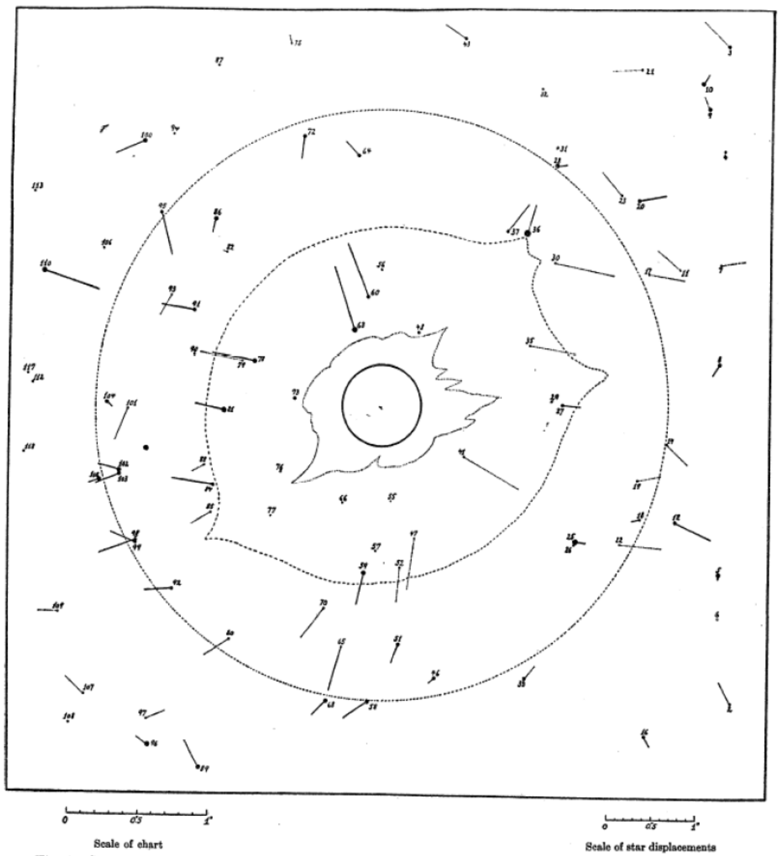



Fig. 1. Star chart of the total solar eclipse of Sept. 21, 1922, containing the 92 stars actually measured. The observed relative displacements are marked by a full line for weights 2.0 to 3.9, by a dotted line for weights 1.0 to 2.0, displacements of smaller weight are omitted. The dotted circle is of 2° radius and gives the inner limit of the reference stars, for which the average displacement has been made zero. The outline of the brighter parts of the corona as well as the limit of the faintest traces of coronal light is drawn in. The border line represents the edge of the plate.

Figure 13: The observed shifts in the arrangement of stars at the total solar eclipse in 1922, measured by astronomers of the Lick Observatory (according to [185]).

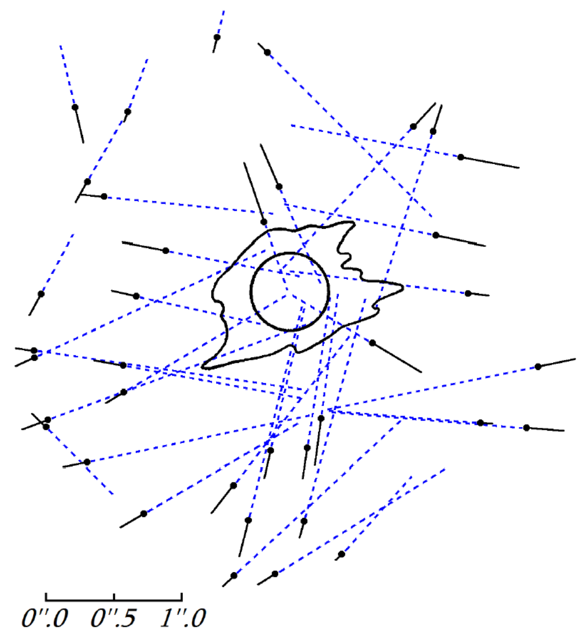



Figure 14: The observed shifts in the arrangement of stars at the total solar eclipse in 1922, measured by astronomers of the Lick Observatory (according to [183]).


M. SERDYUKOVA
A. SERDYUKOV

## 3.6 Cosmological law of radioactive decay

The curves labeled by *(-1)*, *(-5)*, *(-10)*, and *(1)*, *(5)*, *(10)* correspond to the values of reference time $t_{\rm ref}$ equal to $t_0 - 1\,{\rm Gyr} = 23\,{\rm Gyr}$, $t_0 - 5\,{\rm Gyr} = 19\,{\rm Gyr}$, $t_0 - 10\,{\rm Gyr} = 14\,{\rm Gyr}$ and $t_0 + 1\,{\rm Gyr} = 25\,{\rm Gyr}$, $t_0 + 5\,{\rm Gyr} = 29\,{\rm Gyr}$, $t_0 + 10\,{\rm Gyr} = 34\,{\rm Gyr}$ taken in the same sequence.

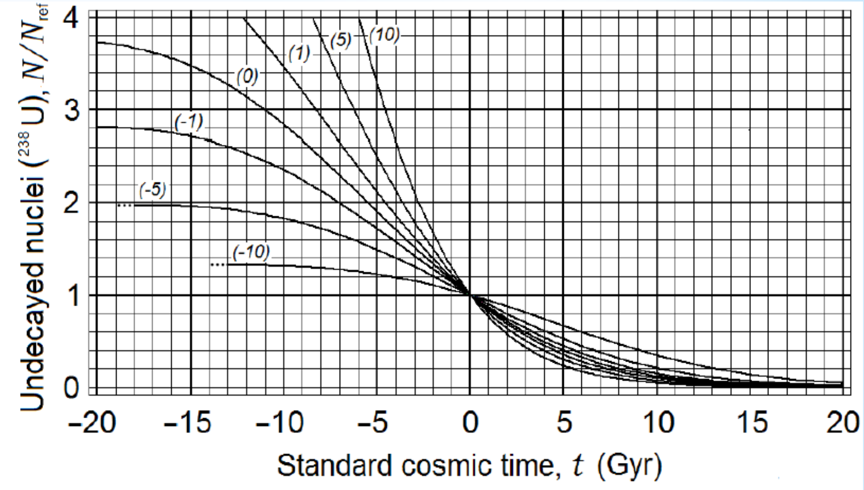



Figure 8: The radioactive decay of long-lived $^{238}$U nuclei in the evolving universe from the point of view of different cosmological epochs.

M. SERDYUKOVA
A. SERDYUKOV