# GRT experiment: Supernova SN1987A

(100 years of general relativity GTR)

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**Abstract**
General relativity (GRT), created by the genius of Einstein from 1907 to 1915 as a geometric theory of gravity, developing special theory of relativity (STR), has been 100 years does not rest and excites minds. Since then, it performed many experiments to confirm with great accuracy GRT. In this paper, we propose to draw attention to the possibility of direct experimental verification of the dependence of the velocity of light by the gravitational potential, what Einstein wrote in 1911 in his article «On the effect of gravity on light propagation» [1, V1, p.172 ]. We assume that nature itself has put this experiment in space in the presence of "dark matter", namely: February 23, 1987 in the Large Magellanic Cloud broke out amazing supernova SN1987A, from which the light came to Earth $2^h$ $47^m$ later neutrinos.
On the basis of numerous observations are given an explanation of this fact in terms of changing the speed of light neutrinos, and depending on the time-varying gravitational potential of the Universe.

Keywords: GRT, Supernova SN1987A, light, photon, neutrino, gravity potential.

## Contents



## 1.Introduction

A. Einstein, outlining the general relativity theory (GRT), resulting in their articles the following experimental confirmation of GRT:

1. Explanation anomalous precession of Mercury peregeliya.

In the article «Explanation peregeliya motion of Mercury in General Relativity» in 1915, Einstein, performing complex calculations came to the result: «The calculation gives for the planet Mercury to turn peregeliya $43''$ in a century» [1, V.1, s.446]

2. Bending of light rays in a gravitational field.

«... The speed of light in a gravitational field is a function of the place ... the light rays propagating across the field of gravity should bend» [1, V.1, p.172]

3. The gravitational red shift, or time dilation in a gravitational field.

«...According to our understanding, the spectral lines of sunlight should be displaced somewhat in comparison with the corresponding spectral lines of terrestrial sources of light in the red end of the spectrum...» [1, V.1, p.171]
«We have no reason to assume that the clock at the points with different gravitational potentials are to be regarded as equally reaching» [1, V.1, p.171]

4. to the dependence of the speed of light by the gravitational potential.

«If we denote by $c_0$ speed of light in the origin, then the velocity of light c in a certain place with the gravitational potential is equal to $\Phi$

$$c=c_0(1+\Phi/c^2)$$» [1, V.1, p.172]

From the time of Einstein's done a lot of experiments that confirm with great accuracy GRT, but we suggest paying attention to Claim 4. from the list. We assume that nature itself has set this experiment, namely: February 23, 1987 in a local group of galaxies in the Large Magellanic Cloud at a distance $R$ = 50 kpk (163,0·$10^3$ light-years = 5.1439 × $10^{12}$s =$T$) in the place the blue supergiant Sanduleak-1 B31 broke out amazing supernova SN1987A, the opening of which the chronology is as follows:

The 2h 52m 36,79s (10357s from 0h 00m 00s) (23.124UT [3, p.726]) «... 23,124 in February Universal Time signal was detected in the Mont Blanc neutrino observatory. The signal consisted of five pulses above an energy threshold for the period 7*MeV* 7s. This is consistent with respect to energy, and duration with the predictions of the standard model with respect to the collapse of the iron core at a distance *50kpk*. The probability of a random match with flash SN1987A is unity $10^4$ years» (telex K.Kastanoli Turin) [3, s.726]

The Rome group detector of gravitational waves in the early 1,4s Mont Blanc group was discovered gravitational signal movement in 2300-kilogram bar. [3, s.727]

«In time of 2: 52: 35,4 UT were recorded as pulses on the two gravitational antennas (in Rome and Maryland)» [5]

The 7h 35m (23.316 UT [3, p.726]) (through 16943s after neutrino bursts under Mount Blanc and ~ 3h = 10800s to the first discovery on the plate) Neutrino Observatory Kamiokande II, IMB, and Baksan neutrino outbreak, which lasted about 13 seconds. «The gap energy was on the threshold of 7.5 to 36 *MeV*» [3, p.727]

This was the first detection of neutrinos from the supernova. According to modern concepts, the neutrino energy is about 99% of the total energy released during a flare. According to estimates in the supernova SN1987A allocated about $10^{58}$ with a total energy of the neutrino in $10^{46}$ J.

The 9h 22m [23.390UT] (through 6420s after the neutrino burst in Kamiokande II, IMB, and Baksan) - «Even before (Feb. 23.390UT) A. Jones. I noticed an object with your telescope search» [4, p.563] - «upper bound shine Observer A. Jones in 9h 22m and the discovery of radio emission SN1987A» [4, p.564]

At 10h 24m [23.433UT] (through 2h 47m = 10020s after neutrino burst in Kamiokande II, IMB, and Baksan) Supernova SN1987A reaches magnitude 6.0

At 10h 41m [23.445UT] (through 11160s after neutrino burst in Kamiokande II, IMB, and Baksan) Supernova SN1987A reaches magnitude 6,2- George. Jerrad and AD Mak-Hom discovered Supernova SN1987A on photographic film. [3, p.726]

The energy neutrinos registered by Supernova 1987A, made: 5,8-7,8 *MeV* in LSD, 20-40 *MeV* in the IMB, 7,5-35,4 *MeV* in KAMIOKANDE II and the mass of electron neutrinos measured by SN1987A, made by $m_{ve}$ <6*eV* to $m_{ve}$ <30*eV*.

On the basis of the above given factual information we can say that the difference between the recorded neutrino bursts in 7h 35m (23.316 UT) and the subsequent outbreak of optical photons in 10h 24m [23.433UT], (when SN1987A reached magnitude 6.0) was 2h 47m (10020s ).

## 2. Light and neutrinos in a gravitational field

The first neutrino and gravitational bursts recorded in 2h 52m 36,79s (10357s) (23.124UT) [3, p.726,727] - this is the beginning of the process of gravitational collapse of a star Sanduleak-1 when there was a catastrophic contraction of the iron core of the star to collapse shell " star exploded inside "so that even neutrinos could not leave the star [4,5,6,9]. After 4h 43m, when George Gamow baryonic matter as a result of the huge stars of compression has become a "dark energy" neutrino emission, which is a reverse shock wave tell the shell and "provoked" photon radiation, and star flared up as a supernova, increasing many times their photon luminescence, so that the neutrino and photon radiation almost simultaneously broke away from the surface of the star, throwing into space up to 99% of stellar matter, but came to Earth yet unexplained difference between the observed neutrino bursts in 7h 35m (23.316 UT) and the subsequent outbreak of optical photons in 10h 24m [23.433UT], which amounted 2h 47m (10020s).

James Franson from the University of Maryland in the journal New Journal of Physics published an article [2], in which, referring to the observation of the supernova SN1987A, believes that photons can be slowed down towards the Earth, and thus keep up with the neutrinos, due to the effect of vacuum polarization.

In this article, we draw attention to the following possible solution to this problem, when the speed of light in accordance with the GRT is a function of the gravitational potential of the Universe:

In our world there are several non-local comprehensive cosmic processes, one of which - the formation of baryonic matter, which resulted in a cosmic scale is a change in the gravitational potential of the Universe at the time equal to the moment $\varphi_t=c_t^2$. Accordingly, with the gravitational potential should vary according to the GRT and the speed of light equal to $c_t=(\varphi_t)^{1/2}\neq const.$

The fundamental factor is the space changes over time of all the processes in the universe according to current observations is Hubble constant $H_0$=2,3655 $10^{-18}$.

According to the theory of relativity, consider the events of the explosion of a supernova Supernova SN1987A and registration of neutrino and photon flares on Earth in the stationary reference frame, taking over the origin of space-time Supernova SN1987A c direction of the x-axis to the Earth ($t$=0, $x$=0, $y$= 0, $z$=0). In this case, taking the start at the same time the neutrino and photon radiation of the reference point of time synchronization of clocks on SN1987A on Earth is not necessary, because the only thing that we can actually measure the world - it is the time difference between the "Destination" on Earth neutrino and photon radiation, which, naturally, will be measured by earthly hours; then photon detection event in the world will have the coordinates ($t=T$, $x=R$, $y$=0, $z$=0).

It is known that currently the gravitational potential of the observed baryonic matter in the universe is $\Delta\varphi_c=c^2$.

The gravitational potential of the Universe at the time of the supernova SN1987A $\Delta\varphi_T$, ie 163 thousand Years ago, in a galaxy LMC was

$$\Delta\varphi_T=\Delta\varphi_c-\Delta\varphi_c TH_0=c^2 (1-TH_0)$$

where $T$=163 thousand years = 5.1439 × $10^{12}$ s - the time elapsed on the clock on the Earth since the explosion c Supernova SN1987A, $H_0$ is a constant Hubble.

Our experiment took place in space in the presence of "dark matter", energy and gravitational potential of which is $\varphi_d=4\pi/3\cdot c^2$=4,18879·$c^2$ (including data and mission WMAP space observatory Plank and the ratio of baryonic "dark matter" in the universe)

The space factor of change in the gravitational potential second 1s baryonic matter in the universe:

$$\gamma_b=\Delta\varphi/\varphi=H_0=2{,}3655\ 10^{-18},$$

where $\Delta\varphi$- a change in the energy potential per second 1s, $\varphi=c^2$, $H_0$ –constant Hubble.

The space factor of change in the 1s energy and gravitational potential "dark matter" in the universe that defines the neutrino radiation, at $4\pi/3$ times and equal to:

$$\gamma_d=\Delta\varphi_d/\varphi_d=4\pi/3\cdot H_0=9{,}908583\cdot 10^{-18},$$

where $\Delta\varphi_d$- changes in energy potential "dark matter" in the second 1s,
$\varphi_d=4\pi/3\cdot c^2$=4,18879·$c^2$– energy potential of "dark matter"

$$\Delta t_f=T(H_0)^{1/2}=5{,}1439\cdot 10^{12}\cdot 1{,}5380\cdot 10^{-9}=7{,}9114\cdot 10^3\text{s}=7911\text{s}.$$

$$\Delta t_n=T(4\pi/3\, H_0)^{1/2}=5{,}1439\cdot 10^{12}\cdot 3{,}1478\cdot 10^{-9}=16{,}1919\cdot 10^3\text{s}=16192\text{s},$$

where $T$=5,1439·$10^{12}$ s – time elapsed on Earth hours

We take into account the path of the photons and neutrinos are complementary to the gravitational potential of the Universe gravitational potentials of our Milky Way galaxy and LMC galaxy, and the potentials of the galaxy Small Magellanic Cloud (SMC), the Sun, the Moon, the Earth will not be taken into account as a minor second and third orders.

Energy-gravitational potential in orbit the Sun in our Galaxy Milky Way is

$$V^2=(2{,}2\cdot 10^5)^2=4{,}84\cdot 10^{10}\ \text{m}^2\text{s}^{-2}=\Delta\varphi_{G.},$$

where $V$=220 km/s — the speed of the Earth as part of the Solar System around the galactic center

The gravitational potential of the baryonic matter in the center of the galaxy LMC is (the influence galaxy SMC will not be taken into account)

$$\Delta\varphi_{LMC}=GM/R=6{,}67384\cdot 10^{-11}\cdot 2\cdot 10^{40}/4{,}63\cdot 10^{19}=2{,}883\cdot 10^{10}\,\text{m}^2\,\text{s}^{-2}.$$

The probability that Supernova 1987A exploded in the center of the LMC is small; so we take an estimated ~ 50% ~ 1/2 of $\Delta\varphi_{LMC}$:

$\Delta\varphi_{LMC}$=2,883·$10^{10}$·0,5=1,4415·$10^{10}$ m$^2$ s$^{-2}$, then

$\Delta\varphi_G$ - $\Delta\varphi_{LMC}$=4,84·$10^{10}$- 1,4415·$10^{10}$=3,3985·$10^{10}$ m$^2$ s$^{-2}$

*Hubble factor* to change the difference in gravitational potential between our Galaxy and LMC is

$$\gamma_{bG}=\Delta\varphi_G — \Delta\varphi_{LMC}/c^2\ T=3{,}3985\cdot 10^{10}/8{,}9876\cdot 10^{16}\cdot 5{,}1439\cdot 10^{12}=0{,}0736\cdot 10^{-18}$$

$$(\gamma_{bG})^{1/2}=0{,}2713\cdot 10^{-9}$$
$$(\gamma_{dG})^{1/2}=0{,}2713\cdot 10^{-9}\cdot 2{,}0466=0{,}5553\cdot 10^{-9}$$

$$\Delta t_{fG}=T(\gamma_{bG})^{1/2}=5{,}1439\cdot 10^{12}\cdot 0{,}2713\cdot 10^{-9}=1396\text{ s.}$$
$$\Delta t_{nG}=T(\gamma_{dG})^{1/2}=2856\text{ s}$$

The calculated theoretical time difference between the arrival of neutrinos and photons to Earth from Supernova 1987A will be

$$\Delta t=(\Delta t_n+\Delta t_{nG}) – (\Delta t_f+\Delta t_{fG})=(16192s+2856s) – (7911s+1396s)=19048 – 9307s=9741s=2^h 42^m.$$

The actual difference between the observed neutrino bursts in 7h 35m (23.316 UT) and the subsequent outbreak of optical photons in 10h 24m [23.433UT] was 2h 47m (10020s) (the discrepancy between theory and experiment ~ 3%), which confirms a high degree of accuracy GRT.

### 3. Supernovae and GRT

In August, 2011, and January 3, 2012 detectors Neutrino Observatory in Antarctica Ice Cube recorded two particles with high energy 1,0-1,14 *PeV* - called "Bert" and "Ernie."
By analogy with the Supernova 1987A, which broke out at a distance of 50 kpk and the difference between the arrival on Earth of neutrinos and photons was 2h 47m, we performed calculations for Supernova SN2011fe in the galaxy Messier M101 (NGC5457), broke out August 23, 2011 at a distance of 6439 kpk, neutrinos from which should arrive at ~ 15 days before that, apparently, and recorded on Ice Cube as the neutrino particle "Bert" in early August 2011. The recorded 3 January 2012 neutrino particle "Ernie" was a messenger photon flash Supernova SN2012aw, observed since March 16, 2012 at a distance of 11650 kpk in the M95 galaxy.
January 13-14 2014 Ice Cube should be fixed neutrino burst from Supernova SN2014J of M82 galaxy, which will serve as confirmation of the speed of light, depending on the gravitational potential in accordance with the GRT.
Chance and the next observation cosmological experiment to confirm GRT: after a registered neutrino burst through time $[(4\pi/3\text{-}1)H_0]^{1/2}T/c^2$ seconds (+ accounting gravitational potentials galaxies) should occur optical photons supernova star.

### References


[1] Einstein A. Collection of scientific works, vol. 1 Moscow., Science, 1965. Эйнштейн А. СНТ, т 1 М.;Наука, 1965.
[2] J D Franson. Apparent correction to the speed of light in a gravitational potential. *New Journal of Physics* 16 (2014) 065008, doi: 10.1088/1367-2630/16/6/065008
[3] Morrison D. R. O. Review of Supernova 1987A: Preprint CERN, 26 January, 1988.
Моррисон Д.Р.О. Сверхновая 1987А: Обзор. УФН, Том 156, вып. 4, декабрь 1988 г.
[4] Имшенник В.С., Надёжин Д.К. Сверхновая 1987А в Большом Магеллановом Облаке: наблюдения и теория. УФН, Том 156, вып. 4, декабрь 1988 г.
[5] О.Г. Ряжская. Нейтрино от гравитационных коллапсов звезд: современный статус эксперимента. УФН, Том 176, №10, октябрь 2006г.
[6] В.А. Рябов. Нейтрино свервысоких энергий от астрофизических источников и распадов сверхмассивных частиц. УФН, Том 176, №9, сентябрь 2006г.
[7] М. Кошиба. Рождение нейтринной астрофизики. (Нобелевская лекция. Стокгольм, 8 декабря 2002 г.) УФН, Том 174, №4, апрель 2004г.
[8] Ф. Райнес. Нейтрино: от полтергейста к частице. (Нобелевская лекция. Стокгольм, 1995г.) УФН, Том 166, №12, декабрь 1996г.
[9] Имшенник В.С. Ротационный механизм взрыва коллапсирующих сверхновых и двухстадийный нейтринный сигнал от сверхновой 1987А в Большом Магеллановом Облаке. УФН, Том 180, №11, ноябрь 2010г.
[10] Measurement of the neutrino velocity with the OPERA detector in the CNGS beam http://static.arxiv.org/pdf/1109.4897.pdf