An Alternative Interpretation of the LIGO Data

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Abstract: There are at least three unsolved basic problems concerning the interpretation of the LIGO data. They are as follows: the total-angular-momentum problem for final black hole as a result of inspiralling binary black holes (the final spin is lower than expected), instability of the gravitational waves (the transverse motions lead to superluminal speeds in the luminal Einstein spacetime), and the low-frequency problem (very low accuracy for frequencies lower than 35 Hz causes that a part of LIGO spectrum is untrustworthy). The unsolved problems cause that the predictions of the General Theory of Relativity (GR) concerning the LIGO data mimic the true phenomena described within the Scale-Symmetric Theory (SST). SST shows that there is the shortest distance between inspiralling black holes so their merger is impossible, shows that instead the gravitational waves there are the ordered motions/flows in the luminal Einstein spacetime that lead to the dark-matter mechanism, and that the LIGO strain-time spectrum is a result of the quantized orbits which are obligatory for binary systems of black holes. SST shows that there is the lower limit for mass of gravitational black holes (24.81 solar masses). Here we calculated the mass emitted during the distinguished transitions (about 3.93 solar masses). We present the frequency-time function, we calculated the time distances between the successive crests of the strain-time wave. To obtain the observed maximum frequency about 250 Hz, we must assume that the binary system is in time distance about 1.2 Gyr. Obtained results within SST are close to the LIGO data except the low-frequency data that are outside the operating range of LIGO - a future more precise measurements should show whether presented here the SST model is correct.

1. Introduction

On February 11, 2016 the LIGO Scientific Collaboration and Virgo Collaboration announced they have discovered gravitational waves, [1], i.e. waves of pure energy moving with the speed of light in "vacuum" c (i.e. they are the zero-mass luminal waves). But in the presented model of merger of two black holes there are at least three unexplained results. It shows that the model is incomplete so some interpretations of the observational facts can be incorrect.

1.1 The unsolved problems

It is obvious that the spins of merging black holes and the angular momentum that follows from the inspiral of the black holes should not counteract each other. But then the final spin of the resultant black hole is lower than expected [2]. There appeared the unphysical idea that the two black holes collide at a low speed. Much more probable is the assumption that the predictions of the General Theory of Relativity (GR) mimic some new physics. Here we will show that the total-angular-momentum problem can be solved within the Scale-Symmetric Theory (SST) [3].

The second unsolved problem follows from the fact that we do not know a physical phenomenon to explain the effects of a plus-polarized or cross-polarized gravitational wave on a ring of particles. Such oscillations could be produced by some transverse motions in the gravitational wave but then some parts of the gravitational wave could propagate with speeds higher than the c. Here we will show that the total-speed problem can be solved by replacing the gravitational waves for the ordered motions/flows in the luminal Einstein spacetime forced by the inspiralling black holes. Such ordered motions lead to the dark-matter mechanism and mimic the predictions of GR.

The third unsolved problem concerns the limitations of the Laser Interferometer Gravitational-wave Observatory (LIGO) [1]. The sensitivity of the advanced LIGO detector is limited by photon shot noise at frequencies above 150 Hz and by a superposition of other noise sources at lower frequencies [1]. They used a 35-350 Hz bandpass filter to suppress large fluctuations outside the two LIGO detectors' most sensitive frequency band. But the end of the frequency-time function, $f = f(t)$, shows that it is the increasing function so the flat part of the curve overlapping with the lower limit for frequency, i.e. for $f = 35$ Hz, is untrustworthy. We can see that we should not take into account the period of time up to about $t = 0.37$ s i.e. we should neglect the spectral lines placed within the $\pm 0.5 \cdot 10^{-21}$ strain ([1]: FIG. 1.). This problem we will refer to as the low-frequency problem.

1.2 The Scale-Symmetric Theory

Within the Standard Model we still cannot calculate exact masses and spin of nucleons from the initial conditions (since 1964). On the other hand, within the Cosmological Standard Model we cannot define properties of the dark matter and dark energy and calculate their abundances from some initial conditions. We as well do not understand the origin of physical constants and applied in physics mathematical constants. It suggests that the two leading mainstream theories, i.e. the Quantum Physics and General Theory of Relativity, are the incomplete theories and that there should be a theory superior to these two theories. Such theory should lead to initial conditions applied in these two theories and should describe the lacking part of the Theory of Everything. We showed that the Scale-Symmetric Theory described in tens of papers (http://vixra.org/author/sylwester_kornowski) is the lacking part.

The GR leads to the non-gravitating Higgs field composed of tachyons [3A]. On the other hand, the Scale-Symmetric Theory shows that the succeeding phase transitions of such Higgs field lead to the different scales of sizes/energies [3A]. Due to the saturation of interactions via the Higgs field and due to the law of conservation of the half-integral spin that is obligatory for all scales, there consequently appear the superluminal binary systems of closed strings (entanglons) responsible for the quantum entanglement (it is the quantum-entanglement scale), stable neutrinos and luminal neutrino-antineutrino pairs which are the components of the luminal gravitating Einstein spacetime (it is the Planck scale), cores of baryons (it is the electric-charges scale), and the cosmic structures (protoworlds; it is the cosmological scale) that evolution leads to the dark matter, dark energy and expanding universes (the "soft" big bangs) [3A], [3B]. The non-gravitating tachyons have infinitesimal spin so all listed structures have internal helicity (helicities) which distinguishes particles from their antiparticles [3A]. SST shows that a fundamental theory should start from infinite nothingness and pieces of space [3A]. Sizes of pieces of space depend on their velocities [3A]. The inflation field started as the liquid-like field composed of non-gravitating pieces of space [3A]. Our Cosmos, which consists of the two-component spacetime (i.e. of the superluminal non-gravitating Higgs field, which is the remnant of the inflation field, and of the luminal gravitating Einstein spacetime) and universe(s), was created because of collisions of big pieces of space [3A], [3B]. During the inflation, the liquid-like inflation field (the non-gravitating superluminal Higgs field) transformed partially into the luminal Einstein spacetime (the big bang) [3A], [3B]. In our Cosmos, the two-component spacetime is surrounded by timeless wall – it causes that the fundamental constants are practically invariant [3A], [3B].

SST shows that to obtain results consistent with experimental data, the big piece of space that transformed into the inflation field had before the collision a rotational energy very low in comparison with kinetic energy [3A]. It leads to conclusion that there was low anisotropy of the inflation field i.e. of the expanding superluminal non-gravitating Higgs field. It means that to such field we can apply the Kasner metric, [4], that is a solution to the vacuum Einstein equations so the Ricci tensor always vanishes. The Kasner metric is for an anisotropic cosmos without matter so it is a vacuum solution for the Higgs field. The one of the two semi-symmetrical Kasner solutions, i.e. (2/3, 2/3 –1/3), we interpret as virtual Higgs cyclones with toroidal and poloidal motions. Such tori appear in the succeeding phase transitions of the Higgs field [3A].

Applying 7 parameters only and a few new symmetries, [3A], we calculated a thousand of basic physical (and mathematical) quantities (there are derived the physical and mathematical constants as well) which are consistent or very close to experimental data and observational facts. In SST there do not appear approximations, mathematical tricks, and free parameters which are characteristic for the mainstream particle physics and mainstream cosmology.

Emphasize that according to SST, there are not in existence black holes with central singularity but there are in existence the modified black holes (MBHs) containing a circle with spin speed equal to the c – such a circle we will refer to as the equator of MBHs. The modified neutron black holes (MNBHs) are such MBHs – all other modified black holes consist of the MNBHs. The equator of MNBHs is physical whereas of bigger MBHs is abstract. Within SST we described MBHs and their accretion discs [5].

Within SST we calculated mass and equatorial radius of MNBH [3B]:

$m_{MNBH} = 4.935 \cdot 10^{31}$ kg i.e. about 24.81 solar masses,

$r_{MNBH} = 3.664 \cdot 10^{4}$ m i.e. 36.64 km.

2. Calculations

SST shows that the surface mass density of the torus/charge inside the core of baryons is about 300,000 times higher than of a plane in the Einstein spacetime [3A]. It causes that rotating or moving nuclear plasma or nuclear matter force ordered motions/flows in the Einstein spacetime. For example, angular velocities of the Einstein spacetime inside a MNBH and of the MNBH are the same i.e. the MNBH is in the rest in relation to the rotating part of the Einstein spacetime – it causes that the Schwarzschild field of rotating MNBH is spherically symmetric.

SST shows that the lower limit for distance between the MNBHs in a binary system must be about $R_{Lower\text{-}limit} = 2\pi r_{MNBH} = 2.3022 \cdot 10^{5}$ m. It follows from the fact that on the equator of the MNBHs are produced virtual loops that are exchanged between the MNBHs – it fixes the distance. It means that the radius of smallest orbit is $R_{Minimum} = \pi r_{MNBH} = 1.1511 \cdot 10^{5}$ m. On this orbit are moving two MNBHs so they produce spinning loop overlapping with the smallest-orbit/ground-state – such loop consists of the entangled Einstein-spacetime components. The 8 successive symmetrical decays of mass of such loop (they mimic the 8 symmetrical successive decays of atomic nuclei containing 256 nucleons at very high temperature [3C]) cause that there appear orbits which radii are defined by following formula (circumference of loop is inversely proportional to its mass)

$$R_{d,MNBH} = d\, R_{Minimum}, \qquad (2)$$

where d = 1, 2, 4, 8, 16, 32, 64, 128, 256.

Since the masses of the MNBHs are quantized so their merger is impossible – it leads to conclusion that the smallest distance between two MNBHs is $R_{d=1,MNBH} = R_{Lower\text{-}limit}$.

An inflow of dark matter into the binary system can cause transition to one of the excited states (notice that both MNBHs must be on the same orbit). Then the excited system can inspiral to the ground state. Assume that a binary system of the modified neutron black holes behaves as follows. There is the radial transition of the MNBH from, for example, $d = 16$ state to $d = 8$ state. Next the MNBH for some short period is in the $d = 8$ state. Then there is the radial transition from $d = 8$ state to $d = 4$ state and the MNBH for some short period is in the $d = 4$ state, and so on. The final/ground state is the $d = 1$ state which is defined by formula (2). It means that there are not perfectly regular two spirals – it results from existence of the d orbits/loops that are the dark-matter structures. But due to the weak interactions of the dark-matter loops with baryonic matter, there can appear the baryonic loops as well [5], [6]. Advection causes that spin speed of the baryonic loops is the same whereas constancy of angular momentum causes that bigger and bigger baryonic loops consist of lighter and lighter atomic nuclei – on the smallest orbit should dominate the nuclei containing 256 nucleons, on the next bigger orbit should dominate the nuclei containing 128 nucleons, on next bigger containing 64 nucleons, 32 nucleons, and so on. The weak interactions between the dark-matter loops and the modified neutron black holes (via leptons) cause that there the advection acts [5], [6]. The advection accelerates the orbital motions so it forces the next radial transition, and so on.

When distance between the two MNBHs decreases then there increases the number density of virtual pairs produced in the Einstein spacetime. According to SST, a virtual object looks as follow. There appears a virtual fermion-antifermion pair (both components have positive mass) and a hole in the Einstein spacetime (its mass is negative) in such a way that resultant mass is equal to zero [7]. Due to the annihilations of the virtual fermion-antifermion pairs, in the Einstein spacetime appear radial motions of groups of the neutrino-antineutrino pairs. It causes that when distance between the MNBHs decreases then there are more and more holes in the Einstein spacetime so the mean mass density of the Einstein spacetime near the binary system differs more and more from the mean mass density of the Einstein spacetime in our Universe. We can see that inspiralling binary system of MNBHs produces a wave/flow composed of divergently moving groups of neutrino-antineutrino pairs. Due to the quantized orbits, the strain of produced gravitational flow changes with time. Most massive gravitational flows are produced during the radial transitions between the d states.

Calculate total mass of the emitted gravitational flow for transition from infinity to $d = 1$ state

$$E = G\, m_{MNBH}\, m_{MNBH} / R_{Lower\text{-}limit} = m_{MNBH}\, c^2\, r_{MNBH} / R_{Lower\text{-}limit} = \\ = m_{MNBH}\, c^2 / 2\pi = 3.95 \text{ solar masses.} \qquad (3)$$

But in the transition from $d = 256$ state to $d = 1$ state (notice that both MNBHs are on the same orbit) is emitted mass equal to

$$E^* = m_{MNBH}\, c^2\, r_{MNBH}\, [1 / R_{Lower\text{-}limit} - 1 / (2\, R_{d=256,MNBH})] \approx 3.93 \text{ solar masses.} \quad (4)$$

Calculate the frequencies of the gravitational flow that follows from the transitions between the d states. The crests in the strain-time wave are for the transitions between the d states so to obtain the frequencies for the crests, we calculate the geometric means of frequencies characteristic for initial d state and final d state.

Frequencies for the d states can be calculated from following formula

$$f_d = v_{Radial,d} / (\Delta d\, R_{Minimum}). \quad (5)$$

where $v_{Radial,d}$ is the radial speed forced by the final d state.

The flows of nuclear matter on defined orbit cause that the spin speed of produced loop is equal to the orbital speed of MNBHs. Since loop consists of the luminal Einstein-spacetime components so there appear the radial motions – the radial speed is defined by following formula

$$v_{Radial,d} = (c^2 - v_{Orbital,d}{}^2)^{1/2}, \quad (6)$$

where $v_{Orbital,d}{}^2 = G\, 2\, m_{MNBH} / (d\, R_{Minimal}) = G\, 2\, m_{MNBH} / (d\, \pi\, r_{MNBH}) = c^2\, 2 / (d\, \pi)$.

Consider, for example, the $d = 16 \rightarrow d = 8$ transition. We have $\Delta d = 8$ and d for final state is $d = 8$ (the transition is realized when orbital speed in $d = 16$ state becomes equal to the orbital speed in $d = 8$ state) so $\Delta d = d$ (it is obligatory for all radial transitions). To obtain the observed frequency, $f_{Obs,d}$, we must take into account the expansion of the Universe. According to SST, the size of volume filled with baryonic matter increased about $N_0 = 72.56$ times whereas the time distance to most distant galaxies is $L_0 = 13.866 \pm 0.096$ Gyr [3B]. Introduce a factor $F = N_0\, L / L_0$ that defines the expansion of the Universe, where L defines time distance to observed object. The F defines increase in length of a wave emitted by observed object. Since $c^2 = G\, m_{MNBH} / r_{MNBH}$, [3B], so we can rewrite formula (5) as follows

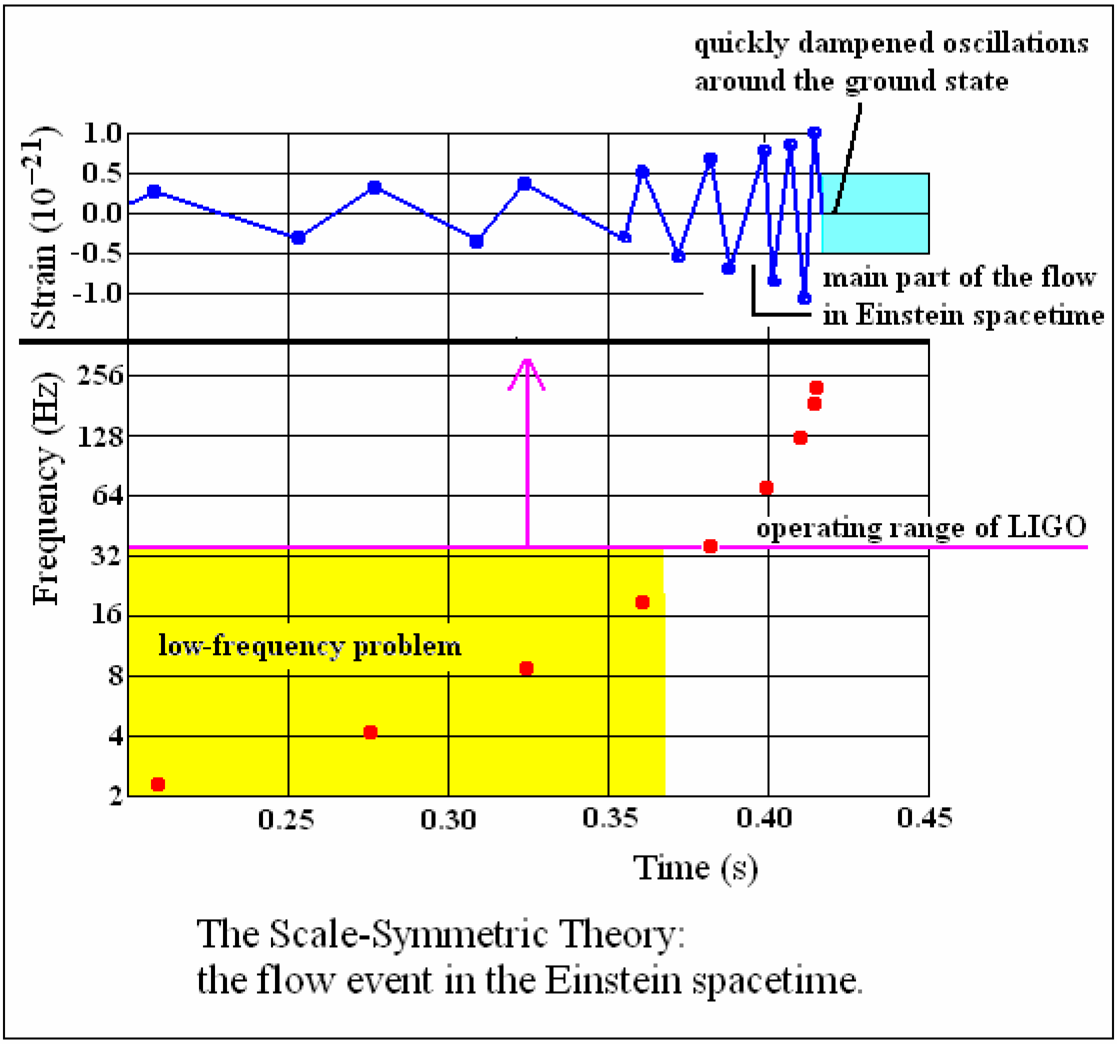
$$f_{Obs,d} = c[(1 - 2 /(d\, \pi)]^{1/2} / (F\, d\, \pi\, r_{MNBH}). \quad (7)$$

To obtain the maximum frequency observed by LIGO ($f_{Obs,d=1,maximum} \approx 250$ Hz; it is for $d = 1$), from formula (7) we obtain $F = 6.28$ so from the definition of F we obtain that the binary system was in time distance 1.20 Gyr. This result is consistent with LIGO data [1].

For $d = 16$ is $f_{Obs,d=16} = 25.4$ Hz, for $d = 8$ is $f_{Obs,d=8} = 49.7$ Hz i.e. for the $d = 16 \rightarrow d = 8$ transition is $f_{Obs,GeometricMean,16\text{-}8} =$ <u>35.5 Hz</u>. For $d = 4$ is $f_{Obs,d=4} = 95.0$ Hz i.e. for the $d = 8 \rightarrow d = 4$ transition is $f_{Obs,GeometricMean,8\text{-}4} =$ <u>68.7 Hz</u>. For $d = 2$ is $f_{Obs,d=2} = 171$ Hz i.e. for the $d = 4 \rightarrow d = 2$ transition is $f_{Obs,GeometricMean,4\text{-}2} =$ <u>128 Hz</u>. For $d = 1$ is $f_{Obs,d=1} = 250$ Hz (it is the upper limit) i.e. for the $d = 2 \rightarrow d = 1$ transition is $f_{Obs,GeometricMean,2\text{-}1} =$ <u>207 Hz</u>.

3. Dynamics of the binary system of modified neutron black holes

To compare our theoretical results with the LIGO data, we assume that the upper limit for frequency (~250 Hz) is for time t = 0.420 s [1]. Due to the low-frequency problem described in *Introduction*, *Paragraph* **1.1**, in our calculations we neglect the initial period up to $t \approx 0.37$ s. We as well neglect the quickly dampened oscillations around the ground state (d = 1) for $t > 0.420$ s. It causes that there are the 4 main crests in the strain-time wave (for ~35.5 Hz, ~68.7 Hz, ~128 Hz and ~207 Hz) during the interval of time from 0.37 s to 0.42 s with the maximum frequency ~250 Hz.



Calculate the time distances between the distinguished crests in the strain-time wave on the assumption that the radial transitions are very quick with speeds close to the speed of light in "vacuum" c – it means that the regions in Einstein spacetime with shifted mass density are emitted very quickly. Then the calculations show that we can neglect the radial times in relation to the orbital times. Assume as well that the orbital distances covered by a MNBH are the same for all orbits and are equal to the smallest distance between MNBHs i.e. are equal to $R_{Lower-limit}$. Then the lower limit for orbital time is (it is for the d = 1 state)

$$\Delta t_{Orbital,minimum} = \Delta t_{d=1} = 2 \pi r_{MNBH} / [c (2 / \pi)^{1/2}] = 0.0009624 \text{ s}. \quad (8)$$

The observed today shortest time between the main crests for binary system in distance 1.2 Gyr should be F times longer

$$\Delta t_{d=1,Today} = F\, \Delta t_{d=1} = 0.006 \text{ s}. \qquad (9)$$

Since there dominate the orbital times so the time distances between the successive main crests defines following formula

$$\Delta T_{f\text{-}f^*,d} = \Delta t_{d=1,Today}\, (d)^{1/2}. \qquad (10)$$

The time distance between the 4-2 and 2-1 crests, i.e. $d = 2$, is $\Delta T_{128\text{-}207,d=2} \approx 0.0085$ s.
The time distance between the 8-4 and 4-2 crests, i.e. $d = 4$, is $\Delta T_{68.7\text{-}128,d=4} \approx 0.012$ s.
The time distance between the 16-8 and 8-4 crests, i.e. $d = 8$, is $\Delta T_{35.5\text{-}68.7,d=8} \approx 0.017$ s.
The time distance between the 32-16 and 16-8 crests, i.e. $d = 16$, is $\Delta T_{18.1\text{-}35.5,d=16} \approx 0.024$ s.
The time distance between the 64-32 and 32-16 crests, i.e. $d = 32$, is $\Delta T_{9.1\text{-}18.1,d=32} \approx 0.034$ s.
The time distance between the 128-64 and 64-32 crests, i.e. $d = 64$, is $\Delta T_{4.6\text{-}9.1,d=64} \approx 0.048$ s.
The time distance between the 256-128 and 128-64 crests, i.e. $d = 128$, is $\Delta T_{2.3\text{-}4.6,d=128} \approx 0.068$ s.

It means that on the assumption that the upper limit 250 Hz is for $t = 0.420$ s (it should be very close to the strain crest for 207 Hz), the crest for 128 Hz should be for $t = 0.411$ s, for 68.7 Hz should be $t = 0.399$ s and for 35.5 Hz should be $t = 0.382$ s. The next successive earlier and earlier 4 crests should be for $t = 0.358$ s (18.1 Hz), 0.324 s (9.1 Hz), 0.276 s (4.6 Hz), and 0.208 s (2.3 Hz). Obtained results are close to the LIGO data for frequencies higher than the operating range of LIGO (35 Hz) [1].

It is not true that gravitational potential energy is emitted via the zero-mass luminal gravitational waves. Due to the transverse motions in the GR gravitational wave, there should appear the superluminal speeds in the luminal Einstein spacetime. SST shows that instead the gravitational waves there is produced radial flow composed of regions with shifted mass density. Such wave/flow causes that there appear compressive forces in directions perpendicular to the flow (it is a part of the dark-matter mechanism) – it partially mimics the effects characteristic for the GR gravitational waves.

From formula (7) follows that frequency for $d = 32$ is $f_{Obs,d=32} = 12.8$ Hz. Since for $d = 16$ is $f_{Obs,d=16} = 25.4$ Hz so for the $d = 32 \rightarrow d = 16$ transition is $f_{Obs,GeometricMean,32\text{-}16} = \underline{18.1 \text{ Hz}}$. Frequency for such crest, i.e. the 18.1 Hz, is below the lower limit for frequency in LIGO so the future more precise measurements should show whether presented here the SST model is correct. Notice as well that from formula (10) we obtain that the time distance between the 32-16 and 16-8 crests, i.e. $d = 16$, is $\Delta T_{18.1\text{-}35.5,d=8} \approx 0.024$ s i.e. for time $t = 0.358$ s so this result is consistent with the LIGO data – there indeed is the crest in the strain-time wave [1].

In the calculations that lead to the strain-time function and to the frequency-time function, we do not take into account the increase in kinetic energy of the MNBHs because contrary to the emitted radial flow in the Einstein spacetime detected by LIGO that follows from the changes in the gravitational potential energy, the increase in kinetic energy is the local phenomenon. Due to the gravitational forces acting on the carriers of photons (i.e. on the neutrino-antineutrino pairs the Einstein spacetime consists of), the Einstein spacetime inspirals [5], [8]. Due to the weak interactions of such inspiralling spacetime and the MNBHs, the kinetic energy of the MNBHs increases. Moreover, there acts the advection between the virtual d loops (they are the dark-matter structures) and the MNBHs [5], [9] that as well increases the kinetic energy of the MNBHs. But both phenomena are the local phenomena.

Calculate the relative strains for the successive crests. We will apply the Stefan-Boltzmann law. We applied this law many times in the Scale-Symmetric Theory, for example, we calculated the change in abundance of helium and hydrogen in the expanding Universe [10], we calculated production of pions/kaons/protons in pp and AA collisions [11], and we calculated the total inelastic cross section versus the centre-of-mass energy for proton-proton collisions [12].

The Stefan-Boltzmann law describes the black body emissive power, j^*, that is directly proportional to the fourth power of the black body’s thermodynamic temperature T

$$j^* = \sigma T^4. \quad (11)$$

We can apply this formula to the flow in the Einstein spacetime produced by the inspiralling MNBHs. The emissive power is directly proportional to changes in the gravitational potential energy i.e. is directly proportional to the masses of the expanding successive regions of the Einstein spacetime with shifted mass density. From formulae (4) and (11) we obtain

$$T_n \sim \Delta M_n^{1/4} \sim (1 / d_n - 1 / d_{n+1})^{1/4}, \quad (12)$$

where $d_n = 2^{n-1}$ and $n = 1, 2, 3, 4, 5\ldots$ In a constant-volume process of ideal gas (we can treat the Einstein spacetime as such a gas) an increase in temperature is proportional to increase in pressure p_n.

Consider a LIGO-arm of any elastic material that can be treated as a linear spring. Its fractional extension or strain, ε_n, is

$$\varepsilon_n = \Delta L / L \sim p_n, \quad (13)$$

where L is the length of the LIGO arm.

But for very small relative increases in length, $\Delta L / L << 1$, it is directly proportional to pressure in the LIGO arms also so we obtain

$$\varepsilon_n \sim p_n \sim T_n \sim \Delta M_n^{1/4} \sim (1 / d_n - 1 / d_{n+1})^{1/4}. \quad (14)$$

To compare our results with the LIGO data, normalize the strain ε_n in such a way to obtain $\varepsilon_1 = 10^{-21}$ for the $d = 2 \rightarrow d = 1$ transition i.e.

$$\varepsilon_n \, [10^{-21}] = C \, (1 / d_n - 1 / d_{n+1})^{1/4}, \quad (15)$$

where $C = 1.1892$.

Applying formula (15) we obtain

$\varepsilon_1\ [10^{-21}] = \varepsilon_{2\text{-}1} = 1$,
$\varepsilon_2\ [10^{-21}] = \varepsilon_{4\text{-}2} = 0.841$,
$\varepsilon_3\ [10^{-21}] = \varepsilon_{8\text{-}4} = 0.707$,
$\varepsilon_4\ [10^{-21}] = \varepsilon_{16\text{-}8} = 0.595$,
$\varepsilon_5\ [10^{-21}] = \varepsilon_{32\text{-}16} = 0.500$,
$\varepsilon_6\ [10^{-21}] = \varepsilon_{64\text{-}32} = 0.420$,
$\varepsilon_7\ [10^{-21}] = \varepsilon_{128\text{-}64} = 0.354$,
$\varepsilon_8\ [10^{-21}] = \varepsilon_{256\text{-}128} = 0.297$.

Obtained results are in good agreement with LIGO data.

4. Summary

Here, applying the Scale-Symmetric Theory, we interpret in a different way the LIGO data. There appeared paper showing that "the apparent detection by the LIGO-Virgo Collaboration is not related to gravitational waves or to the collision and merger of black holes" (i.e. the GR black holes) [13].

On the assumption that observed upper limit for frequency is about 250 Hz, we calculated that the considered binary system is in time distance equal to 1.2 Gyr.

The SST shows that to obtain the observed strain-time and frequency-time spectra, the binary system must start from its ground state i.e. the initial distance between the modified neutron black holes should be $2\pi\ r_{MNBH}$. Due to the very high surface mass density in the cores of baryons, the orbiting MNBHs produce virtual loop overlapping with the ground state. The successive symmetrical decays of mass of such loop produce quantized orbits/loops outside the ground state. An inflow of dark matter excited the binary system. Due to the weak interactions (via leptons) of the MNBHs with the quantized virtual loops (i.e. due to the advection), the system is unstable. It causes that the MNBHs inspiral but due to the quantized orbits/loops, the spirals are not smooth. It causes that produced flow in the Einstein spacetime looks as a wave. The flow is produced due to the virtual processes described in this paper. The ordered radial motions in the Einstein spacetime decrease local pressure in such a way that the compressive forces act perpendicularly to the radial motions. We can see that the maximum phase shift for the laser photons in the LIGO arms should be when the radial motion of the neutrino-antineutrino pairs is parallel to one arm and perpendicular to the other.

Calculated within SST masses of the MNBHs are 24.81 solar masses. Calculated emitted total mass by the binary system for the transition from infinity to the ground state is 3.95 solar masses.

Due to the low-frequency problem, the LIGO data for time up to about 0.37 s are untrustworthy. Here we did not describe the quickly dampened oscillations around the ground state i.e. for time longer than about 0.42 s. Here we described the strain-time spectrum and the frequency-time spectrum for the most important period about 210 ms. Obtained results are consistent with the LIGO data for frequencies higher than the operating range of LIGO.

It is not true that there was a merger of the two black holes – merger leads to the total-angular-momentum problem.

It is not true that gravitational potential energy is emitted via the zero-mass luminal gravitational waves. Due to the transverse motions in the GR gravitational waves, there should appear the superluminal speeds in the luminal Einstein spacetime. SST shows that instead the gravitational wave there is produced radial flow composed of regions with shifted mass density. Such wave/flow causes that there appear compressive forces in directions perpendicular to the flow (it is a part of the dark-matter mechanism) – it partially mimics the effects characteristic for the GR gravitational waves. Moreover, SST shows that gravity can be non-local [3A].

For time $t = 0.358$ s we obtain a crest in the strain-time wave and this result is consistent with the LIGO data. Frequency for this crest is 18.1 Hz and this frequency is below the operating range of LIGO (the lower limit is 35 Hz) so future more precise measurements should show whether presented here the SST model is correct.

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Hadronic Journal Vol. 39, 2016