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Quantum Gravitational Potentials in High Dimensional Spaces and Calculation of Gravitational Wave Signal Carried the Energy

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Abstract We present method for calculation of different gravitational potentials depending on spacetime dimensions and gravitational wave signal carried the energy. These potentials arise from exchange of graviton and are determined by the Fourier transform at the static limit.

Keywords Quantum gravitational potential, propagator of the graviton, Fourier transform, coupling constant, Merger of black holes, gravitational wave.

1. Four Dimensional Case and the Newtonian Potential

It is well known that in the static limit the Coulomb and the Yukawa potentials are related with a photon propagator and a propagator of a scalar particle with mass m by the following formulas:

$$U_C(r) = \frac{e}{(2\pi)^3}\int \frac{d^3p}{p^2} e^{i\vec{p}\vec{r}} = \frac{e}{4\pi}\frac{1}{r}, \quad (1)$$

and

$$U_Y(r) = \frac{g}{(2\pi)^3}\int \frac{d^3p}{p^2+m^2} e^{i\vec{p}\vec{r}} = \frac{g}{4\pi}\frac{1}{r}e^{-mr}. \quad (2)$$

In order to obtain the Newtonian potential by using the graviton propagator we use its form for Minkowski space in general relativity [1]:

$$G_{\alpha\beta,\mu\nu} = \frac{P^2_{\alpha\beta,\mu\nu}}{p^2} - \frac{P^0_{s,\alpha\beta,\mu\nu}}{2p^2} = \frac{g_{\alpha\mu}g_{\beta\nu} + g_{\beta\mu}g_{\alpha\nu} - \frac{2}{D-2}g_{\mu\nu}g_{\alpha\beta}}{p^2}, \quad (3)$$

where D is the number of spacetime dimensions, P^2 is the transverse and traceless spin 2 projection operator and P_s^0 is a spin zero scalar multiplet. The graviton propagator for (Anti) de Sitter space is

$$G = \frac{P^2}{2H^2 - \Box} + \frac{P_s^0}{2(\Box + 4H^2)},$$

where H is the Hubble constant. Note that upon taking the limit $H \to 0$ and $\Box \to -p^2$, the AdS propagator reduces to the Minkowski propagator [2].

As shown in formulas (1) and (2), further, we are not interested in numerator in the form (3). Thus, the Newtonian potential for a body with mass M is given by the formula

$$U_N(r) = \frac{G\cdot M}{2\pi^2}\int \frac{d^3p}{\vec{p}^2} e^{i\vec{p}\vec{r}} = \frac{GM}{r}, \quad (4)$$

where

$$G = 6.6743\times 10^{-11}\,\frac{m^3}{kg\cdot sec^2} \quad (5)$$

is the Newtonian constant.

2. Five Dimensional Case and the Quantum Gravitational Potential

In order to study quantum gravitational potentials in D-spacetime dimensions we need to consider the following integral:

$$U_D(r) = A\int \frac{d^{D-1}p}{p^2} e^{ipr}, \tag{6}$$

where A is a some constant,

$$\begin{aligned} d^{D-1}p &= r^{D-2}drd\varphi\sin\theta_1 d\theta_1 \times \sin^2\theta_2 d\theta_2 \ldots \sin^{D-3}\theta_{D-3}d\theta_{D-3} = \\ &= r^{D-2}drd\varphi \prod_{k=1}^{D-3} \sin^k\theta_k d\theta_k, \end{aligned} \tag{7}$$

$$(0 < r < \infty, \quad (0 < \varphi < 2\pi, \quad (0 < \theta_k < \pi),$$

$$\left.\begin{aligned} pr &= p_1x_1 + p_2x_2 + \cdots p_{D-1}\cdot x_{D-1}, \\ p^2 &= p_1^2 + p_2^2 + \cdots + p_{D-1}^2. \end{aligned}\right\} \tag{8}$$

Let $D = 5$, then from the formula (6) we have

$$U_5(r) = A_5\int \frac{d^4p}{p^2} e^{i\vec{p}\cdot\vec{r}} = 4\pi A_5 \int_0^\infty dp \frac{p^3}{p^2} \times \int_{-1}^1 dx\sqrt{1-x^2}e^{iprx}, \tag{9}$$

where

$$\mathcal{L}_5 = \int_{-1}^1 dx\sqrt{1-x^2}e^{iprx} = 2\int_0^1 dx\cos(pr\cdot x)\times\sqrt{1-x^2} = \frac{2\pi}{2pr}J_1(pr). \tag{10}$$

Here $J_1(x)$ is the cylinder function of the first order, and we have used the integral formula

$$\int_0^1 dx\cos(ax)(1-x^2)^{\nu-\frac{1}{2}} = \frac{\sqrt{\pi}}{2}\left(\frac{2}{a}\right)^\nu \Gamma\left(\nu+\frac{1}{2}\right)J_\nu(a) \tag{11}$$

Then, integral (9) takes the form

$$U_5(r) = A_5\frac{4\pi^2}{r}\int_0^\infty dpJ_1(pr) = \frac{4\pi^2}{r^2}A_5, \tag{12}$$

where we have need to choose constant A_5 with some mass M

$$A_5 = \frac{G\hbar}{c}\cdot\frac{M}{8\pi^2} \tag{13}$$

Then quantum gravitational potential in five dimensional space time is given by

$$U_5(r) = \frac{G\hbar}{c}\frac{1}{2}\frac{M}{r^2} \tag{14}$$

and corresponding quantum gravitational force is

$$\vec{F}_5(r) = -\nabla U_5(r) = \frac{G\hbar}{c}\frac{M}{r^3}\vec{n} \tag{15}$$

which is used in [3], where $\vec{n} = \vec{r}/r$ is the unit vector.

3. Quantum Gravitational Potential in Six-Dimensional Spacetime

In the case of $D = 6$, the formula (6) takes the form

$$U_6(r) = A_6\int \frac{d^5p}{p^2}e^{i\vec{p}\cdot\vec{r}} = A_6\cdot 2\pi\cdot 2\cdot\frac{1}{2}\pi\int_0^\infty dp\cdot p^2\cdot 2\int_0^1 dx\cos(prx)(1-x^2), \tag{16}$$

where

$$\mathcal{L}_6 = 2\int_0^1 dx\cos(prx)(1-x^2) = \frac{2\sqrt{2\pi}}{(pr)^{3/2}}J_{3/2}(pr). \tag{17}$$

Further, we use the following integral

$$\int_0^\infty dpp^{1/2}J_{3/2}(pr) = \frac{1}{2}\frac{\sqrt{2\pi}}{r^{3/2}} \tag{18}$$

Then, potential (16) takes the form in six-dimensional spacetime

$$U_6 = A_6\cdot\frac{4\pi^3}{r^3} \tag{19}$$

If we choose constant A_6 in the form

$$A_6 = \frac{1}{12\pi^3}\cdot\frac{G\hbar^2}{c^2} \tag{20}$$

Then we have quantum gravitational potential force in the form

$$F_6 = -\nabla U_6(r) = \frac{G\hbar^2}{c^2}\frac{1}{r^4} = 1.41\times 10^{44}N \tag{21}$$

which is used in [3] as a drift force for expanding universe, where $r = L_{Pl}$ is the Planck length. An another choice for A_6:

$$A_6 = \frac{1}{12\pi^3}\frac{G^2\hbar}{c^3}M^2 \tag{22}$$

for some body with mass M leads to other quantum gravitational force in $D = 6$ spacetime case

$$\overleftarrow{F}_{6'} = \frac{G^2\hbar}{c^3}\frac{M^2}{r^4}\overleftarrow{n}. \tag{23}$$

4. Quantum Gravitational Potential in Seven-Dimensional Spacetime

In this case, the general formula (6) for definition of the potential reads

$$U_7(r) = A_7\int_0^\infty dp\frac{p^5}{p^2}\cdot 2\pi\cdot 2\cdot\frac{1}{2}\pi\int_{-1}^1 dy(1-y^2)\times\int_{-1}^1 dxe^{iprx}(1-x^2)^{\frac{3}{2}}, \tag{24}$$

where

$$\mathcal{L}_7 = \int_{-1}^1 dxe^{iprx}(1-x^2)^{\frac{3}{2}} = 2\int_0^1 dx\cos(prx)(1-x^2)^{\frac{3}{2}} = \frac{3\pi}{p^2r^2}J_2(pr). \tag{25}$$

Further, we use the formula

$$\int_0^\infty dp\cdot p\cdot J_2(pr) = \frac{2}{r^2}. \tag{26}$$

Finally, we have

$$U_7(r) = \frac{16\pi^3}{r^4}A_7, \tag{27}$$

where

$$A_7 = \frac{1}{64\pi^3}\cdot\frac{G^2\hbar^2}{c^4}M. \tag{28}$$

Therefore, for $D = 7$, quantum gravitational force takes the form

$$\overleftarrow{F}_7 = \frac{G^2\hbar^2}{c^4}\frac{M}{r^5}\overleftarrow{n} \tag{29}$$

for a some body with the mass M.

5. Quantum Gravitational Potential in Eight-Dimensional Spacetime

In this case, from the general formula (6) we have

$$U_8(r) = A_8\int\frac{d^7p}{p^2}e^{ipr} = \frac{8}{3}\pi^2A_8\int_{-1}^1 dx(1-x^2)^{3/2}\times\int_{-1}^1 dxe^{iprx}(1-x^2)^2$$

where

$$\mathcal{L}_8 = \int_{-1}^1 dxe^{iprx}(1-x^2)^2 = 2\int_0^1 dx\cos(prx)(1-x^2)^2$$
$$= 2\cdot\frac{\sqrt{\pi}}{2}\left(\frac{2}{pr}\right)^{\frac{5}{2}}\Gamma\left(\frac{5}{2}+\frac{1}{2}\right)J_{5/2}(pr). \tag{30}$$

Here

$$\int_0^\infty dp\cdot p^{3/2}J_{5/2}(pr) = 2^{3/2}\frac{r^{-5/2}\Gamma\left(\frac{1}{2}+2\right)}{\Gamma(1)}. \tag{31}$$

and

$$\int_{-1}^1 dx(1-x^2)^{3/2} = 2\int_0^1 dx(1-x^2)^{3/2} = \frac{3}{8}\pi. \tag{32}$$

Similar calculation reads

$$U_8(r) = \frac{24\pi^4}{r^5}A_8 \tag{33}$$

If we choose

$$A_8 = \frac{1}{120\pi^4}\frac{G^3\hbar^2}{c^6}M^2 \tag{34}$$

and then we have

$$\overleftarrow{F}_8(r) = -\nabla U_8(r) = \frac{G^3\hbar^2}{c^6}\frac{M^2}{r^6}\overleftarrow{n} \tag{35}$$

quantum force acting in eight-dimensional spacetime.

6. Quantum Gravitational Potential in Nine-Dimensional Spacetime

In this case, the formula (6) has the form

$$U_9(r) = A_9 \cdot \frac{8\pi^2}{3} \int dp \frac{p^7}{p^2} \int_{-1}^{1} dx(1-x^2)^{3/2} \times \int_{-1}^{1} dx(1-x^2)^2 \times \int_{-1}^{1} dx e^{iprx}(1-x^2)^{5/2}, \tag{36}$$

where

$$\mathcal{L}_9 = \int_{-1}^{1} dx e^{iprx}(1-x^2)^{5/2} = 15\pi \frac{1}{p^3 r^3} J_3(pr) \tag{37}$$

and

$$\int_{-1}^{1} dx(1-x^2)^2 = \frac{2}{2} B\left(\frac{1}{2}, 3\right) = \frac{\Gamma\left(\frac{1}{2}\right)\Gamma(3)}{\Gamma\left(\frac{1}{2}+3\right)} = \frac{16}{15},$$

$$\int_0^\infty dp p^2 J_3(pr) = 4r^{-3} \frac{\Gamma(3)}{\Gamma(1)}.$$

Collecting all above calculations, we have

$$U_9(r) = A_9 \cdot \frac{128}{r^6} \pi^4. \tag{38}$$

Here we assume

$$A_9 = \frac{1}{6 \cdot 128 \pi^4} \frac{G^4 \hbar^2 M^3}{c^8}.$$

and obtain quantum gravitational force in nine-dimensional spacetime

$$\overleftarrow{F}_9(r) = \frac{G^4 \hbar^2}{c^8} \frac{M^3}{r^7} \overleftarrow{n} \tag{39}$$

7. Quantum Gravitational Potential in Ten-Dimensional Spacetime for the String Theory

Here the general formula (6) for definition of potentials reads:

$$U_{10}(r) = A_{10} \cdot \frac{8\pi^2}{3} \int_0^\infty dp \frac{p^8}{p^2} \int_{-1}^{1} dx(1-x^2)^{3/2} \times \int_{-1}^{1} dx(1-x^2)^2 \int_{-1}^{1} dx(1-x^2)^{5/2} \times \int_{-1}^{1} dx e^{iprx}(1-x^2)^3, \tag{40}$$

where

$$\mathcal{L}_{10} = \int_{-1}^{1} dx e^{iprx}(1-x^2)^3 = 48\sqrt{2\pi}(rp)^{-7/2} J_{7/2}(pr) \tag{41}$$

and

$$\int_0^\infty dp p^{5/2} J_{7/2}(pr) = 2^{5/2} r^{-7/2} \frac{15}{8} \sqrt{\pi},$$

$$\int_{-1}^{1} dx(1-x^2)^{7/2-1} = \frac{\Gamma\left(\frac{1}{2}\right)\Gamma\left(\frac{7}{2}\right)}{\Gamma(4)} = \frac{5}{16}\pi.$$

Finally, we have

$$U_{10}(r) = 30\sqrt{2}\pi^5 \cdot \frac{1}{r^7} \cdot A_{10} \tag{42}$$

If we assume

$$A_{10} = \frac{1}{210\pi^5\sqrt{2}} \frac{G^5 \hbar^2}{c^{10}} M^4 \tag{43}$$

then quantum gravitational force acting in 10-dimensional spacetime is given by

$$\overleftarrow{F}_{10}(r) = -\nabla U_{10}(r) = \frac{G^5 \hbar^2}{c^{10}} \frac{M^4}{r^8} \overleftarrow{n}. \tag{44}$$

8. Quantum Gravitational Potential in Eleven-Dimensional Spacetime for M-Theory

Definition of the potential for 11-dimensional spacetime is

$$U_{11}(r) = A_{11} \int dp \cdot \frac{p^9}{p^2} \cdot \frac{8\pi^2}{3} \cdot \int_{-1}^{1} dx(1-x^2)^{3/2} \times \int_{-1}^{1} dx(1-x^2)^2 \int_{-1}^{1} dx(1-x^2)^{5/2} \times \int_{-1}^{1} dx(1-x^2)^3 \times \int_{-1}^{1} dx e^{iprx}(1-x^2)^{7/2}, \tag{45}$$

where

$$\mathcal{L}_{11} = \int_{-1}^{1} dx e^{iprx}(1-x^2)^{7/2} = \sqrt{\pi} \frac{2^4}{p^4 r^4} \Gamma\left(4 + \frac{1}{2}\right) J_4(pr) \tag{46}$$

and

$$\int_0^\infty dp \cdot p^3 J_4(pr) = 48\frac{1}{r^4}, \quad (47)$$

$$\int_{-1}^1 dx(1-x^2)^3 = B\left(\frac{1}{2},4\right) = \frac{\Gamma\left(\frac{1}{4}\right)\Gamma\left(\frac{1}{2}\right)}{\Gamma\left(\frac{1}{2}+4\right)} = \frac{32}{35}.$$

Thus, after some calculations we have

$$U_{11}(r) = A_{11} \cdot 48 \cdot 32 \cdot \pi^4\sqrt{\pi} \cdot \frac{1}{r^8}. \quad (48)$$

If we choose

$$A_{11} = \frac{1}{8\cdot 48\cdot 32\cdot \pi^4\sqrt{\pi}}\frac{G^6\hbar^2}{c^{12}}M^5 \quad (49)$$

then we have quantum gravitational force acting in 11-dimensional spacetime for M-theory:

$$\overleftarrow{F}_{11}(r) = -\nabla U_{11}(r) = \frac{G^6\hbar^2}{c^{12}}\frac{M^5}{r^9}\overleftarrow{n}. \quad (50)$$

It is very singular theory.

9. Numerical Values of Constants for Quantum Gravitational Interactions

As shown above, if we can construct quantum gravitational interactions then those constants are very small depending on spacetime dimensions. We define these constants in analogy with electro-magnetic interaction, where the Lorentz force is given by the formula

$$\overleftarrow{F}_L = e\overleftarrow{E}, \quad (51)$$

where an electric field is

$$\overleftarrow{E} = -grad\varphi, \quad \varphi = \frac{e}{r}. \quad (52)$$

Comparing these two formulas (51) and (52) with the quantum gravitational force (15) for five-dimensional spacetime case, one gets

$$g_5 = \left(\frac{G\hbar}{c}\right)^{1/2} = 4.8454 \times 10^{-27}\left[\frac{m^2}{sec}\right] \quad (53)$$

for a constant of quantum gravitational interaction acting in five-dimensional spacetime. Numerical quantities of constants for other dimensional spacetime cases acquire the formulas:

- For $D = 6$

$$g_6 = \sqrt{\frac{G\hbar}{c}} \cdot \sqrt{\frac{\hbar}{c}} = 2.874 \times 10^{-48}\left[\frac{m^2}{sec}\right]\left[\sqrt{kg \cdot m}\right] \quad (54)$$

and

$$g_{6'} = \sqrt{\frac{G\hbar}{c}} \cdot \frac{\sqrt{G}}{c} = 1.32 \times 10^{-40}\left[\frac{m^2}{sec}\right]\left[\frac{\sqrt{m}}{\sqrt{kg}}\right]. \quad (55)$$

- For $D = 7$

$$g_7 = \frac{G\hbar}{c} \cdot \frac{1}{c} = 7.83 \times 10^{-62}\left[\frac{m^3}{sec}\right]. \quad (56)$$

- For $D = 8$

$$g_8 = \frac{G\hbar}{c} \cdot \frac{\sqrt{G}}{c^2} = 2.134 \times 10^{-75}\left[\frac{m^3}{sec}\right]\sqrt{\frac{m}{kg}}. \quad (57)$$

- For $D = 9$

$$g_9 = \frac{G\hbar}{c} \cdot \frac{G}{c^3} = 5.816 \times 10^{-89}\left[\frac{m^4}{kg \cdot sec}\right]. \quad (58)$$

- For $D = 10$

$$g_{10} = \frac{G\hbar}{c} \cdot \frac{G\sqrt{G}}{c^4} = 1.5848 \times 10^{-102}\left[\frac{m^4}{sec \cdot kg}\right]\sqrt{\frac{m}{kg}}. \quad (59)$$

• For $D = 11$

$$g_{11} = \frac{G\hbar}{c} \cdot \frac{G^2}{c^5} = 4.319 \times 10^{-116} \left[\frac{m^5}{kg^2 \cdot sec}\right]. \tag{60}$$

All these dimensional constants are externally very small and therefore they can not play a role in true coupling constant in quantum gravitational theory.

We propose true dimensional coupling constant for quantum gravitational theory, which is given by the following expression

$$g_{true} = \frac{G}{c^2}\sqrt{G\hbar c} = 1.08 \times 10^{-45} \frac{m^4}{kg \cdot sec^2}. \tag{61}$$

According to the general formulas (14) and (15) we see that this coupling constant works in five-dimensional spacetime with potential form

$$U_{5'}(r) = g_{true} \cdot \frac{1}{r^2} \tag{62}$$

and acting force is given by the formula

$$\overleftarrow{F}_{5'}(r) = g_{true} \frac{M_1 \cdot M_2}{r^3} \overleftarrow{n} \tag{63}$$

for two bodies with masses M_1 and M_2.

In conclusion, we notice that quantum gravitational effects appear only in the Big Bang process, in near horizon of black holes with many billions and trillions sun's masses and in the merging of a binary black hole system to produce gravitational waves.

It turns out that unification of Newtonian gravity and quantum gravitational theory takes place in a domain determined by the Planck length, in particular Newtonian force and quantum gravitational force (63) exactly coincide at the Planck length:

$$g_{true} \cdot \frac{M_1 M_2}{R^3} = G \frac{M_1 M_2}{R^2}, \tag{64}$$

for any two particles or bodies with mass M_1 and M_2. Where

$$R = L_{Pl} = \sqrt{G\hbar/c^3}, \quad \frac{g_{true}}{L_{Pl}} = \frac{G}{c^2}\frac{\sqrt{G\hbar c}}{L_{Pl}} \equiv G. \tag{65}$$

In this connection, notice that according to S.Hawking [4], in principle, one can freely travel to different worlds with different spacetime dimensions through the Planck-hole-tunnel with size $L_{Pl} = 1.6162 \times 10^{-35} m$.

Appendix 1

10. Two Stages for Origin of Gravitational Waves and Daughter Big Bang Like Processes

We know that in our twenty first century astrophysical and cosmological phenomena play a vital role in human being's scientific achievements. Indeed, first direct detection of gravitational waves in 14 September 2015 and demonstration of a visible picture of the gigantic black hole with mass of 6.5 billion times of solar mass and located at 55 million light years from us are only striking examples of these achievements.

The gravitational wave signals are originated from the merger of two black holes with masses $M_1 = 36M_{\odot}$ and $M_2 = 29M_{\odot}$. Now we want to calculate the gravitational wave signal carried the energy by using the Newtonian and quantum gravitational potentials (4) and (62) with gravitational constants (5) and (61).

First scene for rising of gravitational waves is caused by usual classical Newtonian gravitational theory and is based on traditional concept of scattering or merger phenomena of cosmic objects like black holes. Second scene for gravitational wave is more deeper and originated from the distortion of spacetime structure and from perturbation of quantum gravitational basic state-vacuum. For some extermal situations, first scene for rising of gravitational waves plays a role as cause of beginning of second stage, i.e., it leads to change of spacetime dimensions from four to five dimensions. We would like to study these two stages separately.

Thus, for first scene, by analogy with classical electrodynamics for a system of massive bodies gravitational radiation is caused by changing of gravitational moments for this system with times.

Moving massive body radiates gravitational waves if its acceleration does not zero. Then lost of energy I by this body per unit time is given by the formula

$$I = \frac{2}{3c^3} GM^2 \left|\frac{d^2 r}{dt^2}\right|, \tag{66}$$

where M is mass of a body and G is determined by the formula (5).

For two bodies with masses M_1 and M_2 those acceleration under mutual attractive Newtonian force is given by

$$(M_1 + M_2)\frac{d^2r}{dt^2} = 2G\frac{M_1M_2}{r^2}. \tag{67}$$

in the system of center inertia.

Here r is a distance between these two bodies. After some elementary calculations we have

$$I = \frac{2}{3}\frac{G^3}{c^3}\frac{M_1^2+M_2^2}{(M_1+M_2)^2}\frac{M_1^2M_2^2}{r^4}, \tag{68}$$

where for two black holes with masses: $M_1 = 29M_\odot$ and $M_2 = 36M_\odot$ and $r = 6.37 \cdot 2R_\odot$ is a minimal distance at the moments of merger and $2R_\odot = 1.39 \times 10^9 m$ is the diameter of Sun. Here $(29^{1/3} + 36^{1/3} = 6.37)$.

Numerical calculations give quantity of energy lost for two black holes:

$$I = 1.056 \times 10^{31} Watts. \tag{69}$$

Since age of merger is approximately $t_m = 1.3$ billion years or $4.09968 \times 10^{16} sec$, then at initial stage of merger for two black holes, the gravitational wave signal carried the energy is

$$E = I \cdot t_m = 4.33 \times 10^{47} Joules. \tag{70}$$

It is mentioned that other authors calculations [5] are

$$E_{other} \sim 5 \times 10^{47} Joules, \tag{71}$$

coinciding with our result. Indeed, due to merger of two black holes if three solar masses are disappeared then according to Einstein's formula one gets radiation carried energy (70) for gravitational waves:

$$E_4 = 3M_\odot c^2 = 5.4 \times 10^{47} Joules. \tag{72}$$

As the second scene for quantum gravitational case in five dimensional spacetime formulas (66) and (68) takes the forms:

$$I_5 = \frac{2}{3c^3}\frac{g_{true}\,M^2}{r}\left|\frac{d^2r}{dt^2}\right|^2, \tag{73}$$

and

$$I_5 = \frac{2}{3c^3}\frac{g_{true}^3}{r}\frac{M_1^2M_2^2}{(M_1+M_2)^2}\frac{(M_1^2+M_2^2)}{r^6}, \tag{74}$$

where g_{true} is given by expression (61) and for vacuum perturbation in quantum gravitational theory, we propose that

$$r = L_{Pl} = 1.6162 \times 10^{-35} m.$$

Then numerical calculation for merger of two black holes with masses $M_1 = 29M_\odot$ and $M_2 = 36M_\odot$ leads to enormous quantities:

$$I_5 = 9.546 \times 10^{209} Watts \tag{75}$$

and

$$E_5 = 3.913 \times 10^{226} Joules. \tag{76}$$

It means that for some unusual situations, it is possible to passage from two black holes' merger governing by classical gravitational theory as an atomic bomb in quantum physics to distortion of spacetime structure from four to five dimensions and to perturbation of gravitational vacuum leading to gigantic explosion as more powerful hydrogen bomb in atomic phenomena.

We call it as the appearance of a daughter Big Bang like process in sky. In other words merging black holes are gained energy from gravitational vacuum.

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