On possibility of sensibility gain
when gravitational waves are received from distant cosmos

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A method of gravitational wave (GW) detection, in which a running electromagnetic wave (EMW) propagates in the same direction as GW, was considered. The method unlike the known system, based on the interferometer with a standing wave, has a number of advantages. It doesn't need for optical length and operating frequency to be constant in the method with a running wave. It was shown that availability of additional information about a source allows increasing the receiving sensibility sharply. Problems of finding GW sources in our Galaxy, necessary space equipment and its possible applications are discussed in the work.

1. At present the problem of GW detection is widely discussed [1-2]. In the pioneer works of Weber [3] mechanical tensions inside of a stretched body for GW detecting with a capacity bias detector were measured [4]. Today the GW detection method by measuring small oscillations of a distance between two mirrors, which was suggested the authors of the work [5], underlies contemporary projects [1-2]. Classification of methods of GW detection was suggested in the work [6]. Let us notice that at the work [5] a measurement result was estimated due to the effect of direct interaction between a GW and a EMW in the vacuum, but no due to motion of interferometer mirrors. Both interpretations, in a special case, for small length of a ray in interferometer have the same results. We will take a field point of view, by considering wave interaction in the vacuum. This allows using all results of the theory of wave interactions and diffraction [7-11]. From the point of view an interaction between an interferometer and GW leads to the effective signal – to the path difference which is equal to $L_{gr} \approx hL$, where L is a distance between mirrors, h is an amplitude of GW (the amplitude of metric disturbance). To detect the effective signal it is necessary that the operating frequency of a signal would be constant and parasitic beatings of L don't exceed the L_{gr}.

Recently a method for GW detection in distant cosmos [12], which is free from the above lacks. The method is based on an interaction between a running EMW and a GW, which propagate in one direction. The effective signal in the method with a running wave is phase raid of an EMW which depends on mutual orientation of polarizations for a GW and an EMW. This method may be applied if the location of a source is known. The length of the interaction between a GW and an EMW may be considerably longer than in an interferometer, and thereby we have a possibility to gain sensibility.

A GW is characterized by Hermit matrix with the null trace

$$H = \begin{Vmatrix} h_1 & h_2 \\ h_2 & -h_1 \end{Vmatrix}, \; h^2 = h_1^2 + h_2^2 \qquad (1)$$

and has two transverse polarizations at the place of reception, which are defined with processes in a source.

The astrophysical prediction of the magnitude h is not exactly defined. It can be found as $h \approx 10^{-16}$ in the Weber's experiments, the magnitude $h \approx 10^{-21}$ is expected in the project LIGO-I [1-2]. The prediction h for GW from the pulsar in Crab Nebula is $h \approx 10^{-24}$ [11]. Without discussing truth of a prediction, let us consider $h \approx 10^{-24}$ as a sensibility threshold which is desired to reach.

Let us consider other possible GW sources, located close. The close double system of the two stars $SS433$ is interesting that it vents gas jets. The mechanism of the jet formation can be linked with the presence of the close double system [12]. The potential of a gravitational field in the center of gravity of the stars depends on time: when the stars are very close the potential hole is deeper. The potential has a minimum along the line passing through the center of gravity and being perpendicular to the orbit plane, and the potential has a maximum in the orbit plane. If a particle of substance moves along a perpendicular and falls in a deep hole, but exits from a shallow hole, so it obtains energy. When it deviates from the perpendicular, it early or lately will fall on one of the stars. Therefore, the jets are narrow.

If the prediction of jet formation is true, so, having defined variability in optical lines of jets, we can make the matrix H to be known. With accuracy up to parameters we know its Fourier-series expansion and polarization of each harmonics of a GW. Therefore, it is known the EMW polarizations for which phase raid is equal to $\pm hkL$, $h = h(t)$, where k is a wave vector of a radio wave, L is length of the trace between transmitting and receiving space crafts. More over, there is a GW with the polarization that the GW doesn't contribute a phase shift, i.e. there is a signal standard, which would be if there was no a GW. To detect a GW we should measure EMW phase modulation, which was caused by a GW.

2. Let us consider energy relations. Energy flux density of a gravitational wave is equal to [13]:

$$\frac{dE_{gr}}{dS\,dt} = \frac{c^3}{16\pi G} h^2 \omega^2 , \tag{2}$$

where ω is gravitational wave frequency, G is the gravitational constant. Therefore, we have for the power of an isotropic radiation:

$$P_{gr} = \frac{dE_{gr}}{dt} = \frac{c^3 h^2 \omega^2 R^2}{4G}, \tag{3}$$

where R is distance to a source. A real radiation has some gain due to the directivity diagram in a reception direction, which we don't consider. It is profitable to take a gravitational wave source, which is directed on the Earth in the maximum of its directivity diagram. Spatial orientation of an astrophysical source can be defined with the method, offered in the work [14].

The phase raid of an electromagnetic wave is equal to

$$\varphi = hkL, \tag{4}$$

where k is the wave vector of an electromagnetic wave, L is length of a interaction field. Therefore, the power of a effective signal – spectral components of modulation is equal to:

$$P_{ps} = \varphi^2 P_{el} = h^2 (kL)^2 P_{el}, \tag{5}$$

where P_{el} is electric power at the entrance of a receiver. The power can be expressed with the power of a transmitter P_{rad} and diameters of antennas. In the wave zone the effective signal is

$$P_{ps} = P_{rad} \frac{\pi^4}{8} \left(\frac{D_1 D_2}{\lambda^2} \right)^2 h^2 , \tag{6}$$

where λ - is the radio-signal wave length, D_1 and D_2 are diameters of receiving and transmitting antennas, respectively. Large values of the relation D/λ lead to narrow beam and demand for antenna orientation to be fine adjusted.

Let us compare the power (6) with the receiver noises power. The power of receiver noises is equal to $\kappa T_N B$, where B is the frequency bar, which is inversely proportional to storage time, T_N is the noise temperature of the receiver. As the temperature of an antenna can be low, it is possible that $T_N < 300^\circ K$. Numerical estimations will be presented below.

3. The main astrophysical problem, when P_{gr} is estimated, is that the relativistic task for two bodies has not been solved now. Also the principal questions, linked with arising complex non-stationary topology in strong fields, has not been decided. As to the existing projects scientists hope that the considerable part of rest energy (the estimation about $\Delta\varepsilon_0/\varepsilon_0$>0,3) will turn into gravitational radiation energy when two dense bodies collide (or merge). The expected duration of an impulse of gravitational waves is in order r_g/c, where r_g is a gravitational radius. We would like to express our doubts in correctness of the above statements as to energy and duration:

3.1. The gravitational radiation is quadruple that, but there is no quadruple moment at all: $\varepsilon_0 \approx 0$, when percussion is central.

3.2. A neutron star consists of nuclear substance, so it can be considered as a unit nucleus with tremendous atomic weight $A = 10^{56}$. When nucleuses with high energy collide, jets of nuclear substance and hard radiation forms, and therefore there are no reasons to expect high energy of gravitational radiation. As example, when the supernova SN1987A flashed, the energy was given off as γ-radiation and neutrino.

3.3. A static black hole accordingly the traditional point of view is a gravitational "grave" for matter, quanta of a gravitational and electromagnetic radiation. Hence, we don't know answer to the question: in which cases gravitational radiation doesn't hit a black hole. It should be studied.

3.4. A behavior of a trial particle in a field of a dynamic black hole is more complicated than in a field of a static black hole. There is a class of trajectories, when a particle goes under the horizon and then exists again. In the case, the process lasts longer than the characteristic time r_g/c, the impulse is stretched, its sharp changes, and the average power in time reduces. How such impulse can be distinguished on the noise background?

We would like to emphasize that the doubts follows from the known observed facts. There were many discussions on the topic, but despite of common opinion that gravitation radiation exists it is not convincing.

4. Let us consider double systems. In double systems the above doubts fail. Energy receive in the double system with mass m can be estimated with the upper limit $\approx mc^2$. We think that the estimation is strongly overstated. For the mass of the solar system $mc^2 \approx 10^{54}$ erg. The energy flow at the Earth is equal to:

$$\varepsilon = \frac{10^{54}}{4\pi R^2} \frac{\Delta\varepsilon_0}{\varepsilon_0} \frac{\tau}{T} \frac{\text{ýðã}}{\text{ñì}^2} . \tag{7}$$

Here τ is measurement time, T is duration of the active stage of emission $(\tau << T)$. The time of energy loss can be estimated if we know revolution frequencies – frequencies of optical variability and masses of stars. The formula for energy loss in approximation for circular orbits [13] can be led to the view:

$$\frac{d\varepsilon}{dt} = \frac{16}{5}\varepsilon \frac{r_{g_1} r_{g_2}}{r^2} \frac{r\omega^2}{c}; \ \varepsilon = -\frac{Gm_1 m_2}{2r}, \tag{8}$$

where

$$r_{g_1} = \frac{2Gm_1}{c^2}, \quad r_{g_2} = \frac{2Gm_2}{c^2}$$

are gravitational radiuses of stars – components of a double system, r is distance between masses, ω is revolution frequency, ε is the total energy of the double system. The formula (8) was deduced on the basis of the Newtonian mechanics, although, it is written in relativistic designations. The applicability limit is convenient to write in a view:

$$r > \beta\sqrt{r_{g_1} r_{g_2}}; \quad \beta > 2. \tag{9}$$

The dimensionless coefficient β depends on masses and ellipticity of orbits, and it can be defined only from the exact solution, which is not known. We can hope that $\beta < 10$. If we substitute the applicability limit in the expression for the total energy of a system, we will obtain the energy

$$\varepsilon = -\frac{\sqrt{m_1 m_2}}{4\beta} c^2, \tag{10}$$

which is essentially less than the rest energy.

Forming of jets is connected with the double system of massive dense stars, have been formed with collapse of a high rotating star. And the formula (9) is relative to the system. As we cannot calculate the system today, so the question arises: is it is possible to define its parameters using the observation data? Optical spectra of the dense object are not observed, but we can observe jets and their optical variability. By using the optical variability we can define ω, if we know that mass is in order of several solar-masses, we can find r. We hope that the information allows getting data of power of gravitational radiation.

Thus, at first it is necessary to search possible sources of gravitational waves by astronomic methods, using the next criteria of selection:

- small distance to the Earth,
- availability of jets,
- high frequencies of optical or X-ray variability,
- favorable orientation of an orbit relative to the direction to the Earth.

We think that quantity estimations can be done after processing the astronomic information. But we will try to estimate beforehand. Let turn our attention to the formula (6), having taken $h = 10^{-24}$, $P = 1\ kWt$, $D/\lambda = 10^4$, then $P_{ps} = 1{,}25 \times 10^{-28}\ Wt$. Let us take, for example, accumulation time a year ($3{,}7 \times 10^7\ s$). When a radio signal with the known phase, it corresponds to the band $1{,}6 \times 10^{-8}\ Hz$ and the threshold signal $10^{-29}\ Wt$. Thus, with $h = 10^{-24}$ the expected relation signal-to-noise is 10 dB. The estimation don't give reasons for pessimism, at though it costs to emphasize that, namely, the astrophysical part is the least reliable.

5. The expected applied results. The scientific aspect of importance of the gravitational wave detection was discussed many times, but expensive scientific projects are accomplished in the case when other important applied tasks can be solved at the same time. To carry out such a project it is necessary to create corresponding equipment:

- space-based high-velocity electric propulsions, including for an orientation system, [15-17];
- power space-based electric sources [17];
- long-base antennas, made in weightlessness [18].

The equipment has different applications. One of them is creating the protection system of the Earth from asteroids [20]. It costs remember that in 2002 the number of asteroids, which passed close to the Earth, were more than the predicted number, and they were detected to late. In the work [15] space-based high-velocity electric propulsions were considered, a compatible propulsion for an orientation system with low power consumption can be made using the same principle.

The protection system of the Earth from asteroids includes a reliable early warning system and an active effect [19]. Up-date ground-based systems [20] provide warning lately and unreliable. We think that the system will be essentially cheaper.

The second application is space burying of radioactive waste. The solution of the problem of burying can be safer, if dual-fuel propulsions are used. In the case combustible and oxidant are spatially separated, and so an explosion is excluded. Further by using a space-based propulsion [15], radioactive waste can be sputtered far beyond the Solar system.

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