WHITE AND GREY HOLES IN ASTROPHYSICS

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Abstract. Astrophysical applications of white and grey holes are considered. Four types of anticollapsars in extended manifolds of general relativity are distinguished: canonical white and grey holes, light- and dark-grey holes. White and grey holes can be revealed in the form of bursts of gravitational and electromagnetic radiation, neutrino, and cosmic rays. Quasars, active galactic nuclei, jets, and cosmic voids can be associated with relicts of white and light-grey holes, and black holes do with relicts of canonical grey and dark-grey holes.

1. Introduction

The legitimacy of application of general relativity (GR) for astrophysics and cosmology is generally acknowledged (Weinberg, 1972). Black holes (Chandrasekhar, 1983) acquired a major popularity in astrophysics (Blandford and Thorne, 1979; Shapiro and Teukolsky, 1983). Antipodes of black holes, white holes (Penrose, 1979) are of no lesser interest for high-energy astrophysics (Narlikar *et al.*, 1974; Narlikar and Apparao, 1975; Trofimenko and Gurin, 1986), but heuristic possibilities of white holes are not used in a necessary measure. Models of grey holes, oscillating objects, were not considered practically as applications for astrophysics. Grey holes are a combination of white and black hole properties (Zel'dovich and Novikov, 1971). Black, white, and grey holes belong to the more wide class of theoretical relativistic objects, otons, possessing event horizons (Zel'dovich and Novikov, 1971).

The first version of the white hole origin (Novikov, 1964; Ne'eman, 1965) as explosive nuclei of matter from under their gravitational radius, which is retarded in the general cosmological expansion, encountered a number of difficulties (Novikov and Frolov, 1986; Trofimenko and Gurin, 1986). The second version of the white hole origin (Trofimenko, 1978) is based on consideration of anticollapsing objects in extended space-time manifolds (ESTM) of GR (Hawking and Ellis, 1973). In the second (otonic, transmetagalactic) version not only difficulties in the white hole existence problem are eliminated (Trofimenko and Gurin, 1989) inherent to the 'retarded cores' model, but also the range of possible astrophysical applications of otonic models are extended (Trofimenko, 1978).

In the present work the range of astrophysical applications of white holes is extended due to involvement of new cosmic phenomena, and application of grey holes and their relicts are considered for the first time. The four types of anticollapsars in ESTMs are distinguished and investigated: canonical white and grey holes, light-grey and dark-grey holes. Immediate manifestations of white and grey holes in the form of transient ($t \sim r_g/c$) radiation bursts are considered (gravitational, neutrino, electromagnetic

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gamma-bursts). Cosmic voids, intergalactic X-ray gas with abundance of heavy elements, etc., are associated with white hole relicts; quasars and active galactic nuclei, jets, search-lights, etc., do with light-grey holes. Black holes and semi-closed worlds are relicts of canonical grey and dark-grey holes, respectively, which make the wider astrophysical applications of black holes (hidden mass, primordial inhomogeneities, millisecond pulsars).

2. Anticollapsing Objects in Extended Space-Time: the Second Way of White Hole Formation

The Kerr–Newman metric is the theoretical basis of white and grey hole models construction. In the oblate quasi-spheroidal Boyer–Lindquist coordinates it is described in the following form (here the geometrized units are used, $c = G = 1$):

$$\begin{aligned} \mathrm{d}s^2 = & -(\Delta/\rho^2)(\mathrm{d}t - \sin^2\theta\,\mathrm{d}\phi)^2 + (\Delta/\rho^2)^{-1}\,\mathrm{d}r^2 + \\ & + \rho^{-2}\sin^2\theta[a\,\mathrm{d}t - (r^2 + a^2)\,\mathrm{d}\phi]^2 + \rho^2\,\mathrm{d}\theta^2\,; \end{aligned} \tag{1}$$

$$\Delta = r^2 - 2Mr + Q^2 + a^2\,; \tag{1a}$$

$$\rho^2 = r^2 + a^2\cos^2\theta\,, \tag{1b}$$

where M is the total mass of oton, Q is its charge, a does rotating momentum per unit mass, and Δ is the horizontal function.

Surfaces of event horizons for the metric (1) are defined by the expression in the usual units:

$$R_\pm = GM/c^2 \pm [(GM/c^2)^2 - GQ^2/c^4 - a^2/c^2]^{1/2}\,, \tag{2}$$

where R_+ is the external event horizon, R_- is the inner one.

Surfaces of infinite shifts are defined by

$$r_\pm = GM/c^2 \pm [(GM/c^2)^2 - GQ^2/c^4 - (a^2/c^2)\cos^2\theta]^{1/2}\,, \tag{3}$$

r_+ is the infinite red-shift surface, r_- does the infinite blue-shift one. The STM region between R_+ and r_+ surfaces is referred to as the ergosphere. The structure of STM appears non-trivial due to the pseudo-singular surfaces. In the case of a Kerr oton ($M \neq 0$, $a \neq 0$, $Q = 0$) the picture qualitatively is the same, since from (2) and (3) $r_+ = R_+$ and $R_- = r_-$, i.e., event horizon surfaces coincide with coresponding shifts surfaces. Thus, the condition $a = 0$ makes the STM structure more poor: only two peculiar surfaces remain, which unit properties of horizons and infinite shifts surfaces. For the Kerr–Newman otons this coincidence occurs only along the symmetry axis ($\theta = 0$).

Lastly, for a Schwarzschild oton the single pseudo-singular surface occurs: $r_+ = R_+ = R_g$, R_g is the gravitational radius, which has the value

$$R_g = \frac{2GM}{c^2}\,. \tag{4}$$

The second peculiar surface ($r_- = R_- = 0$) coincides with the point of true singularity. This simplest Schwarzschild metric, which has most poor STM structure, was used for construction of the first white hole model as 'retarded cores'. It is not surprising, therefore, that this model abstracting from such universal properties of cosmic objects as rotation collides on a number of theoretical difficulties.

The most realistic model of an otonic white hole is associated with the Kerr ESTM, since all known astrophysical objects possess rotation. Let us consider the Penrose diagram for the Kerr ESTM along the symmetry axis (Figure 1), that gives the qualitative picture on the ESTM's global structure (in the general case its analysis is complicated technically).

Taking into account results of extended relativity, an arbitrary region of the Kerr ESTM M which is separated by event horizons from another one, can be denoted by the general symbol (cf. Trofimenko, 1986, 1988)

$$M^k_{(P)}, \tag{5}$$

where $P = (i)^N$ (N is the number of event horizons separating an arbitrary M from on originate M_+), $-\infty < k < +\infty$.

Since k is not restricted, one can be unlimitedly number of regions by the type of $M(+)$. Each region ought to be an independent world (Trofimenko, 1978), which is similar to our metagalaxy. However, it is necessary to note, each $M(+)$ to be in the case of such interpretation a curved rather than asymptotically flat space-time (spherical or pseudo-spherical Friedmann world with 'holes'). In the pseudo-spherical case this circumstance will hardly change the Kerr STM global structure, since the region $M(+)$ is approached to the flat one asymptotically. The spherical case connected with the 'Big Crack' epoch requires a special analysis.

From the fact that a number of black holes exist in our metagalaxy one can conclude about the impressive diversity of worlds connected one with another through wormholes (otons). They were called otonic (Trofimenko, 1978). One can give the following definition: the otonic world is an independent STM restricted by event horizons with matter in it.

Anticollapsing objects in similar ESTM are formed as the results of relativistic collapse-anticollapse process from black hole matter, which 'flows' (Figure 1) through wormholes from one (M^0_+, M^0_i) ESTM region (otonic world) to another (M^1_{-i}, M^1_+). The cause of transformation of collapse to anticollapse consists in rotation for the Kerr oton. Rotation leads to expansion at a certain step of contraction, namely, in the region (M^0_-) at $R = R_0 = a^2/c^2R_b$. Therefore, the otonic model of white holes does not require a special introduction of negative C-field in order to base collapse-anticollapse process: rotation plays ($a = L/M$) its role. Thus, in white hole concept we should go from the Schwarzschild STM to the Kerr ESTM, which explains the nature of expansion quite naturally and leads to motion on non-trivial ESTM structure, on worlds variety. This scheme is the second possible version of the white hole origin (Trofimenko, 1978; Trofimenko and Gurin, 1989).

Thus, the black hole (regions M^0_+, M^0_i) is associated with the passive stage in life of

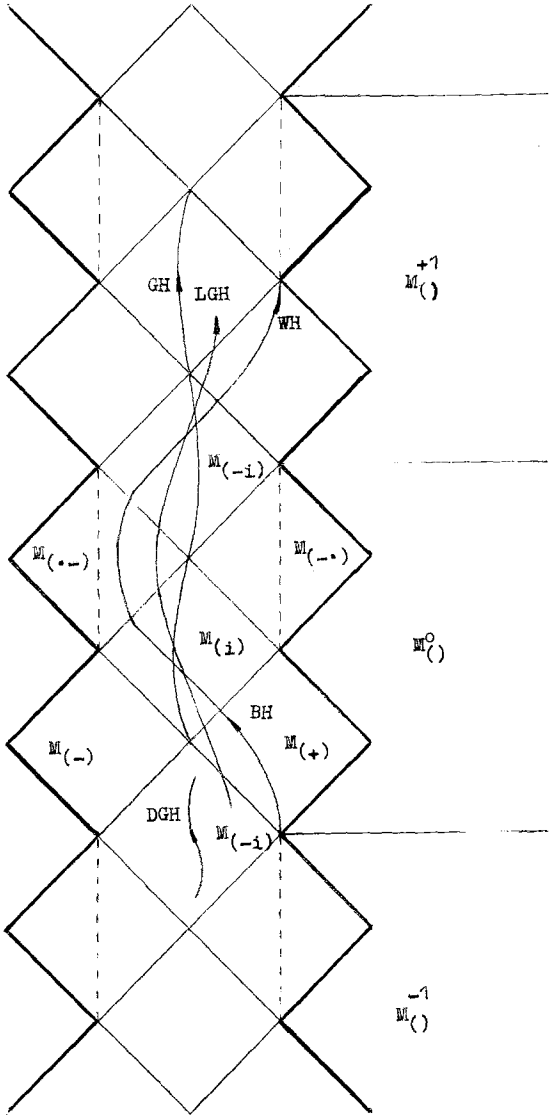

Fig. 1. The Penrose diagram for the extended along the symmetry axis Kerr STM. The broken line means the ring singularity. The stencil picture $M^k(\,)$ including regions $M(+)$, $M(-)$, $M(i)$, $M(\cdot-)$, $M(-\cdot)$, and $M(-i)$ is repeated unlimitedly to the both sides. When $k \to \infty$ we obtain the complete Kerr STM. Curves show possible geodesics (time-like) which correspond to black hole, BH; white hole, WH; and grey hole, GH; light GH, LGH; dark GH, DGH.

the cosmic oscillator (oton) when the accumulation of energy and matter dispersed in originate space occurs; white hole does with the active (regions M^1_{-i}, M^1_+) stage when otonic matter saturated by energy is expanded impetuously (fragmentized).

The otonic white hole model allows to remove some difficulties connected with the 'retarded cores' idea. Otonic white hole does not have a retardation time, it anticollapses

just from the moment of its appearance in a concrete otonic world; i.e., at the beginning in M_+^1 there is not a stationary gravitational field in which effects of the 'blue layer' and the quantum particle creation leading to the self-closing are possible.

Spectral features of anticollapsar in the most general case of the Kerr–Newman white hole are considered in the work by Dadhich (1977). The following correlations between ν_0, the frequency of signal emitted radially from the white hole surface, and ν, the frequency of light signal received by a remote observer.

(1) The Reissner–Nordström anticollapsar

$$\frac{\nu}{\nu_0} = (\psi_b)^{1/2} \pm (\psi_b - \psi)^{1/2}, \tag{6}$$

$$\psi = f(r) = g_{00} = 1 - 2GM/c^2R + GQ/c^4R^2, \tag{6a}$$

ψ_b is the value of g_{00} at R_b, the maximal expansion point ($\mathrm{d}R/\mathrm{d}t = 0$). The sign (+) will hereafter correspond to a white hole, and (−) to a black hole.

(2) The Kerr–Newman anticollapsar in the equatorial plane

$$\frac{\nu}{\nu_0} = \left(\frac{\Delta_b - a^2}{R_b^2}\right)^{1/2} \pm \left(\frac{\Delta_b - a^2}{R_b^2} - \frac{\Delta - a^2}{r^2}\right)^{1/2}. \tag{7}$$

It is easily seen (6) and (7) coincide, since

$$\frac{\Delta - a^2}{r^2} = \frac{r^2 - 2Mr - Q^2}{r^2}.$$

(3) The Kerr–Newman anticollapsar along the symmetry axis ($\theta = 0$)

$$\frac{\nu}{\nu_0} = \left(\frac{\Delta_b}{\rho_b^2}\right)^{1/2} \pm \left(\frac{\Delta_b}{\rho_b^2} - \frac{\Delta}{\rho^2}\right)^{1/2}, \tag{8}$$

where $\Delta/\rho^2 = g_{00}$.

There three cases can be represented in the general form

$$\frac{\nu}{\nu_0} = (f_b)^{1/2} \pm (f_b - f)^{1/2}, \tag{9}$$

where $f = f(r) = g_{00}$ is the metrical coefficient of the time coordinate in corresponding metric $f_b = g_{00}(r = R_b)$.

The expressions (6)–(8) do not show explicitly the role of horizons in white hole radiation, though their importance is quite known for black holes, at their horizon radiation has the infinite red shift and under horizon it is unobservable. In order to show the role of horizons in anticollapsar's radiation we represent (9) as

$$\frac{\nu}{\nu_0} = \left[\frac{(R_b - R_+)(R_b - R_-)}{\rho_b^2}\right]^{1/2} \pm \left[\frac{(R_b - R_+)(R_b - R_-)}{\rho_b^2} - \frac{(r - R_+)(r - R_-)}{\rho^2}\right]^{1/2}. \tag{10}$$

Depending on the value of R_b with respect to R_+ one can pick out the four types of anticollapsing otons with their features of radiation.

(1) Note, the canonical white hole must be parabolic ($R_b = \infty$), since in contrast case we have the oscillating collapse ($R_0 < R_b < \infty$), i.e., one of kinds of grey holes. For the parabolic white hole we have from (9) and (10)

$$\frac{v}{v_0} = 1 \pm (1 - f)^{1/2} = 1 \pm \left[1 - \frac{(r - R_+)(r - R_-)}{\rho^2}\right]^{1/2}. \tag{11}$$

(2) The canonical grey hole corresponds to the condition $R_b = R_+$. For the canonical grey hole we have from (9) and (10)

$$\frac{v}{v_0} = \pm(-f)^{1/2} = \left[-\frac{(r - R_+)(r - R_-)}{\rho^2}\right]^{1/2} \tag{12}$$

is real during all the anticollapse $R_0 = R_- \leq r \leq R_+ = R_b$. The peculiar character of canonical grey holes is the stability of oscillations. The light-grey hole ($R_+ < R_b < \infty$) must be fragmented at local inhomogeneities. As for the Kerr oton, oscillations at $R_b > R_+$ are more difficult, since the gravitational field itself is the factor destroying initial structure. Dark-grey holes are localized in the region $M_{(-i)}$ and can accumulate energy up to the level of the canonical grey hole.

(3) To the condition $R_+ < R_b < \infty$ the over-horizontal light-grey hole corresponds, superhorizontal anticollapsar: i.e., $R_0 < R_- < R_+ < R_b$.

(4) For the condition $R_b < R_+$ the underhorizontal dark-grey hole, subhorizontal anticollapsar, corresponds: $R_- < R_0 < R_b < R_+$. The dark-grey hole in contrast with the light-grey one, which intersects horizons passes different ESTM regions $M^{(1)}_{(+)}, M^1_{(i)}, M^1_{(-)}, M^2_{(-i)}, M^2_{(+)}, \ldots$, and oscillates in the region $M^k_{(-i)}$ until it becomes the canonical grey hole when it attains the event horizon.

From the above and the expression (10) it is clear peculiar character of horizons reveals for anticollapsars not for the point which radiation emerges but for R_b, i.e., the parameter of maximal extension.

The period of white and grey holes existence at the anticollapse stage is marginally short ($t < r_g/c$), and the form of their manifestation can be very similar as transient bursts of radiation. But, relicts of anticollapsing otons exist considerably longer and can be easily distinguished: remnants of explosion (expanding clouds, dispersing cosmic objects, voids) for white and light-grey holes; black holes with every different parameters for grey and dark-grey holes. First, we shall discuss astrophysical manifestations of anticollapsar's bursts.

3. Astrophysical Manifestations of White and Grey Holes Bursts

Anticollapsing otons are radically different from black holes in observational respect, since they reveal immediately. White holes can be seen for external observers: radiation is emitted directly from their surface. Moreover, anticollapsars must be rather bright

objects, since a radiation from their surface can be unlimitedly blue-shifted (Novikov, 1964; Narlikar *et al.*, 1974). Grey holes, however, reveal for very short time in the form of radiation bursts (gravitational, electromagnetic, neutrino, and cosmic rays). In a properly sense, astronomy of white and grey holes is astronomy of the most transient processes in the Universe and, possible, compared with phenomena in micro-world in its duration.

Note that although rotation and charge weaken the blue shift, it can become large enough also in these cases. Let us give the explicit expressions for $\nu_{\max}$ via the global parameters.

White hole:

(1) $Q \neq 0$, $a = 0$:

$$\nu_{\max} = \nu_0 \left[1 + \frac{M(G)^{1/2}}{Q} \right],$$

(2) $Q = 0$, $a \neq 0$, $\theta = 0$:

$$\nu_{\max} = \nu_0 \left[1 + \left(\frac{GM}{ca} \right)^{1/2} \right]. \tag{13}$$

Grey hole:

(1) $Q = 0$, $a = 0$:

$$\nu_{\max} = \nu_0 [(M^2 G/Q^2) - 1]^{1/2},$$

(2) $Q = 0$, $a \neq 0$, $\theta = 0$:

$$\nu_{\max} = \nu_0 [(GM/ca) - 1]^{1/2}. \tag{14}$$

From the expressions (13)–(14) we see that the bigger mass and smaller charge (rotation) the more the maximum blue shift of radiation from anticollapsar. Thus, the stronger action of gravitation the more the blue shift – i.e., gravitational interaction has a character of antigravity. Thus, though charge and rotation make the blue shift more weak, but when $M(G)^{1/2} \gg Q$ and $GM \geq ca$, $\nu_{\max} \gg \nu_0$, i.e., it can be considerable big. In the Schwarzschild case ($Q = 0$, $a = 0$) we obtain $\nu_{\max} = \infty$, that coincides with the Kerr anticollapsar in the equatorial plane. Therefore, anticollapsars give a broad spectrum of possibilities for model construction of phenomena of high-energy astrophysics.

The canonical white hole radiates with the blue shift (Figure 2) during all the extension process (except points R_0 and R_b, where $\nu = \nu_0$). In the Schwarzschild case $R_m = (a^2/c^2) \to 0$ or $R_m = (Q^2/Mc^2) \to 0$ the expression (13) gives $\nu_{\max} = \infty$, and the graph becomes as on Figure 2. $\nu_{\max}$ in the point $R_m = (a^2/c^2)$ for Kerr oton.

The canonical grey hole in contrast to the white one reveals itself for a finite time, and its radiation during anticollapse has not only the blue shift but also the red one (Figure 3). Radiation of grey hole has the spectral feature in occurrence of the expressible increrase of frequency with the sharp ascent and the more gentle descent in the region $r < R_g/2$. In the region $(R_g/2) < r < R_g$ there is the specific 'plateau' with relative long

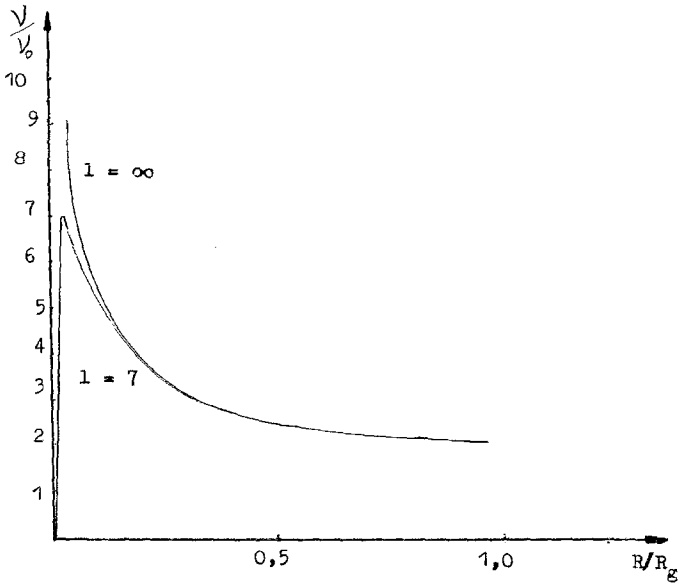

Fig. 2. Frequency variation depending on R (the spatial coordinate of a point of radiation) for the canonical WH ($l = \nu_{max}/\nu_0 = 7$); the Schwarzschild canonical WH ($l = \infty$).

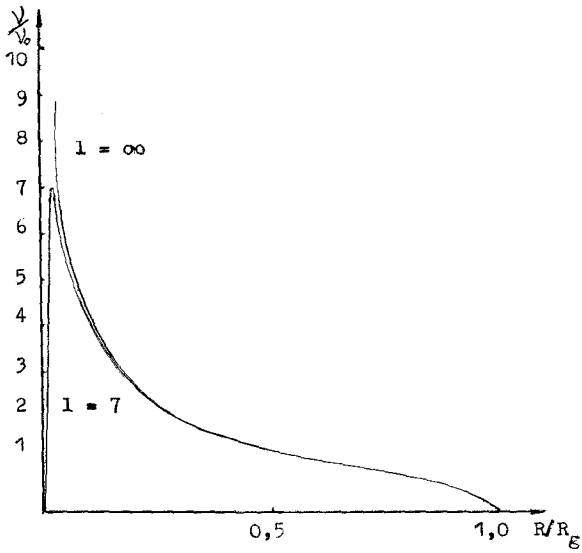

Fig. 3. Frequency variation depending on R for the canonical GH ($l = 7$); the Schwarzschild canonical GH ($l = \infty$).

time of radiation. Canonical grey holes can explain in natural way bursts of cosmic gamma-radiation (Trofimenko, 1978).

Powerful bursts of cosmic gamma-radiation have different observational manifestations (Ruderman, 1975) which give support for their identification with oton blasts

(Trofimenko, 1978). The spatial distribution of gamma-bursts is isotropic, their manifestation is unique, i.e., it corresponds to momentary oton explosion act. Gamma-bursts are transient events (0.01–80 s) localized in small regions (10^8 cm). Their spectral have the tendency of softening. They have no stable correlation with other cosmic phenomena, and there are insufficient foundations for their identification with some other astrophysical objects. A complicated structure of a gamma-burst ought to be explained within the framework of straight consideration of otonic blast mechanism and by a corrected influence of surrounding matter. The short and superhard start and the long soft 'tail' of radiation are the specific features of anticollapsar's blast.

In the case of white hole explosion it should be expected to further its active observable manifestations in another range of electromagnetic waves after the gamma-burst that was not until then observed. Therefore, the gamma bursts are likely to be connected with canonical grey holes caught in the burst. We give the correlation between frequency of radiation and time of burst and 'plateau'.

At $R_m \ll R_g$ the time of ascent is

$$t \approx (R_m/c)\,[(R_g/2R_m) - 1]^{-1/2}\,,$$

and the time of descent $t_c \approx (R_g/c)\,[(R_g/2R_m) - 1]^{1/2}$ time for the 'plateau' period $t_{pl} \approx R_g/c$.

Evidently, $t_n < t_c < t_{pl}$, and at $R_m \ll R_g$, $t_n \ll t_c \ll t_{pl}$, i.e., the time of burst $t_b \ll R_g/c$. The following correlation is true between maximum frequences in burst (ν_m) and 'plateau' (ν_0)

$$\frac{\nu_m}{\nu_0} = [(R_g/2R_m) - 1]^{1/2} \approx \left[\frac{t_{\text{bur}}}{t_{pl}}\right]^{-1}. \tag{15}$$

This correlation for soft gamma-radiation and visible light gives $\nu_m/\nu_0 = 10^6 = [t_{\text{bur}}/t_{pl}]^{-1}$. Thus, at the grey hole explosion it should be expected comparatively long 'tail' of softer radiation after powerful transient burst. If the burst of soft gamma-radiation is lasting about 10 s, visible (also ultraviolet and infrared) radiation on the 'plateau' will be lasting during year with decreasing frequency.

For the Schwarzschild (or for the Kerr one in the equatorial plane) grey hole the transformation from the infinite blue shift of radiation frequency to the infinite red one appears for the finite time. However, the time of manifestation even for massive grey holes is insignificant for cosmic scales. For the grey hole with galaxy mass is of the order 10^6 s, i.e., shorter than a month, the burst itself is lasting else faster and can coincide with gamma-bursts according to duration.

Since the blue shift can be rather big, an identification of spectral lines being a very complicated problem. Perhaps lines related to electron-positron annihilation are spectral lines of hydrogen of other elements. Also, if gamma-bursts are associated with grey hole bursts, we can predict that bursts of gravitational radiation are to be observable synchronously with gamma-bursts.

Bursts of gravitational radiation have been registered by Weber (1969), but these results

were rejected according to energetic considerations as the fact of gravitational waves discovery. In Weber's experiment, gravitational waves were associated with processes in the galactic nucleus, and the annual energy output corresponding to these events had to be of the order of 10^2–$10^3\ M_\odot c^2$. Such an energy extraction should be followed by the evaporation of the Galaxy's nucleus for several million years; this should be sufficient to disprove the fact that gravitational waves have been detected.

White and grey holes from other otonic worlds must lead to powerful transient bursts of gravitational radiation, providing extreme perturbations of STM of our metagalaxy and gravitational field. In the case of grey holes a gravitational burst can be correlated with also such transient burst of electromagnetic waves. Hence, one must expect no large-scale processes at this point of the celestial sphere, since a single black hole can appear as the relict of the grey hole. The discovery of synchronously of gravitational and gamma-bursts would be the decisive argument in support of white and grey hole discovery.

White holes in contrast with grey ones after transient powerful radiation burst can reveal in the form of huge cosmic explosions. In this respect the supernovae 1987A is of interest (Bionta *et al.*, 1987), for which an anomalously big burst of gravitational radiation was registered.

Bursts of neutrinos and cosmic rays can be observed for white and light-grey holes. Energy of neutrinos and cosmic rays attain 10^{20} eV and they, possible, are ejected from white holes.

The fast varied blue shift of spectral lines (6–12) is the feature of anticollapsars and, hence, objects with unidentified spectral lines are of interest in the respect of a white hole discovery, for example, BL Lacertae-objects. Their relicts are another evidence of white and grey holes.

4. Astrophysics of White Hole Relicts

Relicts of white and light-grey holes when $R_b \gg R_+$ are remnants of explosions of various power. When $R_b \sim R_+$, a part of matter of light-grey hole can collapse to black hole, and another part as the result of impetuous expansion forms heat expanded clouds, different extractions, and other explosive cosmic phenomena.

Quasars and active galactic nuclei, jets, intergalactic X-ray gas, voids, and heavy chemical elements can be related to white hole relicts. Also, cosmic phenomena associated with Ambartsumian's (1985) *D*-bodies and hypothetical pregalactic stars of type III (Layzer, 1984) can be related to white and grey holes manifestations.

Quasars, active galactic nuclei, jets are good candidates for the relicts of light-grey holes. At once after the discovery of quasars – objects with huge luminosity ($L \approx 10^{48}$ erg s^{-1}) – anticollapsars (white holes) (Novikov, 1964) or collapsars (black holes) (Blandford and Thorne, 1979) were suggested to explain their nature. The white-hole model for the explanation of quasar's energetics was abandoned, since the life-time of a white hole was much less than the quasar age. At present black holes are the generally accepted models activity of quasars and galactic nuclei. For such model

the particular trouble is caused by the presence, in galactic nuclei and quasars, of directly contrasting cosmic phenomena-jets, expanded clouds, other manifestation of explosive activity together with collapsars.

The solution of these and other problems is possible if we regard quasars and active galactic nuclei as grey hole relicts (Trofimenko, 1978). Light-grey holes explain easily how explosive non-stationary phenomena are present together with black holes in quasars and galactic nuclei: one part of the light-grey hole, going far above the event horizon, forms explosive, anticollapsing objects, and other part collapsing forms a black hole. Axially-symmetric grey holes explain anisotropic phenomena by the natural way: searchlights, jets, etc.

X-ray intergalactic gas with metal abundance ought to be another relicht of light-grey holes. There exist certain evidences in support of explosive formation of galaxies (Henriksen and Reinhardt, 1977; Narlikar and Burbidge, 1981), and a white hole model was proposed for the formation of galaxies (Gribbin, 1974), but relict of white holes are rather voids and the grey hole model (Trofimenko, 1978) is closer for galaxies.

The presence of spectral lines corresponding to metals in this gas testifies about distinction of the chemical content from the primeval cosmological matter, which consists of hydrogen and helium. The X-ray gas with abundance of metals could enter intergalactic space only from galactic space as the result of explosion of a pre-galactic object – a light-grey hole, small part of which could collapsed with the black hole formation in the Galaxy centre.

Chemical elements can be products of white and grey holes. Mechanisms of element formations which exist up to date entail a number of difficulties. The most essential one appeared in connection with the discovery of heavy elements in early galaxies, quasars, intergalactic X-ray gas, that gives the evidence on the early pre-galactic origin of the most of chemical elements. One introduces hypothetical stars of the type III which have been formed and burned at this pre-galactic stage of the metagalaxy expansion (Layzer, 1984). The theory of such stars is troublesome. Models of transmetagalactic otonic white and grey holes possessing a wide range of parameters, necessary for production of different chemical elements, encounter no difficulties which are inherent to type III stars.

Cosmic voids (Kirchner, 1981) represent one of the most hopeful candidates for white hole relicts. These are gigantic regions in which light galaxies are absent. The characteristic feature of voids is the fact that galaxies are located as if on the surface of gigantic 'bubbles', interior of which is practically free from galaxies.

Indications of the presence of metals in voids and some other observational data support the explosive formation of voids. The ideal model of a powerful cosmic explosion leading to the formation of voids is a white hole.

Infragalactic regions with low density of neutral hydrogen, holes H I (Brinks and Bajaja, 1986; Appleton *et al.*, 1987) are candidates for white hole relicts. However, apart from the above-mentioned cosmic phenomena, one can find other candidates for relicts of white and light-grey holes, but to these we come when we discuss the relicts of grey and dark-grey holes, black holes.

5. Black Holes as Relicts of Grey Holes

Black holes as relicts of grey holes possess a number of superior aspects in comparison with usual black hole interpretations (evolutionary and primordial) in their application for a number of cosmic phenomena; and also open a way for new astrophysical applications, millisecond pulsars, the Sun and other stellar objects, planets, the Earth (the heat flow, the rotation period variation, the shift of the rotation axis, gravitational anomalies, etc.), explosions of small black holes in different cosmic objects.

The first version of black hole formation has been proposed in 1939 by Oppenheimer and Snyder is connected with the collapse of evolutionary stars. The discovery of pulsars (Hewish *et al.*, 1968), objects whose sizes are comparable with their gravitational radius, has become the convincing evidence in support of the reality of black holes formed as the result of stellar evolution. At present, models of collapsed (evolutionary) black holes are applicable widely in astrophysics (Weinberg, 1972; Blandford and Thorne, 1979; Shapiro and Teukolsky, 1983) not only for an explanation of the nature of stellar-mass objects (X-ray sources), but also for solution of problems connected with globular clusters, galactic nuclei, quasars, hidden mass, etc.

The second version of black hole formation has been proposed by Zel'dovich and Novikov (1967) and further by Hawking (1971) as a result of possible inhomogeneities at early stages of cosmological expansion. These black holes are called primordial (or relict), and they can possess the Planck mass and more. Primordial black holes can also be applied for explanation of the above astrophysical phenomena (Blandford and Thorne, 1979). However, the isotropy of relict background, the absence of a strong flow of gamma-radiation, and a number of other facts disclose that if primordial black holes exist, the mean density of their matter in the Universe is in many orders less than the critical one (Blandford and Thorne, 1979; or Novikov and Frolov, 1986). Some difficulties are also encountered with application in the astrophysics of both evolutionary as well as primordial black holes. For example, in quasars, radio-galaxies, active galactic nuclei, violent explosive phenomena are observed which are difficult to account for by black holes of evolutionary or relict origin.

By consideration of extended space-time manifolds (ESTM) with non-trivial structure (Hawking and Ellis, 1973; Misner *et al.*, 1973; Chandrasekhar, 1983) the third version of black hole formation was discovered (Trofimenko, 1978).

If $R_b = R_+$ or $R_b < R_+$, after the end of anticollapse a black hole in M_+^1 is formed. Such black hole is the relict of grey hole, matter of which comes from other regions of ESTM, from other metagalaxies. Mass of otonic black holes can be from the Planck one up to metagalactic: $10^{-38} M_\odot < M < 10^{21} M_\odot$. Time of observational grey hole appearance at the anticollapse stage (perhaps in the form of gamma-bursts) as marginally small, $t \sim R_g/c$. And after the stop of anticollapse they become black holes, i.e., good candidates for the hidden mass.

The hidden mass ought to be formed by grey and dark-grey holes, since there is no shortage of them for this role, which would be time of the evolutional and primordial black holes. Otonic black holes as relicts of dark-grey holes are formed for the time less

in many orders than the time of evolutionary black hole formation. The density of matter around the otonic black hole should be much less than that of the evolutionary black hole, for the formation of which a sufficient density of cosmic matter is needed. All that weakens observational manifestations of dark-grey hole relicts and increases their chances for the hidden mass role. Otonic black holes can emerge at every stage of the metagalaxy expansion; and, hence, they do not suffer from the restrictions of primordial black holes, the formation of which is associated with the earlier stages of the expansion. Grey holes are formed outside of our metagalaxy's STM in STMs of other otonic worlds, say, before 'creation' of the metagalaxy itself.

The relicts of grey holes can also be considered *as universal centres of formation* of classical astrophysical objects (meteorites, comets, planets, satellites of planets, stars, globular clusters, galactic nuclei, clusters of galaxies, etc.). The necessity to introduce similar relativistic, otonic centres of condensation is forced upon us by another kind of difficulty: namely, the primeval non-homogeneities in the model of the expanded uniform metagalaxy. If so, developed black holes as grey hole relicts should be expected to be encountered in central regions of cosmic systems and objects; the presence of black holes in them is not accidental but necessary for the cosmic objects formation. Relicts of grey holes as primeval non-homogeneities for the cosmic objects formation can occur at every stage of the metagalaxy expansion with, and does not contradict with observational data – for instance, with the degree of the relict radiation isotropy. Let us consider some manifestations of black holes in cosmic objects.

The flow of solar neutrinos, which appears to be by several orders of magnitude smaller than its theoretical expectations, was an argument for involving black holes as a constituent of the solar nucleus model (Hawking, 1971). This succeeded to explain the low flow of solar neutrinos due to the black hole with mass of $10^{-5} M_{\odot}$ in the Sun's centre, which provided the half of the solar luminosity (Clayton *et al.*, 1975). We shall add that black holes cannot be in rest, but can move around some general centre of masses both in stars and other cosmic objects. Perhaps this movement can explain in some way cycles of the solar activity.

Terrestrial and giant planets, not only Jupiter (Clayton *et al.*, 1975), ought to include black holes in the planet's interior, which produce the heat flow. Such black holes, moving in planets as in an empty space practically, can lead to redistribution of rotating momentum that can influence peculiarities of the planetary rotation.

For the Earth the annual variations of the rotation period, shifts of poles and the heat flow from the interior can be explained on the unified basis by black hole, which moves in the planet around the general central of masses. The mass of such black hole is likely not more than $10^{-3} M_{\oplus}$ and sizes 10^{-3} cm. Such a black hole in the Earth's interior with good approximation can be considered as the gravity point, which can lead to the essential periodical redistribution of the rotating momentum by its movement possessing a significant mass. Gravitational anomalies also can be associated with the phenomenon of micro-black hole. Having defined the centre of a similar gravitational anomaly, one can attempt to dig up in the direct sense with $M > 10^9$ g. Black holes with $M < 10^{15}$ g can exist at present, since the effect of black hole evaporation in a dense media can be depressed by the matter accretion.

Millisecond pulsars can include black holes constituting their essential part of mass. The discovery of the millisecond pulsar 1937 + 214 ($T \approx 1.558$ ms) (Backer *et al.*, 1982) approximated the period of neutron star rotation to the minimal possible one, $T \approx 0.5$ ms. In spite of the fast rotation one relates millisecond pulsars to old ones according now of circumstances, which increase their rotation by the expense of accretion, but the discovery of the single millisecond pulsar 1821 – 21 in the globular cluster M28 (NGC 6626) provided the doubt of such explanation (Romani *et al.*, 1987). The properties of millisecond pulsars are explained by the natural way – the presence of black holes in the pulsar's interior. A black hole, drawing the neutron shell and decreasing by that the pulsar's size, increase the rotation period. Thus, the pulsar's size and the rotation period can be decreased. Millisecond pulsars ought to have mass, explicitly less than 1.2 $M_{\odot}$, and be formed from white dwarf through the collapse of a part of matter into black hole. This model predicts two phenomena. First, the existence of pulsars with the rotation period less than the minimum $T < T_{\min} \approx 0.5$ ms, which is not admissible by the model of neutron stars in principle. Secondly, there are possible disappearances of millisecond pulsars as the result of collapse into black hole. The less the rotation period, the more probable the pulsar's disappearance.

Note that white and grey holes, besides of astrophysical applications, possess also purely physical aspects: particles in the strong gravity (Trofimenko, 1988) 'windows' from higher dimensions (Gurin and Trofimenko, 1986a, b) evidences of other worlds (Trofimenko, 1978), the production of tachyons and antiparticles (Trofimenko and Gurin, 1986b, 1987). Astrophysical applications of white and grey holes considered in the paper require special studies which the author hopes to carry out in the future.

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