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OBSERVATIONAL PHYSICS OF MIRROR WORLD

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1. Introduction.

The existence of the whole world of shadow particles, interacting with each other and having no mutual interactions with ordinary particles except gravity [1,2], is a specific feature of modern superstring models, being considered as models of the theory of everything. The presence of shadow particles is the neccesary condition in the superstring models, providing compensation of the asymmetry of left and right chirality states of ordinary particles. If compactification of additional dimensions retains the symmetry of left and right states, shadow world turns to be the mirror one, with particles and fields having properties strictly symmetrical to the ones of corresponding ordinary particles and fields [3,4]. Owing to strict symmetry of physical laws for ordinary and mirror particles, the analysis of cosmological evolution of mirror matter provides rather definite conclusions on possible effects of mirror particles in the Universe [5-8].

In the present paper we"ll give more general, than [5-8] qualitative discussion of possible astronomical impact of mirror matter, in order to make as wide as possible astronomical observational searches for the effects of mirror world, being the uniqueway to test the existence of mirror partners of ordinary particles in the Nature.

2. Physics of mirror particles.

One puts into correspondence to each ordinary particle (photon, electron, leptons, quarks, gluons, W,Z-bosons etc) respective mirror partner. Interactions between mirror partners are strictly symmetrical to the ones between the corresponding ordinary particles. Putting mirror and ordinary particles into the same space-time results in the indentity of the gravitational properties. (The questions on the difference in these properties and on the existence of mirror and ordinary

particles in the different space-times as a possible solution of the problem of cosmological constant were discussed in [9]).

Assume, that no other interactions except gravity act between mirror and ordinary particles. So we exclude from the further consideration ordinary - mirror particle oscillations [10], corresponding to the mixing of mirror and ordinary quantum states, as well as the existence of mixed particles, participating both ordinary and mirror interactions-mirrons [11] and fractons [12].

Strict symmetry of properties of ordinary particles and their mirror partners means, that their masses, spins and constants of respective interactions are equal. So, for example, ordinary electron corresponds to mirror electron-a particle with spin 1/2, with the mass equal to the mass of electron and with the charge of its interaction with mirror electromagnetic field equal by the absolute magnitude to the electric charge of electron. Mirror electron is electrically neutral. It has no interactions with ordinary photons. Mirror photons, interacting with mirror electron, do not interact with the ordinary charged particles, penetrating freely through the ordinary matter. Ordinary nucleons correspond to mirror nucleons, forming mirror nuclei. Mirror nuclei and mirror electrons form atoms of mirror matter, building material structeres similar to the ones, built by the atoms of the ordinary matter.

The modern theory ascribes the particle masses to the interaction of these particles with the scalar Higgs field, breaking respective local gauge symmetry (see cf. [13]).Equal masses of ordinary particles and their mirror partners implies strict symmetry of all the parameters of the ordinary Higgs fields and their mirror partners.

3. Mirror particles in the early Universe.

a) Inflation and constraints on the domain structure.

Modern theoretical ideas relate the global properties of the observed part of the Universe - its homogenity, isotropy and flatness - to the existence in the very early Universe of the stage of exponential expansion, of the so called inflational

stage. In the framework of inflational cosmology ofter the end of inflation the reheating of the Universe takes place, so that the further cosmological evolution follows the scenario of hot Friedmann (i.e. big band) model. The ratio of the ordinary and mirror matter densities, which is maintained after the transition from inflational to Friedmann stage of expansion, is determined by the relative probability of ordinary and mirror particle production in the course of reheating of the Universe.

If there is an interaction in the energy scale $F \gg 10^2$ GeV, maintaining transitions between ordinary and mirror particles, then, assuming that the cross section of such transition is (in the units $h=c=1$)

$$\sigma(T)=\begin{cases} \gamma/T^2 & T>F \\ \gamma T^2/F^4 & T<F, \end{cases} \qquad \text{where} \quad \gamma<1$$

one obtains, that the thermal equilibrium is established between the ordinary and mirror particles at the rate $n\sigma v \sim T^3\sigma$ exceeding the rate of cosmological expansion for $F<\gamma m_{pe}$ and for the reheating temperature $T_R > (F/\gamma m_{pe})^{1/3}F$ only. These conditions being valid, independent on the mechanism of inflation after its end the cosmological reheating leads to equilibrium symmetric distribution of ordinary and mirror matter. These conditions being invalid, the equilibrium distribution of ordinary and mirror matter may be established, if the decay of the inflaton field is induced by the interaction mutial for ordinary and mirror particles, by gravity, in particulas.

The latter is surely true in the case of inflation, induced by R^2 effects in the polarisation of gravitational vacuum, or in the case of inflaton, having symmetric interactions with ordinary and mirror particles. If the products of inflaton decay have distinguished mirrority, the symmetry of ordinary and mirror particles demands the existence of the mirror partner of such an' inflaton.

Within the frame of the model of chaotic inflation [14] the difference in the random values of the amplitudes of these field may arise, what leads to the formation of the domain structure in the distribution of ordinary and mirror matter [15]. Where the amplitude of the ordinary inflaton is higher than the

amplitude of the mirror one, ordinary particles would dominate after the end of inflation and the admixture of mirror particles will be exponentially small (and vice versa for the inverse ratio of inflaton amplitudes).

Since inflation embraces generally regions, much greater than the one within the modern cosmological horizon, this case would have been corresponded to the exponentially small density of mirror matter in the observed part of the Universe.

If inflaton has no definite mirrority, and equal amount of ordinary and mirror particles are produced after the end of inflation, the domain structure may have been formed owing to random local asymmetry of the amplitudes of ordinary and mirror scalar field in various periods after general inflation, in the periods of phase transitions, in particular. The scale of such a domaine structure is determined by the concrete parameters of the fields [15] and it may be much smaller, than the scale of the modern horizon. If this is the case, the analysis of the effects of matter streaming into the mirror domain on the light element abundances and on the spectral and spatial properties of the thermal electromagnetic background determines the allowed scales of the domain structure. This scale must be either significantly smaller, than the size of horizon in the period of big band nucleosynthesis, or much larger than the size of superclusters.

The case of the allowed small scale structure ($M < M_\odot$) has no practical difference by its cosmological features from the case of initially homogeneously mixed ordinary and mirror matter, cosidered earlier in [5-8]. Allowed large scale mirror domains ($M \geq 10^{16} M_\odot$) would have been looked like giant voids in the distribution of the ordinary matter and in a particular, highly peculiar case might have lead to the "island" model of the Universe [16-17]. The observed isotropy of the thermal electromagnetic background excludes the case, when the modern outer border of the mirror domain is beyond the cosmological horizon. It excludes the structure of such domains [15] in the scales

$$l_H(t_{rec}) * \sqrt{1+z_{rec}} < l < l_{H(1)}$$

where $l_H(t_{rec})$ is the size of the horizon in the period of recombination at $z=z_{rec}$ and l_H is the size at the modern horizon.

b) *Baryosythesis and possible inhomogenity of mirror baryon distribution.*

The neccesity to invoke the mirror world followed from the fact, that left- and right- handed coordinate systems turn to be inequivalent in the presence of CP-violation in the world of ordinary particles [4]. For mirror particles CP-violating effects are equal by the magnitude and have the opposite sign to the corresponding effects of ordinary particles. So the generation of the baryon excess at the baryosynthesis of the ordinary particles [18,19] in a strictly symmetrical way corresponds to the generation of the same excess of mirror antibaryons. However, since the sign of the baryon number for the mirror particles is, inobservable, we shall mention the baryon excess in the cases of both mirrority.

Since the evolution of ordinary and mirror matter is symmetric, local processes of baryon excess generation in the very early Universe lead to simultaneous production of equal baryon excesses in the ordinary and mirror matter. In the absence of domain structure equal local densities of mirror and ordinary baryons are produced in the Uuniverse. In the presence of domain structure domain scales and averaged densities of mirror and ordinary baryons are to be equal. If the genesisis of baryon excess is not related to CP-violating local baryon – non – conserving processes of ordinary and mirror matter, new interesting possibilities of "entropy" density perturbations of the ordinary and mirror baryon excesses arise, in principle at any scales.

The mechanism [20] of baryosynthesis in supersymmetric GUT models, ascribing the baryon asymmetry of the Universe to the existence of primordial condensates of scalar quarks and leptons, can lead to inhomogeneous distribution of mirror and ordinary baryon excesses. At the equal densities of ordinary and mirror relativistic particles all the scales are possible for such inhomogenities. In the difference from mirror domains,

considered in a), in which the concentration of both baryons and radiation is exponentially suppressed, in the regions of enhanced mirror baryon density, being discussed here, the concentration of ordinary baryons only is small, where as the density of radiation is equal to the averaged one. In this case of entropy (isothermal) density perturbations formation of astronomical objects - baryon islands of the fixed mirrority is possible at any scale up to the modern horizon.

c) Nucleosynthesis and mirror world

It should be noted, that in all the cases, except the case of large-scale mirror domains, the presence of relativistic mirror particles (mirror photons, electron-positron pairs, right-handed neutrinos and left-handed antineutrinos) in the period of big band nucleosynthesis results in the growth of the primordial ^{4}He abundance up to $Y \geq 28\%$ [5-8,21,22]. Then the radical restrictions $Y_{prim} < 25\%$, widely used in the literature, lead to the conclusion [22] that homogeneous mixing of mirror and ordinary matter is excluded by the observations. However, taking in mind, that observed averaged ^{4}He abundance (see rev. [21] and refs. wherein) is $Y=(28\pm12)\%$ and it do not contradict the predictions of the mirror world model by itself, and that the question on the reliable model independent estimation of the possible primordial ^{4}He abundance seems not yet to have obtained its final answer, well follow in the successive discussion the general stream of the scenario of cosmological evolution of homogeneously mixed mirror and ordinary matter [5-8].

4. Formation of inhomogenities of mirror matter.

According to scenario [5-8] on the radiation dominancy stage equal by densities ordinary and mirror radiation and light neutrinos dominate in the Universe with a small admixture of equal densities of ordinary and mirror baryons.(and, possibly, a small admixture of equal densities of nonrelativistic ordinary and mirror particles - c.f. ordinary and mirror photino, ordinary and mirror axions etc)

After the end of the radiation dominancy stage nonrelativistic dark matter particles start to dominate in the

Universe and to form the large scale structure of its inhomogenities. The concrete choice of the model of the structure formation is not essential for the bulk of our further conclusions on the effects of the mirror matter. Mirror baryons, having the averaged density equal to the one of the ordinary baryons, maintain admixture of nonrelativistic matter, participating the general development of gravitational instability. The scenario of structure formation is determined by the form of the dark matter, dominating in the cosmological density. The influence of the mirror matter on the observed properties of such structure are possible only at large scale domain (with $M > 10^{16} M_{\odot}$) or island distribution of mirror baryons.

In the latter case the scale of baryon inhomogenities may be arbitrary, and the formation of "pure" mirror objects is possible in all the scales. Having this possibility in mind, we discuss below effects of mirror objects in all the possible astronomical scales.

Numerical simulations [23] show, that the models of unstable dark matter (unstable massive neutrinos in the simpliest case) make it possible to reproduce rather naturally the observed large scale structure, where as in the cold dark matter scenarios such a reproduction implies physically unclear hypothesis on "biasing" in the distribution of the luminous and dark matter. Large scale island baryon distribution may play the role of the physical mechanism for such a biasing in the cold dark matter scenario. Mirror baryon islands would have looked in this case like voids, devoided of ordinary matter galaxies. However, the problem of rapid structure evolution seens to retain is this case, being inherent to all the models of structure formation by stable dark matter [23].

We"ll consider below for definiteness the "pancake" scenario of sructure formation, the main features of which are retained in the cosmology of hot unstable dark matter. In the absence of island or domain structure of baryon distribution the evolution of mirror inhomogeneities follows the scenario [5-8]. Fragmentation of ordinary and mirror matter within the "pancakes" results in the course of development of thermal instability in the formation of gas stellar complexes with the

definite mirrority and with the mass scale $M \approx 10^6 M_\odot$. Depending on the conditions of pancake formation the value of M may be in the range $(10^2-10^9)M_\odot$ [5-8].

Spatial separation on the scales M of ordinary and mirror matter inhomogenities in the initially homogeneous mixture is provided by small gravitational potential of such inhomogenities, their large velocity dispersion and by the separate development of thermal instability in the ordinary and mirror matter. Within the complexes of definite mirrority further fragmentation takes place parallel to their hierarchical clustering first in galaxies and then in galaxy clusters.In this scenario, not accounting for affects of accretion, fragments of the mass, not exceeding the one of globular clusters, are the objects of definite mirrority, and larger formations contain approximately equal amount of mirror and ordinary matter with equal averaged density and symmetric distribution of types, masses and velocities for corresponding objects of definite mirrority.

In particular "local dark matter" must exist in the Galaxy with the density equal to the density of the ordinary matter and with symmetric content and distribution of astronomical objects. This prediction of the model [5-8] is well confirmed by the data [24,25].

Based on this picture, contemplated by possible effects of island baryon distribution, lets consider observational effects of mirror matter predicted on different astronomical scales.

5. Effects of mirror astronomical objects on scales of galaxies and stellar clusters.

It is clear from the above discussion, that all the possible observational affects of mirror matter must be induced exclusively by its gravitational interaction with the ordinary matter, and that any type of mirror objects is possible to exist.

From the most general view point one may point out two types of effects, i.e. the case of pure gravitational interaction and the situations, in which gasodynamical effects

are also induced by gravity. In the first case effects of mirror matter induce peculiar velocitis of the ordinary objects. Effects of this kind may be called "kynematical" ones. It is clear, that they are mostly pronounced in the cases, when the ordinary object is in the gravitational field, induced by the mirror configuration of much larger mass. In the second case one considers effects, arising due gravitational action of different types of objects on the gas of the opposite mirrority.

Various effects of the mirror and ordinary matter interaction may be classified with the case of the Table1. All the possible effects are noted in its cells, arising for different combinations of interacting objects. We"ll consider below in more details some examples of the interactions of different objects of the opposite mirrority, which may be accesible for observational discovery.

a) Galaxies and galaxy clusters of definite mirrority

In the case of island baryon distribution on scales of galaxies or clusters of galaxies these astronomical objects are of definite mirrority. Possible admixture of the ordinary matter in the ordinary galaxies or of mirror matter in the mirror galaxies may be related either to the presence of small initial admixture, determined by the local assymetry of mirrority, arising in the process of baryosynthesis (See 3b), or to accretion of intergalactic gas on such objects. One may consider the following observational effects of mirror galaxies and clusters of galaxies.

1) The capture of ordinary galaxies by the cluster of mirror galaxies can result in the appearance of object with large peculiar velocities or of small groups of galaxies with anomalous virial paradox, i.e. with velocity dispersion up to $(1-2) \cdot 10^3$ km/s, inherent to dense rich clusters of galaxies [26]. Peculiar velocity component of massive galaxy can be found, in principle at the level of $\geq 10^3$ km/s by the methods, suggested by Zeldovich and Sunyaev [27] for measurement of peculiar velocities of galaxy clusters, i.e. by the measurement of distorsions of black body radiation induced by its scattering on the electrons of the gaseous galo of the galaxy. The probability for the capture of galaxy by rich cluster seems to

be rather large. Assuming that the dissipation of energy, neccessary for the capture, takes place at the distance between the centers of galaxies of the order of the diameter of galaxy d, one obtains, that the cluster, containing N galaxies and with diameter D will capture background galaxies with the probability given by

$$\omega = \pi d^2 \cdot \rho \cdot \frac{2}{3} D = 4N(d/D)^2 \simeq 0.01 - 1 \qquad (2)$$

Here ρ is the number density of galaxies in the cluster. The numerical estimation is given for the rich cluster with $N = 10^3 - 10^4$ and $d/D = 10^{-3} \div 10^{-2}$.

2) In the described above process of the capture by the mirror galaxy cluster of the ordinary matter galaxies, the latter will inevitably loose significant ammount of gas. As a result the poor cluster of ordinary matter galaxies, formed in the potential well of the mirror cluster, beyond the strong virial paradox may have significant amount of intergalactic gas (IGG), filling the region with the size typical for rich clusters. The amount and, consequently, the density of IGG must be $k = \alpha \cdot N_M/N_O$ times smaller than in the rich clusters, where N_M and N_O are respectively the numbers of galaxies in the rich mirror cluster and of the ones of ordinary matter, captured by it, and $\alpha < 1$ is the factor, taking into account, that in the difference from rich clusters, capturing galaxies of the same mirrority, the cooling flow (see revs [28-30]) will not be maintained and gas is not lost by the cluster. Thus, at $N_O/N_M \approx 10^{-2}$ one may await $k \approx 0.03$ and the measure of emission of IGG $M \sim k^2 \sim 10^{-2} \div 10^{-3}$ from the case of rich galaxy clusters. The next generation of X ray telescopes will make possible to discover QSO up to the redshift $z = 5 \div 10$ and IGG with $z = 1-3$ in rich clusters up to $z = 2-4$. Consequently in the case, considered here, IGG may be observed for $z = 1-3$ .Observations of hot IGG without visible rich galaxy cluster may be a strong argument in favour of existence of the mirror (shadow) world.

3) Interaction of ordinary and mirror galaxies results to the distorsion of their form. In the ordinary galaxy the

distorsion must be observed in the absence of its visible source. The evolved numerical methods of calculation of fidal actions of galaxies on each other (see [32-34] and refs. wherein) may provide solution of the inverse problem of determination of the parameters of the body, inducing perturbations, by the form of the distorted galaxy. In the difference from the perturbation, induced by a single black hole of the same mass, the perturbation by the mirror galaxy is not related to the observational effects of accretion on such black hole. Respective effects of accretion on the black hole in the active nuclei of a mirror galaxy will be suppressed by the mass ratio of the nucleus and of the whole galaxy ($\leq 10^{-2} \div 10^{-4}$) for active galaxy nuclei, see cf [35]).

4) In the ordinary galaxy rich of gas or in the protogalactic cloud of the ordinary gas gravitational perturbation, induced by the mirror galaxy, may initiate the burst of stellar formation. As a result the ordinary galaxy will be observed as an irregular one.

The phenomena described in 3) and 4), may be also induced by invisible gravitationally bound clusters of dark matter, which may be formed due to biasing in the distribution of dark matter relative to baryons. However, the collisionless gas of dark matter particles can not form dense inhomogenities, typical for the mirror matter, having the mechanisms of dissipation. So one must look for effects, induced by the mirror matter of moderate concentration, differing both from the effects of black holes and from the ones of rather diffused dark matter.

5) If the activity of galaxy nuclei is determined by the existence inside them of black holes with masses of the order of $10^6 - 10^{10}$ solar masses, the symmetry of properties of ordinary and mirror matter provides the conclusion on the presence of such black holes in nuclei of mirror galaxies. In this case mirror galaxies with active nuclei will be observed as single super massive black holes, and their observational properties will be determined by the amount of the ordinary matter in their neighbourhood. As it was noted in [5-8] the presence of mirror matter makes it easy to explain the appearance of closed binary supermassive black holes in galaxy nuclei.

6) Massive mirror galaxies may induce the effect of gravitational lens without optically visible source of this effect.

7) Rapid motions of mirror matter masses may be the source of gravitational waves without any other observational effects. (Supermassive black holes, which can also be the sources of gravitational radiation, may be discovered by effects of accretion).

8) The presence of the ordinary matter gas in the mirror galaxy will result in the observed single gas clouds or small mass galaxies with large internal velocity dispersion, i.e. with large internal virial paradox. As possible candidates in such formations intergalactic gaseous clouds may be considered: in a number of neighboring groups of galaxies cold gas in the form of massive ($M > 10^6 M_\odot$) HI clouds is observed [36] with the sizes typical for galaxies: 20-25 knc. The most massive from the knowwn HI clouds is discovered in the galaxy group G11 in the Lion constellation near M 96 [37]. This cloud has the size no less than 100÷30 knc, the mass of HI $M > 10^9 M_\odot$ and the concentration $n = 4 \ 10^{-9} \ h_{50} \ cm^{-3}$ ($h_{50} = H/50km/s \cdot Mpc$) [38,39]. The surface brightness of this cloud [40] is in the optical range smaller than 30 stellar magnitudes from the square are second. Such clouds may appear in the absorbtion spectra of QSO.

b) Globular clusters of definite mirrority

Get's consider now the case of separation of mirror and ordinary matter at the scale of globular clusters. Globular clusters are one of the oldest astronomical objects, being formed possibly before the galaxy formation from inhomogenities of the scale $10^6 \ M_\odot$, which seem to be the objects of definite mirrority even for the homogeneous initial mixing of ordinary and mirror matter [5-8] (see Sec.4).

1).The capture of ordinary stars by the mirror globular cluster may lead to the formation of diffused cluster of ordinary stars, being capable to exist without destruction for very long time and possesing strong virial paradox. The better chances to form such objects by captures of back ground ordinary stars have mirror globular clusters, moving near the galactic

plane along the orbite with no large excentricitet. But for diffused cluster to be in the gravitational field of mirror globular cluster the better chances are in the case, when diffused cluster is formed from the ordinary gas, captured by the mirror globular cluster in the period of separation of the matter of different mirrority. According to [5-10] the fraction of gas of the opposite mirrority is in this case to be of the order of $\approx 10^{-2}$.

The timescale of decay of normal diffused clusters is $t=(1-3)\ 10^8$ years [4], whereas such a cluster, being formed in the potential well of mirror globular cluster may have the age $t \approx 10^{10}$ years. There are several thus old diffused clusters observed in the Galaxy. For NGC 188 the age is estimated as 5-10 byllion years [42,43], for M67 it is (5±0.5) years [44], for NGC752 it is 2 byllion years [45], for NGC 2243 and Melloffe 66 it is 6 byllion years [46].

Stars,captured by mirror globular cluster, may have various ages in the difference from the usual diffused clusters. This is to be taken into account, determining, whether the star belongs to the diffused cluster.

2) At the capture of ordinary star by mirror globular cluster or of mirror star by the ordinary globular cluster, close binaries may be formed with the components of the opposite mirrority. The existence of nonrelativistic invisible companion is the specific feature of such sistems. In the cases, when the gas clouds of ordinary and mirror matter, giving birth to globular clusters, are close to each other or in the same region of space, the mixed globular cluster may be formed. Besides the evident virial paradox in the compact mixed globular cluster of the radius R, contaning N stars, during the time t due to tidal dissipation binaries can be formed as a result of close neigh bouring of stars. For $N=2\ 10^5$, R=5 ps, $t=10^{10}$ ars, $N_{bin}=60$, about half of which will have mixed mirrority.

c) *Effects of mirror matter in the clouds of the ordinary molecular gas*

Giant molecular clouds are the most abundant among the massive unitary objects in galaxies. Having the mass of the

order of the one of globular cluster, these clouds are by an order of the magnitude more numerous than globular clusters in the Galaxy [49]. So in the Galaxy, containig comparative amonts of mirror and ordinary matter cross penetrations through each other of mirror and ordinary clouds are to be reather frequent. Molecular clouds contain large amount of internal inhomogenities (i.c. the regions of the enhanced density), being in the condition close to the initiation of development of gravitational instability. The structure of the regions of star formation shows, that even a comparatively small perturbation can initiate the formation of stars within molecular clouds. Shock waves are usual triggers for star formation, so that the youngest objects are found in a thin outer layer of molecular clouds [50]. Penetration of a massive body through molecular cloud may also initiate star formation, so that the region of star formation will be determined by the spatial distribution of gravitational perturbation and may embrace significant part of the cloud volume.

In the case of comparative amounts of ordinary and mirror matter in the galaxy, cosidered here, the source of such perturbations will be related, first of all, to mirror molecular clouds and, a little bit more rare, to mirror globular clusters. Since molecular clouds inersert with small ($\sim$ 10 km/s) relative velocities and are strongly dissipating objects, the intersection of ordinary and mirror clouds may from a giant molecular cloud with mixed mirrority, inside which the probability for formation of mixed mirrority stars and binaries of the opposite mirrority is enhanced.

Multiple gravitational interactions of stars with inhomogenities within molecular clouds may lead to the capture of some stars by molecular clouds, what should strongly enhance the effects of accretion of interstellar gas on such stars. This effect may give rise to higher accretion rate of gas on the star of the opposite mirrority.

d) Effects of mirror matter at stellar scales.

1) The analysis [5-8] of accretion of interstellar gas on the star of the opposite mirrority have lead to the estimation

of the amount of the admixture of the matter of the opposite mirrority in stars $\Delta M \approx 10^{-6} \div 10^{-7}$ $M_\odot$.

If such a mirror admixture in the Sun forms a mirror planet near the solar surface, it may give, according to [5-8], an explanation of the source of solar oscillations with the period $T \sim 160$ min [51].V.F. Shvartzman have pointed on the possibility of the observation of accretion of ordinary interstellar gas on the single mirror neutron star (see for details [52]).

2) Due to Doppler effect rotation of an ordinary neutron star and of an admixture of mirror matter in it around their common centre of masses must lead to periodical variations of pulsar period. In the difference from the similar effect of hardly observed ordinary matter planets the variations due to mirror matter may have period, corresponding to so close orbits, for which the formation of ordinary planets or their retention after Supernova explosion are impossible. Searches for these effects need highly precisional timing of pulsars on the time intervals, smaller than few hours.

3) Disk of protoplanet type without yound star in its centre will be formed in the interstellar medium as a result of accretion of ordinary gas and dust on a mirror star. Such discs may be observed by radio line of the molecule CO-2,6 mm. The mass of the central configuration may be determined by the Doppler effect, and it will be in sharp contradiction to the low luminocity of the central body.

Accretion in the regions of the enhanced density of gas of the opposite mirrority and formation of binaries, consisting of ordinary and mirror stars, give new possibilities of searches for mirror matter. Besides the case of formation of the binary of the mutually opposite mirrority inside the globular cluster, pointed aut in 5 b, such a situation may take place at the star formation while mutual penetration of giant molecular clouds (see 5c).

4) Star formation or evolution of a binary with mixed mirrority can give birth to a mixed star, containing comparative ammounts of ordinary and mirror matter. For the ordinary matter in the mixed star the relationship between the main stellar parameters (mass, radius, luminocity, colours, effective temperature arc) may be strongly violated. In particular, such

must occupy an unusual position on the Herzsprung-Rassel diagram. After supernova explosion in the mirror matter of the mixed star rearrangement of its gravitational field takes place, followed inevitably by the rearrangement of the structure and by a single change of properties of the optically visible object. The star seem to enlarge its size and to decrease its surface temperature.

5) In close binaries of the oppposite mirrority accretion of the ordinary matter on the potential well, induced by the mirror star, must result in the formation of accretion discs without visible centre of accretion. In the case of nonrelativistic mirror star, when the potential well has comparatively "flat" bottom, there are to be formed geometrically thick accretion discs or spheroidal configurations at the place of the companion of the ordinary matter. For the rates of mass exchange, typical for close binaries, typical for highly nonspherical stars. One of perspective methods to study such objects is the analysis of linear polarization of their radiation [53,54]. For the ordinary companion of low mass such discs are to remain rather cold, being likely to look like low luminocity infrared sources, being in sharp contradiction to the value of the "disc mass", determined by the Doppler and equal to the mass of mirror star.

In the separated pair of stars of the opposite mirrority effects of accretion on nondegenerated mirror star may be absent. Such star may be discovered as invisible massive companion of the ordinary star.

Estimation of fraction of sistems with the opposite mirrority of stars among binaries may be obtained on the basis of existing catalogue of spectral binaries. So, in the catalogue [55-57] the physical parameters and the elements of orbits of about 1500 spectral binaries are given. 45 among them have the mass of the second companion $M > 3M_{\odot}$[*] (their function of masses $f(M) > 3M_{\odot}$). Among these 45 binaries only 6 have no lines of

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[*] The constraint $M > 3M$ is taken to exclude the the sistems with faint white dwarfs and neutron stars. Theoretical upper limit for the mass of a neutron star is according to [58] $3M_{\odot}$.

the second companions. Accounting for possible discovery in these binaries the second more faint star and for black holes as invisible components, the fraction of binaries with mirror companion is estimated as $\alpha < 6/45 = 13\%$. The properties of these 6 spectral binaries and short discussion of observational test to distinguish the variants of black hole and massive mirror star as the second component are given the Appendix.

6) The onflow of the ordinary matter on the mirror white dwarf or on the mirror neutron star may give birth in the centre of accretion disc to a dense region, having the size of the mirror star or of it central core. The latter is by an order of the magnitude smaller, than the size of the whole star. Observational properties of such a dense region will be close to corresponding properties of ordinary degenerated stars with some quautitative differences (possibly smaller size and higher temperature).

Besides that, in the case of mirror white dwarf presumably hydrogen object will be observed on its place. Detonation in such an object may lead to phenomene looking like Nova explosion with some possible difference in quantitative properties. In the case of mirror neutron star phenomena looking like bursters may arise with quantitative parameters possibly different from the usual ones.

The ordinary neutron star, being in the binary with normal mirror star, will be observed as radio pulsar in a binary with invisible companion. It can be distinquished from the binary of ordinary relativistic stars by the change of the binary orbite by many orders of the magnitude more rapid, than owing to gravitational waves radiation. Such an evolution of the orbit may follow from: a) the motion of the apside line induced by the final size of the normal companion, b) accretion of the mirror matter of the normal component on the observed neutron star, c mass loss by the sistem owing to nonconservative mass exchange or from other reasons.

6. Conclusion

The given above qualitative analysis of the observational effects of the mirror matter extends significantly the possibilities of astronomical search for the mirror world, as

compased to the previous results [5-8]. The development of the modern superstring theory, for which the existence of mirror or shadow world is an inevitable fundamental prediction, makes such search especially actual. It should be noted in this relationship, that many of effects, mentioned above, do not imply strict symmetry in the properties of ordinary and mirror matter and are appropriate to the case of dissipative shadow matter. So, if there "ll be no effects of mirror matter in the observations, one not only obtains the observational disproval of the hypothesis of the mirror world, but also puts constraints on the possible properties of the shadow world, thus providing important "experimental" data for development of the particle theory in the fields, inaccesible to direct laboratory tests. On the other hand, the discovery of such effects, the whole significance of which can be hardly overestimated, will provide on the base of their whole set to make the conclusion on the symmetry of the physical laws of the visible and invisible matter. Note, that since the search for the mirror world is possible by its gravitational action only, and such an action on the scales of galaxies and their clusters may be due to the presence of collisionless gas of dark matter particles, the scales, smaller than the galactic ones, are preferable for "pure" extraction of the mirror world effect. But on the geometrical scales, smaller than the size of normal stars, effects of mirror matter can be hardly distinguished from similar effects of black holes. So for the search for the mirror world the most optimal are the phenomena, taking place on the scales 10^{10}-10^{20}cm, i.e. from the size of nondegenerated stars to the size of giant stellar clusters,assosiations and gas-dust complexes. The search for mirror matter effects at other scales has nethertheless general astrophysical significance, stimulating the search for new astronomical phenomena. The actuality and importance of the problem and the presence of observational possibilities to solve it imply the need to elaborate cooperative programms of astronomical search for effects of the mirror world.

Appendix

In the table A1. the parameters of 6 spectral – binaries from catalogue [55-57] are given, for which the function of masses is $f(M) > 3M_\odot$ and there are no lines observed, belonging with sure to the second companion. From the definition of the function of masses $f(M) = M_2 \sin^3 i/(1+M_1/M_2)$ one obtains

$$M = f(M)\ (1+M_1/M_2)^2/\sin^3 i > f(M) > 3\ M_\odot$$

In the neither case can the second component be the white dwart, or the black hole. If the successive detailed study of these sistems make it possible to exclude with definiteness the presence in them of the second component, being on the stage of burning of the central thermonuclear source, that will mean, that either black hole, or mirror star is present in the sistem.

The main criterium to choose between these two variants seems to be the total power of additional energyrelease in the binary. In the case of black hole the power of energy release is to be by several orders of the magnitude higher, than in the case of mirror star. Accounting for possible effective shielding of the radiation by thich accretion disc one should consider just the integral over all the ranges luminosity. Besides that, very fast variatious of luminosity with the minimal timescale of the order of r_g/c [59] are to arise in the case of accretion on black hole. In this context the binary A0620-00, being the X ray Novae with millisecond bursts [60], should be related to the sistems with black hole, and hot to ones with mirror star.

For example, in the binaries W Cru and V600 Her lower estimations of mass of the invisible component give 16 and $32M_\odot$, respectively. The second components, being neither black hole, nor mirror star, would have had the luminosities higer than the ones of visible components.

Table A1. Spectral-double sistems with invisible massiv second component.

The name and other names	Brigtness in the band V; the spectral class	Orbital periods, days	Amplitude of orbital velocity, km/s	Mass function f(M), $M_\odot$
A0620-00	18.2	0.323	457	3.18
HD 72754	6.9 B8Ipe	33.7	137	9
HD 105998 W Cru	9 G1Iab	198.5	65.7	5.82
HD 149881 V 600 Her	6.6 B0.5III	5.2	21.4	5.2
HD 193928 WN6	6.8	21.6	130	4.94
HD 235679	8.9	225.2	64	5.9

Table 1. All the possible variants of effects of interactions between astronomical objects at various scales.

O-objects \ ---- \ N-objects \ of galaxies	1 Clusters of galaxies	2 Galaxies	7 Gas of galaxy	8 Molecular cloud	3 Globular clusters	4 Dispersed clusters	5 Stars	6 Relativ. objects
I Clusters of galaxies	1-I k							
II Galaxies	2-I k	2-II k						
VII - Gas of Galaxy	7-I g	7-II k		7-VIII g	7-III g		7-V g	7-VI g
VIII - Molecular clouds		8-II k		8-VIII g	8-III g		8-V g	8-VI g
III - Globular clusters		3-II k						
IV - Dispersed clusters				4-VIII k	4-III k			
V - Stars			VII-5g	VIII-5gk	5-III k		5-V g	5-VI gk
VI - Relativistic objects			VII-6 g	VIII-6gk	6-III k		6-V g	6-VI k

Comments to the table: The first number corresponds to the object, being in the gravitational fields of its partner; the letter "g" and "k" denote respectively gasodynamical and kinematical effects (see the text).

1-I k. Mirror cluster of galaxies in the ordinary cluster of galaxies (kinematics): the velocity dispersion is determined by the mirror matter (dark matter), relative movement of mirror and ordinary clusters may induce distorsions in the matter distribution in the ordinary cluster.

1-I g. Mirror cluster of galaxies in the ordinary cluster of galaxies (gasodynamics): hot gas is localized not in the center of the cluster but in the gravitational well of the mirror cluster. Effect of gas trap- ping.

2-I k. The ordinary galaxy in the mirror cluster of galaxies (kinematics): anomalous velocity induced by the gravitational field of the cluster,i.e., galaxy with anomalous redshift.

2-II k. The ordinary galaxy, interacting with a mirror one (gasodynamics): gas structure distorsions with induced star formation.

3-II k. The ordinary globular cluster in the mirror galaxy (kinematics): globular clusters - 'runners' in the Galaxy and intergalactic space.

3-IIIk. The ordinary globular cluster in the mirror globular cluster (kinematics): anomalous stellar velocity dispersion induced by the dark matter of the mirror cluster.

4-IIIk, 4-VIIIk. The ordinary dispersed cluster in the mirror molecular cloud or in the globular cluster (kinematics): anomalous dark matter, preventing the dispersed cluster from decay.

5-VII g - 6-VII g. The ordinary star or relativistic object in the mirror interstellar medium (gasodynamics): effects of accretion, changing the mass and the rotational momentum of the ordinary object.

5-VIII g -6-VIIIg   The ordinary star or relativistic object in the mirror molecular cloud (kinematics): capture of the ordinary object, resulting in its anomalous velocity induced by the dark matter of the cloud.

5-VIII g, 6-VIII g. The ordinary star or relativistic object in the mirror molecular cloud (gasodynamics): accretion on the ordinary object of the dense gas of the mirror cloud, resulting in the effects similar to 7.1.

5-III k, 6-III k. The ordinary star or relativistic object in the mirror globular cluster (kinematics): capture of the ordinary object by the mirror globular cluster (stars - 'runners', high-velocity pulsars).

5-V k, 5-VI k The ordinary star, interacting with mirror star or relativistic object (kinematics): binaries without visible ordinary companion.

5-V g. The ordinary star, interacting with a mirror one (gasodynamics): effects of accretion on the invisible graviting center with grawita- tional well of finite depth. The presence of mirror mass in the center of the ordinary star, influencing the relationship colour - luminosity etc.

5-VI g. The ordinary star, interacting with mirror relativistic object (gasodynamics): intensive accretion on the gravitational well with fin- ite depth and without surface effects in the energy release.

6-V k, 6-VI k. The ordinary relativistic object, interacting with mirror star or relativistic object (kinematics): periodic variations of the period of ordinary pulsars in such pairs.

6-V g. The ordinary relativistic object, interacting with mirror star (gasodynamics): accretion of mirror star on the ordinary pulsar, chang- ing its mass and, consequently, the period.

7-II k.. Similar to 2-II k.

7-III g,7-V g -7-VIIIg. Accretion of the ordinary galactic gas by potential wells of mirror molecular clouds, globular clusters, stars and relativistic objects, respectively.

8-II k. Capture of molecular cloud by mirror galaxy viewing as high- velocity molecular cloud on the periphery or beyond the galaxy.

8-VIII k. Capture of the ordinary molecular cloud by the mirror one: effects of dark matter and velocity dispersion in the cloud.

8-III k. Capture of the ordinary molecular cloud by mirror globular cluster:effects in the gas velocity dispersion.

8-III g, 8-Vg - 8-VIg. Accretion of molecular cloud gas by gravitational wells of globular clusters, stars and relativistic objects.

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