III. ASYMMETRY AND ANISOTROPY OF THE UNIVERSE

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Any violation of geometrical symmetry leads to the incompatibility of the original form and its mirror image. Therefore this incompatibility could be considered as one of the fundamental definitions of asymmetry. Figures with mixed symmetry cannot be divided into equal parts and therefore are considered as asymmetrical. Any asymmetrical figure can be made in two enantiomorphous forms: "left" form and "right" one. There are no absolute criteria to distinguish "left" from "right", and consequently if naming one of the two enantiomorphous forms "right" (*R*) one must name the other "left" (*L*).

Fundamental significance of the left and right antipodes in nature is a result of peculiar features of the mirror reflection operation – coordinate's inversion: $\bar{r} \rightarrow -\bar{r}$, which is the simultaneous mirror reflections (the change of the sign) relative to the three mutually perpendicular planes at the origin of coordinates. Folding hand palms in a prayer, people simulate the coordinate's inversion operation. Multiplying pairs of standard left and right figures (*R*, *L*) with the use of different symmetry operations, it is possible to develop all the symmetry groups: null-dimensional, linear, planar and spatial.

The word "asymmetry" often is used as statistical term to designate the inequality in shares of left and right objects in some totality. A most simple asymmetry measure is the share of the dominating symmetry type. For example, the "right-handedness" is the universal feature of all the nations. Though the share of right-handed children varies substantially, the share of right-handed adults is stable enough being around 90%. Therefore, this type of statistical asymmetry often is designated as $R_{0.9}$.

Fig. 3.1. Left. The Stone Age fresco with spotty hoses in the Pech Merle cave in France (http://phys.org/). Right. Prints on walls of the ancient cave in Patagonia (http://cdn2-b.examiner.com/).

The lively attention of people to the left-right asymmetry has a very long history. A multitude of left and right hand imprints decorates walls of many Paleolithic caves. Inside the French 25 000-year-old Pech Merle cave hand stencils surround the famous “Spotted Horses” mural (Fig. 3.1). The wall decoration in Patagonian Stone Age cave exclusively consists of hundreds of hand stencils (Fig. 3.1). After the study of more than 500 hand imprints in 26 Spanish and French caves French scientists published sensational findings: 10–30 thousand years ago, left-handers outnumbered ours almost twice and the majority of Paleolithic cave artists were women and children.

Left-right asymmetry was a popular subject of Pythagoreans, which often use the term “symmetry” as the synonym of “harmony” and included left-right asymmetry into their ten fundamental oppositions of the Universe. Swords in the right hands of the army’s right-handed majority, defending homeland, long ago gave cause to consider in many cultures the “right” as a symbol of the “good” and the “left” as a symbol of the “evil”. The highway robber crucified at the right side of Christ has repented his sins and ascended to heaven. Saint Matthew dramatically expressed the symbolic meanings of left and right in Christian culture (Matthew 25: 32, 33):

32. Before Him will be gathered all the nations and He will separate people one from another as a shepherd separates the sheep from the goats.

33. And He will place the sheep on His **right**, but the goats on the **left**.

The shadows of sun-clocks in the Northern hemisphere move from left to right. So as far back as in Babylon era the direction of the hour hand movement was established as “right”. Contemporary industry producing billions of right screws that screwing in when their heads move from left to right, finally has imprinted in our minds the choice of right screw as the synonym of clockwise movement, which was firstly made more than four millenniums ago. Following these ancient traditions, now we usually attribute positive value of the symmetry index to the “right” objects and to virtual or real clockwise rotations.

At first the study of the inorganic Nature did not discover significantly asymmetrical phenomena. Only a relatively small part (less than 9 %) of minerals can exist in two forms – crystals with left and right types of symmetry. Long study of crystals does not reveal reliable difference in quantities of left and right forms among thousands minerals. However, there are many examples of special thermo-dynamical conditions that lead to the formation of some dominating crystal symmetry, left or right, but this is a subject of peculiar field of science – the stereo-specific synthesis.

The study of mirror asymmetry in biology started from the discovery in 18th century by Bernarden de Sen-Pier of the significant asymmetry in orientation of the mollusk shells (Fig. 3.2). Further investigations demonstrated that among snails (*Gastropoda*) left-right asymmetry with some dominating type of symmetry is a widespread phenomenon revealing sometimes dramatically high values of asymmetry $R_{0.96}$. Astonishing asymmetrical phenomena were discovered among Amazonian fishes. There are species that have two different reproductive races: one with R-males and L-females and another with L-males and R-females, and the reproduction is possible strictly inside each race.

Apparent symmetry of mammals with one plane of symmetry hides many asymmetrical features inside: the heart, stomach and spleen are on the left; the liver and appendix are on the right. People usually have right hand slightly larger than left and left foot slightly larger than right. Primates like people have dominating arms: among chimpanzee and gorillas the majority is left-handers and among orangutans and gibbons the majority is right-handers.

The growing attention to the problem of mirror asymmetry in biochemistry was connected with the discovery of optical isomerism in 1848 by Beshan and Pasteur. This pioneering investigation discovered that gray-blue mold (*Penicillium glaucum*) selectively consumes only one of two tartaric acid stereoisomers. Right and left stereoisomers are chemical compounds, having the same atomic composition, structure of chemical bonds and thermodynamic characteristics that can exist in two left and right enantiomorphous molecular configurations. Many sterioisomers are optically active, changing the direction of polarization in the passing light.

Fig. 3.2. Illustration in the book by Nicolai Gualtieri *Index Musei*, 1742.

A multitude of optically active chemical compounds was discovered in the study of live cell chemistry: sugars, amino acids, proteins and nucleic acid. An analysis of bio-chemical mirror asymmetry demonstrated many astonishing phenomena: there is no left desoxyribonucleic acid (DNA), all the living creatures have left amino acids and right carbohydrates. **Summing up we can say that contrary to the almost symmetrical inorganic nature, Life is the flourishing kingdom of asymmetry.**

In 1894, Pier Curie, who was very interested in the problems of symmetry, formulated the following statement in his article: "Physical phenomena symmetry. The symmetry of electric and magnetic fields"[1]:

"The symmetry of generating media seems to be overlapped on the body forming in this media. As a result, the body's form preserves only those proper symmetries, which coincide with the symmetries of generating media".

Those body's symmetries, which were lost in the process of forming, so-called "vanished" symmetry, Curie named "dissymmetry". In 1898, English chemist Frensis Jepp, always stated in his popular lectures "Stereochemistry and vitalism" that "only asymmetry can generate asymmetry".

In the second part of the 20th century the principle of dynamical formation of asymmetric phenomena and asymmetric objects gained a common recognition. In order to study physical processes it is always necessary to introduce some reference system of coordinates and its choice determines some privileged directions of its axes. This situation contradicts the idea of homogeneous and isotropic spacetime that is frequently applied in science, and this is the reason why only the relations invariant relative to shifts and rotations in the reference frame coordinates are considered to have physical meaning. These requirements of invariance significantly limit the diversity of possible "physical laws" and restrict them via group theories of symmetry.

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[1] Curie, P. Oeuvres. Paris, 1908.

One of the characteristic features of decelerating physical time: $\tau = t + H/2 \cdot t^2$ is its asymmetry (see sections “Irreversible-Time Physics” and “Antitime and Antispace” in this site and [16]). This asymmetry is rooted in the irreversibility of the physical time and is determined by the Hubble constant $\mathrm{H} = 1.7 \cdot 10^{-18} \mathrm{s}^{-1} (61.6 \mathrm{km/s/Mpc})$ (1.78) in [16]: $A_{\tau} = \tau(t) + \tau(-t) = Ht^2 > 0$ and $A_{r(\tau)} = c\tau(t) + c\tau(-t) = cHt^2 > 0$.

Using the cosmological scale for the Newton time: $t_p = H^{-1}$, one can estimate the present value of this asymmetry:

$$A_{\tau p} = Ht_p^2 = H^{-1} = 16.131 \text{ Gyr} \qquad (3.1)$$

$$A_{rp} = cHt_p^2 = c/H = 4.932 \cdot 10^3 \text{ Mpc} \qquad (3.2)$$

These estimations make clearer the physical meaning of such parameters as “the age of the Universe” and “Hubble radius” in classical cosmology. “The age of the Universe” is the measure of the physical time asymmetry for the conjugate measure of the space asymmetry – the “Hubble radius”, and they **have nothing in common with the age and history of the “expanding” Universe** since they can be determined for any moment of time.

Any asymmetric object is always a material realization of some dynamical process where it is possible to find some violations of dynamical symmetry. Physical time is the global asymmetric factor, firstly, due to the asymmetry of the “Time arrow”, directed from the past to the future, and secondly, due to the asymmetry of spacetime with the decelerating physical time. Therefore, **many natural phenomena, developing in the asymmetric spacetime and material objects forming with the assistance of these processes, should reveal some sort of asymmetry** that, however, sometimes is difficult to observe and describe formally.

3.1 Mirror asymmetry of spiral galaxies

In the inexhaustible diversity of cosmic structures, spiral galaxies (spirals) exceeding 60 % of all galaxy population, invariably attract the attention of astronomers. One of the riddles of spirals is their strange asymmetrical distribution in cosmos – in the population of “field galaxies” 70 % are spirals, however in galaxy clusters the spiral share is only about 20 %. These beautiful cosmic structures consist of a flat, rotating disk containing stars, gas and dust, and a central concentration of stars known as a bulge. Spiral central structures are surrounded by a much fainter halo of stars, many of which reside in the globular clusters.

Spiral galaxies are named for the usually two-armed spiral structures that extend from the center into the disk. Edwin Hubble in his 1936 work “The Realm of the Nebulae” named such galaxies “normal” (S-class: Fig. 3.3, upper row). The spiral arms are sites of ongoing star formation and are brighter than the surrounding disk parts because of the young hot stars that inhabit them. In H_{α} rays, spiral arms became more contrast because the hydrogen fields stretch along the spiral arms.

Roughly, half of all spirals are observed to have an additional component in the form of a bar-like structure, extending from the central bulge, at the ends of which the spiral arms begin. Such spiral galaxies are “barred spirals” (SB-class: Fig. 3.3, lower row). Our own Milky Way galaxy has recently (in the 1990s) been confirmed to be a barred spiral, although the bar itself is difficult to observe from our position within the galaxy disk.

At first rotation of spiral galaxies was measured using spectroscopic methods in 1917 by Vesto Slifer and Heber Curtis. Later it appeared that the kinematics of the galaxies rotation usually is a complex combination of the spiral arm solid-body rotation and several types of differential rotations. Besides, a multitude of deviations from circular rotation, movements along the spiral arms and even opposite rotations of spiral arms in one galaxy, were observed. For galaxies with disk diameters from 10 to 50 kpc peripheral rotation velocities estimated as 50–300 km/s with average period of global galaxy rotation around $3 \cdot 10^8$ years.

There is no univocal correspondence between galaxy rotation and profiles of the spiral arms. Therefore, for example, both galaxies at Fig. 3.3 in upper row could rotate in the same direction, say counter-clockwise. In such a case, spiral arms of the "left" galaxy (M51) are named "lagging" and spiral arms of the "right" galaxy (M74) are named "leading".

There are no ideal spiral forms in the family of spiral galaxies and usually astronomers see such additional elements as arcs, hoops, radial branches, lines of compactions that cross and often pass into spiral arms. Nevertheless, basing on the dominating direction of spiral arms and other asymmetrical morphological elements one can confidently classify a galaxy as "left", S-like (negative) morphological type (for example, Fig. 3.3, left column) or "right" (positive) morphological type (for example, Fig. 3.3, right column).

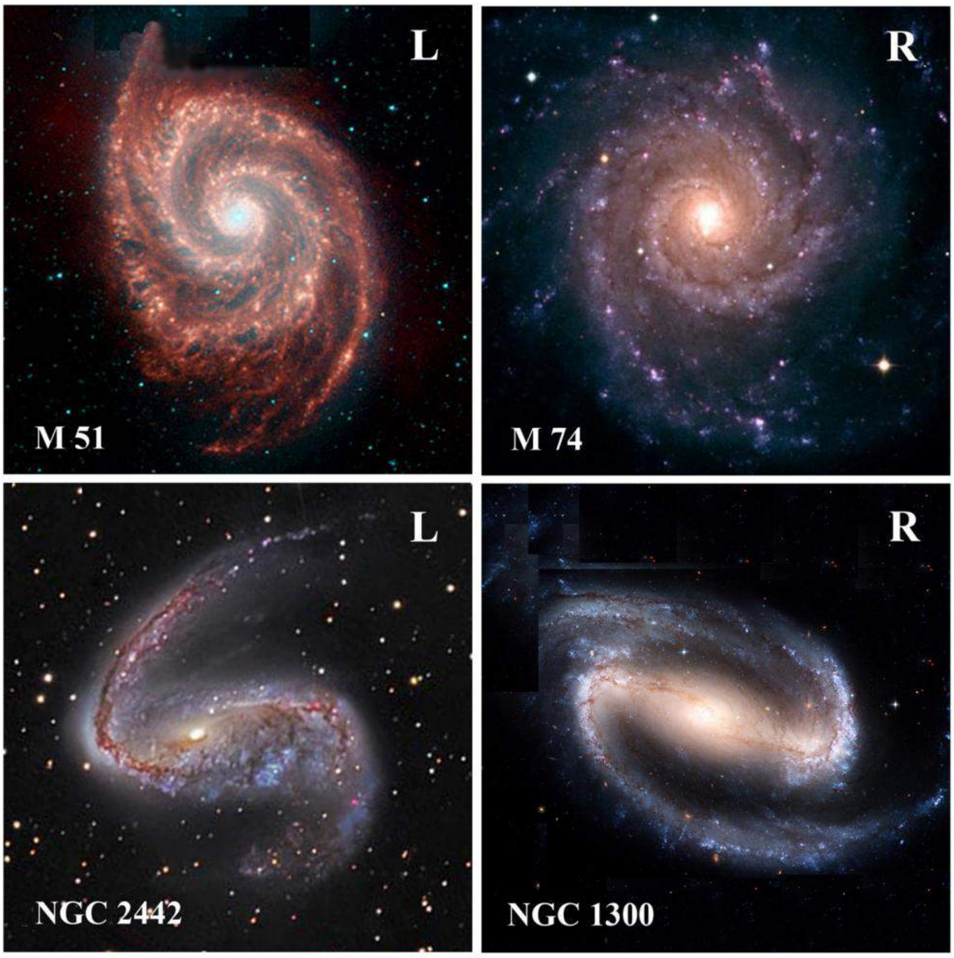

Fig. 3.3. Typical morphology of the spiral galaxies with left (*L*) and right (*R*) types of symmetry. (http://hubblesite.org/)

During many years a team of Russian astronomers headed by Professor Boris Voroncov-Veljaminov studied the galaxy morphology, and during 1961–1974 five volumes of "Morphological galaxy catalogue" containing detailed description of more than 30 000 galaxies were published [20]. This catalogue describes morphology of galaxies with stellar magnitudes up to 17^m. However, reliable attribution of the spiral symmetry type is possible only for galaxies with stellar magnitudes up to 15^m and when the observation angle is not less than 45^o. For our study in 2005–2007, a statistics of 6650 spiral galaxies of such a type discovered at the Northern sky was chosen from Voroncov-Veljaminov's catalogue.

It is convenient to estimate the degree of left or right forms excess by the following "asymmetry" of the sample:

$$A_{RL} = (R-L)/(R+L) \quad \sigma_A = 1/\sqrt{R+L} \quad (3.3)$$

Here R and L are correspondingly the number of right and left morphological types in the sample $N = R + L$ of spiral galaxies.

The observations of the sample of 6650 spiral galaxies of Northern hemisphere clearly demonstrated the domination of left S-type spirals (Fig. 3.3, left column): $R = 3026; L = 3624$. The mirror asymmetry of Northern hemisphere spiral galaxies was estimated according to the relation (3.3) to be: $A_{RL} = -0.09 \pm 0.012$.

An interesting project was undertaken in 2008 – more then 100 000 volunteers took part in the Internet studies of the morphology of spiral galaxies from the SDSS DR6 catalog. They analyzed 13140 spiral galaxies of the Northern sky, which gave the mirror asymmetry measure: $A_{RL} = -0.0706 \pm 0.0087$ [8]). Catalog [6] allowed to estimate the asymmetry of the sample of 3118 Southern galaxies to be: $A_{RL} = +0.047 \pm 0.029$, which is positive because «left» galaxies dominating on the Northern sky are seen as «right» ones in the south.

Table 3.1. Results of mirror asymmetry estimations of the spiral galaxies samples

	N	m	z	A_{RL}	References
1	6650 (Northern sky)	$\leq 15^m$	-	-0.09 ± 0.012	[15]
2	13140 (Northern sky)	-	≤ 0.3	-0.0706 ± 0.0087	[8]
3	15158 (Northern sky)	$\leq 17.4^m$	≤ 0.085	-0.0607 ± 0.0118	[10]
4	3118 (Southern sky)	-	-	$+0.047 \pm 0.029$	[6, 10]

Our study of 750 spiral galaxies with magnitudes up to 14^m revealed **a new natural phenomenon – the clustering of spirals in accordance with the type of symmetry** (Taganov 2010 [15]). Spirals tend to form pairs (26%) or groups (44%) with one certain type of symmetry, so that the share of single field galaxies is only about 30% (Figs. 3.4, 3.5).

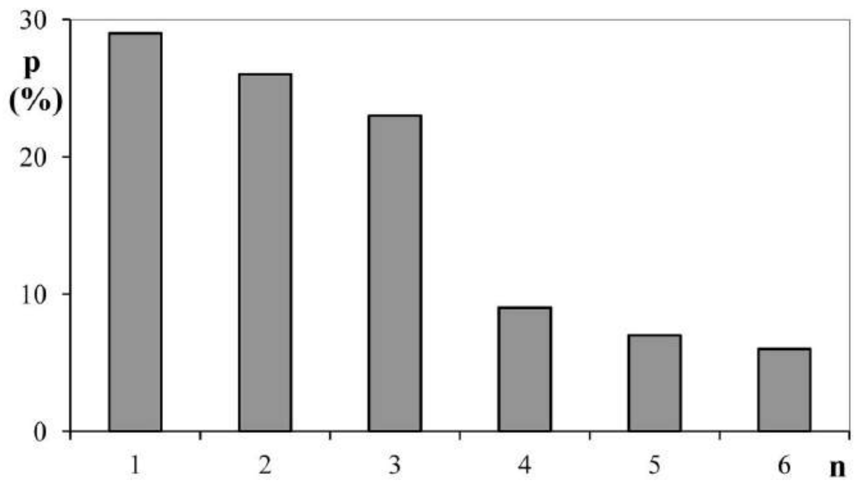

Fig. 3.4. Histogram (p %) of galaxies distribution of a certain symmetry type (either all R, or all L) over the galaxies groups with different galaxy quantity (n).

Fig. 3.5. Typical pair of spiral galaxies in a group with the same «right» (*R*) type of symmetry. (http://hubblesite.org/)

The formation of groups of galaxies with the same type of symmetry leads to an excess of groups with "left" galaxies and to the mirror asymmetry of clusters to which they belong. Preliminary estimation of the mirror asymmetry of clusters in the Northern sky is: $A_C \simeq -0.05$.

3.2. Anisotropy of the Universe.

Spacetime manifests itself as an integrated system and due to this fundamental system property – the "Arrow" of physical time inevitably induces its imprint in the space as the large scale anisotropy axis ("Creator's Shadow"), which, in its turn, determines the specific symmetry disturbances in the large-scale astrophysical data. The first hints to the existence of such disturbances appeared already before the middle of the 20th century in the epoch of classic cosmology formation.

As early as in antique times the nature of light and the speed of its propagation were already subjects of philosophical discussions and scientific guesses. Empedocles considered light to be the "moving something" and Aristotle accepting the existence of such "something" however denied its motion. At the same time Euclid suggested the curious "emission theory of sight" where light is emitted from eyes. From this theory, Heron of Alexandria concluded that the speed of light is infinite because stars are seen "immediately after opening eyes".

In 1021, Arabian alchemist and optical scientist Ibn al-Khaitam (Alkhaizen) in his work "Book of Optics" described several experiments supporting the theories of vision where light moves from source to observer's eye and suggested the finite value of its speed being lesser in more dense media. Abu al-Beruni in his multi-volume compendium of Arabian science at the end of 11th century also stated that the speed of light is finite and far exceeds that of sound.

In the beginning of the 17th century, Kepler proposed that the speed of light should be infinite because there are no obstacles to its propagation in space. Descartes also arrived at the same conclusion and even worried about the irreparable damage to his whole philosophy if the speed of light happened to be finite.

Dutch astronomer Ole Remer, who worked in the Paris observatory, was the first who carried out the observations, which suggested a relatively reliable estimation of the speed of light. In 1676, he published his observations of Io – the satellite of Jupiter, which allowed him to evaluate the speed of light as 220 000 km/s. His observations did not impress the astronomical community, but only a decade later Newton remarked in his *Principia* that "according to astronomer's measurements the speed of light is finite". However, not later than in 1704 in his *Optics* he gave his own estimation of the speed of light: "16.6 Earth's diameters per second", i.e. about 210 000 km/s, which was by 30% lower than the presently adopted value.

The problem of the accurate estimation of the speed of light only attracted the attention of the physical community after the publication of results of the famous experiments by Albert Michelson and Edward Morley in 1881–1887. Those experiments were aimed to measure the so-called "speed of the ether wind" – the speed of Earth relative to the immovable substance, which in accordance with the Fresnel hypothesis is the media sustaining the propagation of light. Mickelson and Morley were very cautious in interpretation of their results [23]:

"If we consider the Earth's orbital motion, then our experiments demonstrate that the velocity of Earth relative to ether is probably less than one sixth of the Earth orbital velocity *(about 30 km/s)* and definitely is less than one quarter of it *(i.e. less than 7.5 km/s)*".

However, this cautious statement was interpreted by many scientists as a "zero result", i.e. the absence of the "ether wind" and the absence of ether itself. The experiment of Mickelson and Morley served the crucial role as a basic motivation for creation of the special relativity theory in 1887–1908.

Many physicists, including Einstein himself, doubted in physical reality of the "Fitsgerald-Loretz contraction", in spite of the logical perfection of special relativity theory, and did not consider the experiments of Mickelson and Morley as a sufficient ground to reject the idea of ether. That is why the Nobel committee awarded the prize to Albert Michelson in 1907 only for the "construction of the precise optical instruments" without any mentioning of Edward Morley, "ether wind" and the special relativity theory.

In 1905–1906 Edward Morley and Dyton Miller built a new interferometer four times more accurate than that of Michelson's and reliably determined the speed of the "ether wind" on the top of 90-meter hill near the Erie lake in the USA, which turned out to be around 3.5 km/s. This success initiated an idea that the "ether wind" speed grows with the height of measurement point over the sea level. In 1921–1925 Miller reliably measured and studied during several years the "ether wind" on the top of the Mount Wilson and evaluated the average speed of 10 km/s on the 1800 meter level. In 1929, intrigued Albert Michelson conducted several measurements himself also on the Mount Wilson and confirmed Miller's results with his estimation of the "ether wind" being about 6 km/s. [14, 23].

The studies of the "ether wind" revealed many peculiar features of this phenomenon. It turned out that dense materials and in particular metals "absorb" or "reflect" the ether wind with its velocity being variable with time. Moreover, numerous experiments indicated that ether wind blows not opposite to the Earth's orbital motion but in nearly perpendicular direction – from the direction of the Draco constellation (**right ascension about 262^o, declination +65^o**).

Many experiments with precision interferometers, which have been conducted during many years, have not provided convincing arguments allowing us to give up the idea of ether wind. The studies of the "ether wind" have been going on and there even formed an exotic branch of physics – the "ether dynamics". The contradictions in the interpretation of the results of Michelson-Morley experiments and the absence of convincing proofs of the reality of "Fitzgerald-Lorentz contraction" caused half a century delay in adopting the Principle of constancy of the speed of light.

Summarizing the studies of the "ether wind" Sergey Vavilov made the following conclusion [23]:

"It is necessary to state that Michelson-Morley experiments proved the existence of the ether wind with the velocity from 3 to 6 km/s, which does not correspond to the "theoretical" value of 30 km/s but at the same time it is definitely not the "zero result".

It is quite possible that in 1990s, Yuri Baurov discovered one more manifestation of the large scale anisotropy of the Universe. He studied the influence of his experimental equipment orientation in space on testing a test-body's motion in magnetic fields and the rate of beta decay. [2, 18]. The results of his studies of fluctuations in his sensitive devices indicate the existence of a "cosmological vector potential" influencing many terrestrial physical processes, which invariable is directed toward the constellation of Hercules (**right ascension about 275^o, declination about +28^o**).

The studies of the fluctuations of the CMB (Cosmic Microwave Background) radiation by the space probes COBE DMR (Differential Microwave Radiometers), WMAP and Planck allowed the investigation of its large scale structure. In the study, the expansion of the deviation of CMB temperature from its average value is used: $\Delta T(\theta,\varphi) = \sum_{l=1}^{\infty}\sum_{m=-l}^{l} a_{lm} Y_{lm}(\theta,\varphi)$. Summation over *m* under the fixed *l* determines the multipole map of the temperature fluctuations $\Delta T_l(\theta,\varphi)$ of the order *l*.

Figure 3.6 displays the multipole maps of the CMB of the first five orders where signs plus and minus mark the regions of positive ("hot") and negative ("cold") temperature deviations from the mean value. Even superficial inspection of this picture reveals the asymmetry of dipole ($l=1$), quadrupole ($l=2$) and octupole ($l=3$), where the hot and cold zones alternate around the preferential directions. Multipoles of higher orders ($l=4$ and $l=5$) demonstrate much more isotropic temperature distribution.

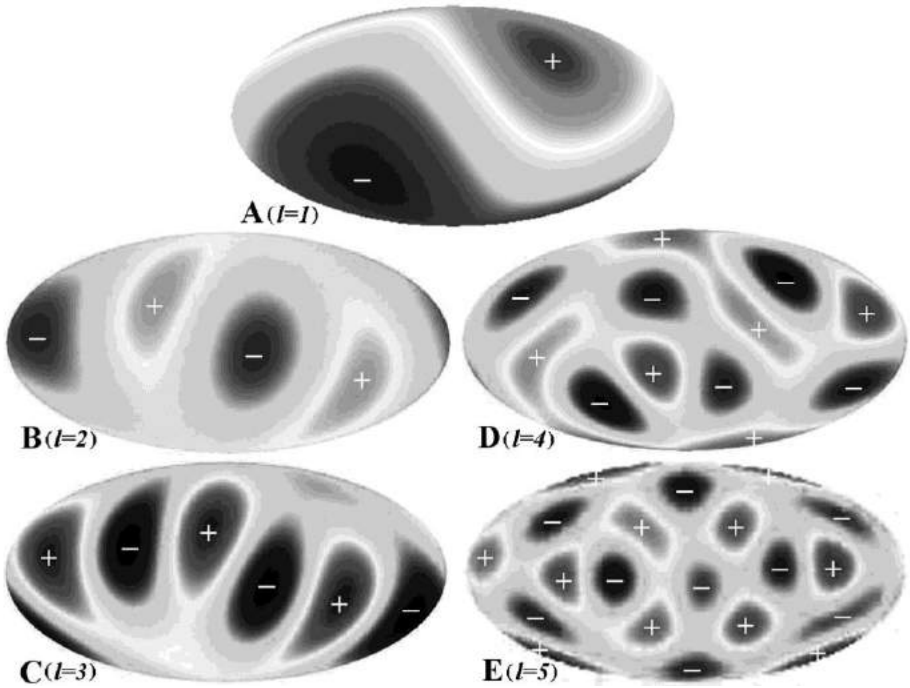

Fig. 3.6. Multipole maps of the CMB: A. Dipole $(l=1)$; B. Quadrupole $(l=2)$; C. Octupole $(l=3)$; D. Hexadecapole $(l=4)$; E. $(l=5)$. [3]

To find the spatial orientation of the CMB, vector representation of its multipole maps already introduced by Maxwell is used. The dipole is represented by one vector that is normal to the plane of its map, the quadrupole requires two vectors determining its "oriented" plane and one vector, which is normal to this plane. The octupole map occupies three planes with corresponding normal vectors.

The dipole temperature difference $\Delta T = 3.36$ mK with the characteristic vector directed to the point with right ascension 264^o and declination +48^o is determined by the Earth's orbital motion and

Solar System motion together with our Galaxy's motion in Local Group with the velocity about 385 km/s relative to the CMB towards the point with **right ascension** $276° \pm 3$ **and declination** $+30° \pm 2$**.** The dipole map reflects the Doppler Effect – the CMB temperature is somewhat higher in the direction of the Earth's relative motion [9].

The values of the quadrupole CMB temperature fluctuations are much lower – about $\Delta T = \pm 19$ mcK, and the quadrupole map depends on the adopted method of noise filtering. Also, the quadrupole maps are significantly different for high-frequency channels $\mathrm{Q(40.7GHz); V(60.8GHz); W(93.5GHz)}$ and low-frequency ones $\mathrm{K(22.8GHz); Ka(33GHz)}$. These factors allow us to determine the direction of the characteristic vector only for the high-frequency channels and only with limited accuracy – right ascension $275° \pm 11$ and declination $+67° \pm 4$ [3].

The octupole map demonstrates temperature fluctuations of the order $\Delta T = \pm 34$ mcK and also depends on the frequency of channels used for calculations. This map depends on the calculation method and method of noise filtering in much lesser degree compared with the quadrupole map. It became possible to determine the direction of the geometrical mean of three characteristic vectors of quadrupole component of CMB (for the high-frequency channels) with sufficient accuracy: right ascension $308° \pm 2$ and declination $+63° \pm 1.5$ [3].

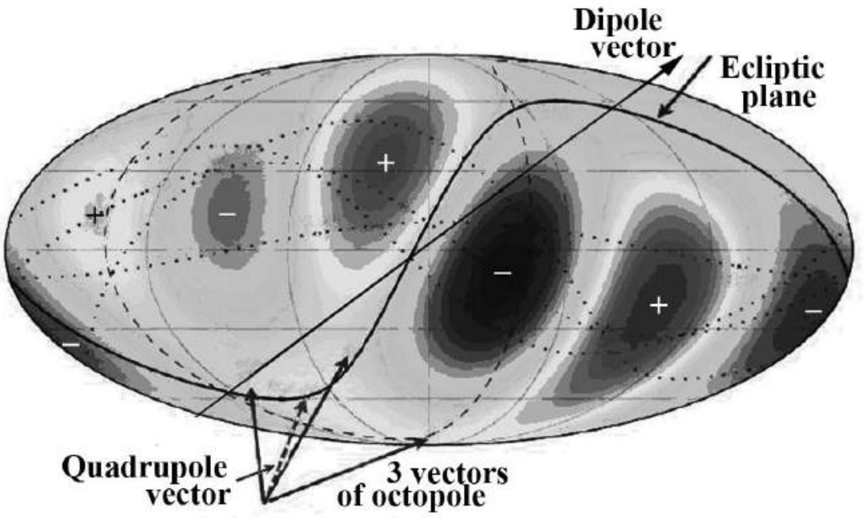

Fig. 3.7. The characteristic vectors of multipoles at the combined maps of quadrupole and octupole of the CMB [3].

The directions of characteristic vectors of the dipole, quadrupole and octupole components of the CMB temperature fluctuation field, which display spatial anisotropy, closely coincide. The discovery of the anisotropy of fluctuations of CMB temperature together with the reliable correlation and close coincidence of the characteristic vectors of quadrupole and octupole cannot be convincingly explained in the Big Bang hypothesis and present serious difficulties for it. Therefore the CMB anisotropy with the average direction towards the **right ascension** $287° \pm 20$ and **declination** $+63° \pm 7$ was even called "The Axis of Evil" by cosmologist Joao Magueiro from the London Imperial College.

The studies of quasars revealed one additional piece of evidence of the anisotropy of the Universe. Optical radiation of quasars demonstrates significant polarization, and the mean angle of polarization $\langle \theta \rangle$ rotates with redshift having the rate about 30^{o} per 1000 Mpc. The dependence $\langle \theta \rangle - z$ has the mirror symmetry – in Northern galaxy hemisphere polarization angle rotates clockwise and in Southern – counter clockwise.

The studies of radiation polarization of several hundreds of quasars carried out by two independent groups of astronomers revealed that polarization vector orientations are not random for the scales larger than 1000 Mpc – the correlation of orientation for both low $z \sim 0.5$ and medium $z \sim 1.5$ redshifts grows towards the direction with **right ascension** $266°.5 \pm 0.5$ **and declination** $+65° \pm 4$.[5, 12].

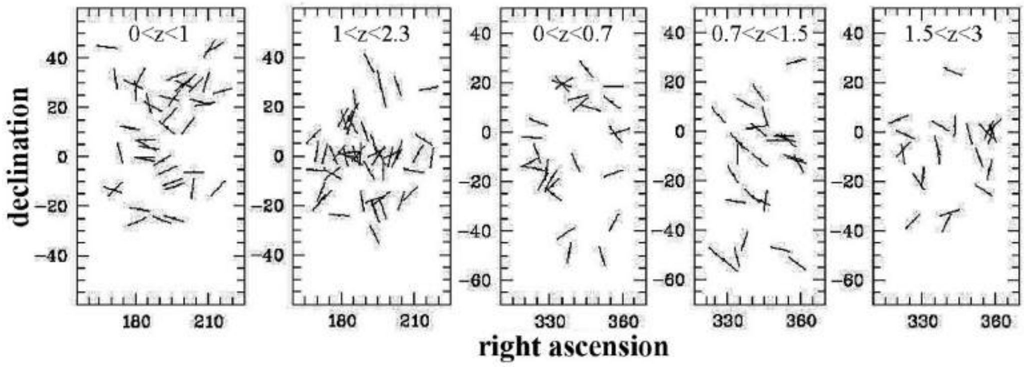

Fig. 3.8. Orientations of polarization of quasar radiation (optical range) for quasars with different redshifts in two parts of celestial sphere [5].

The rather high value of the "absolute" velocity around 385 km/s of our galaxy Milky Way relative to the CMB estimated by the dipole map leads to a difficult question for the astronomical community. What is the cause of such high velocity if at the same time the velocity of our galaxy within the Local Group doesn't exceed 60 km/s? The acuteness of this problem is connected with the fact that in modern Standard cosmological model the velocities of large-scale massive structures cannot significantly exceed 200 km/s. The attempts to solve this problem motivated the launch of several research projects aimed to determine the values and directions of the large-scale bulk flows of galaxies and clusters.

Table 3.2. Estimations of the direction and absolute velocity values of the large-scale bulk flows of galaxies and clusters relative to the CMB.

	R (Mpc)	*N*	*U* (km/s)	*l*	*b*	Ref.
1	Earth's motion	-	$385 \pm 78(115)$	276 ± 3	30 ± 2	[9]
2	65	24	444 ± 194	276	-8	[4]
3	107	56	630 ± 200	260	27	
4	130	63	104 ± 119	300	18	
5	136	119	832 ± 252	349	51	
6	180	15	1000 ± 438	277	27	
7	The average for 1–6	277		288 ± 30	25 ± 18	
8	110	158	400 ± 190	270	0	[4]
9	162	4630	407 ± 81	287 ± 9	8 ± 6	[17]
10	600	516	934 ± 352	282 ± 34	22 ± 20	[7]
11	800	547	1242 ± 329	292 ± 21	27 ± 15	
12	1000	694	1051 ± 293	290 ± 24	30 ± 16	
13	1250	838	1016 ± 266	296 ± 29	39 ± 15	
14	The total average	7660		288 ± 27	24 ± 19	

Table 3.2. displays the results of the most known projects of studies of large-scale bulk flows of galaxies and clusters. Second column in the table presents the number (*N*) of studied objects. Table 3.2 demonstrates, in particular, that the errors of estimations for the flow direction coordinates (*l*, *b*) are significantly less than that of velocities, which values are estimated with up to 60% relative

errors. In spite of large estimation uncertainty there is a reliable excess of observed velocities over the velocity limit in Standard cosmological model – dashed line 1 at the Fig. 3.9.

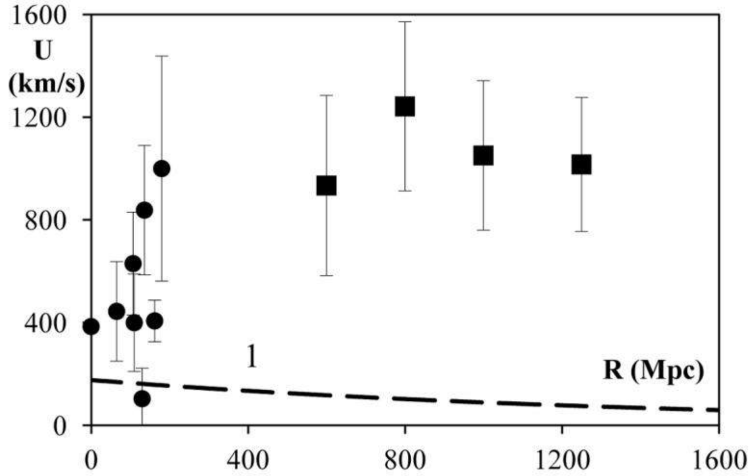

Fig. 3.9. Absolute values of the large-scale bulk flows of galaxies and clusters: circles – the data from lines 1–8 in Table 3.2, squares correspond to lines 9–12 in Table 3.2.

Quite unexpected for the astronomical community became the very close coincidence of the directions of large-scale bulk flows, which consist of several thousand galaxies and clusters in different parts of the celestial sphere. Recent studies (in particular lines 7 and 14 in the Table 3.2) demonstrate impressive statistical stability of the estimations of direction coordinates of the large-scale bulk flows – **right ascension** $288° \pm 27$**, and declination** $+24° \pm 19$ [4, 7].

Recently it became possible to apply supernova observations for the analysis of cosmological anisotropy. Using the database "Union2", containing the observations of 557 supernovae in the redshift range of $z = 0.015 - 1.4$ with the following data for each supernova: supernova coordinates (l_i, b_i), redshift z_i, distance modulus μ_i and its dispersion $\sigma^2_{\mu i}$, it is possible to determine the value of cosmological parameter $\Omega_M \simeq 0.27$ (Perlmutter, Riess [11, 13). This value corresponds to the hypothesis of the accelerating expansion of our Universe in the present epoch.

The authors of [1] made an attempt to find the direction in space corresponding to maximum appearing "acceleration" of the Universe expansion. They took 400 random directions determined by $r^{(j)}; j = 1 - 400$ random vectors where each vector gave the poles of a new galaxy coordinate system. Then, using the database *Union2* they calculated stellar coordinates $(l_i^{(j)}, b_i^{(j)})$ in these systems and for each new system they divided all stars from *Union2* into two groups – stars of the upper hemisphere indexed by "*u*" (up) and lower one indexed by "*d*" (down).

For each randomly chosen system of coordinates were calculated two values of cosmological parameter $\Omega^{(j)}_{M,u}$ and $\Omega^{(j)}_{M,d}$ for the upper and lower galactic hemispheres and then the "anisotropy indexes": $A^{(j)}_{\Omega} = 2[\Omega^{(j)}_{M,u} - \Omega^{(j)}_{M,d}] / [\Omega^{(j)}_{M,u} + \Omega^{(j)}_{M,d}]$ were estimated. Maximal negative values of the "anisotropy index" correspond to the maximal values of the apparent expansion acceleration.

The statistics of 400 different orientations of coordinate systems allowed to determine the average anisotropy index values with sufficient accuracy: $A^{\max}_{\Omega} = -0.43; A^{\min}_{\Omega} = +0.43$ and coordinates of the maximal (**right ascension** $309°^{+23}_{-3}$**, declination** $+18°^{+11}_{-10}$) and minimal (right ascension $129°^{+23}_{-3}$, declination $-18°^{+10}_{-11}$) poles of the apparent Universe's "expansion acceleration". It is interesting that in the vicinity of maximum and minimum poles there are the higher concentrations of the observed supernova explosions as seen in the Fig. 3.10.

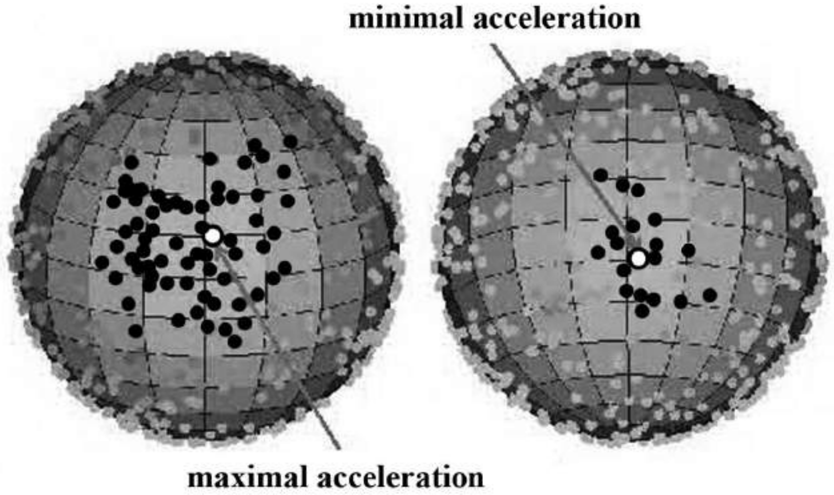

Fig. 3.10. The distribution of supernovae over the celestial sphere as it is seen from the poles (countered open circles) of maximal and minimal apparent expansion acceleration. Black circles indicate higher concentrations of the observed supernovae explosions at the vicinity of these poles [1].

The Table 3.3 and Fig. 3.11 display the results of the discussed research projects, which give grounds to suggest the existence of large-scale anisotropy axis of the Universe. All six independent studies performed in different countries and in different periods of time give close estimations of the galactic coordinates of this hypothetical anisotropy axis in the Northern sky.

Table 3.3. Estimations of the Universe's anisotropy axis pole coordinates in the Northern galactic hemisphere.

		$l°$	$b°$	References
1	Direction of the "ether wind"	262	+65	[14, 23]
2	Direction of the Baurov's "cosmological vector potential"	275	+28	[2, 18]
3	Geometrically average direction of the characteristic vectors of CMB multipole maps	286 ± 22	$+62 \pm 9$	[3, 9]
4	Direction of the correlation growth of polarization vectors of the quasars radiations	266.5 ± 0.5	$+65 \pm 4$	[5, 12]
5	Average direction of the large-scale bulk flows of galaxies and clusters	288 ± 27	$+24 \pm 19$	[4, 7, 17]
6	Direction between the extremes of apparent acceleration of the Universe expansion	309^{+23}_{-3}	$+18^{+11}_{-10}$	[1]
	Average coordinates of the pole of the Universe's anisotropy axis in the Northern galactic hemisphere	286 ± 27	$+43 \pm 25$	

The direction of the "absolute" Earth's velocity relative to the "immovable" CMB marked in the Fig. 3.11 is close enough to the pole of the Universe's asymmetry axis. This is not surprising because the major part of the Earth's velocity is determined by the Local Group velocity in the large-scale flow, which direction is close to the Universe's axis of the asymmetry (see Table 3.2).

All the estimations of the coordinates of Universe's anisotropy axis lay within relatively small region of the Northern galactic hemisphere $l = 262^\circ \div 332^\circ; b = 8^\circ \div 65^\circ$ with total coverage of 2540 square degrees even with account for their root mean square errors. Probability of the random location in this area of any of the above estimations is the ratio of this area and the total hemisphere: $2540/20626 = 0.123$. Therefore, the probability of accidental location of all six independent coordinate estimations in considered area is: $(0.123)^6 = 3.5 \cdot 10^{-6}$, which is very small.

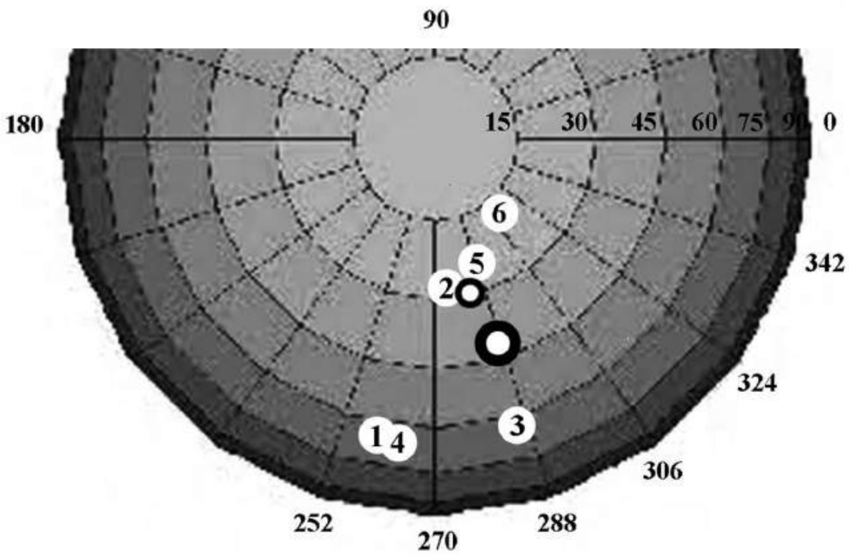

Fig. 3.11. Estimations of the coordinates of anisotropy axis pole of the Universe in Northern galactic hemisphere. Circles with numbers mark estimations presented in the Table. 3.3. Large countered circle marks the most probable pole coordinates. Small countered circle marks the direction of the "absolute" Earth's velocity relative to the "immovable" CMB.

Thus, astrophysical studies have led to convincing evidence in favor of the Universe's asymmetry – the existence of a mirror asymmetry of the most numerous cosmic structures – spiral galaxies, and the existence of a large-scale Universe axis of spatial anisotropy.

3.3. Mirror asymmetry of the Micro World

Mirror symmetry in the Micro World is determined by the concept of "Parity" (see e. g. [2]). Spatial parity of micro particles is the quantum number $P = \pm 1$, which characterizes the behavior of the wave function of a particle or system of particles after spatial mirror transformation. After space inversion scalar and pseudo-vector do not change their signs, and therefore it is considered that they have a positive parity ($P = +1$). Pseudo-scalar and vector change signs after mirror transformation and, therefore, have the negative parity ($P = -1$).

The change of particle wave function $\psi(\bar{r})$ is determined by its "internal parity" and in the reference frame connected with the particle can be described as:

$$\psi(\bar{r}) \to P\psi(-\bar{r}) \quad (3.4)$$

Particles with the spin $J = 0$ and internal parity $P = +1$ ($J^P = 0^+$) are sometimes called "scalar particles", particles with $J^P = 0^-$ are "pseudo-scalar particles", those with $J^P = 1^-$ are "vector particles", and those with $J^P = 1^+$ are "pseudo-vector particles".

In the system consisting of two particles, the parity of whole system is determined by the internal parities of particles and system's "orbital parity" $(-1)^L$ defined by the particles relative motion in the reference frame with origin in the inertia center of a system:

$$P_{12} = P_1 P_2 (-1)^L \quad (3.5)$$

[2] Cheng, T.P., Li, L.F. *Gauge theory of elementary particle physics*. Oxford University Press, 2006. ISBN 0-19-851961-3. Sozzi, M.S. *Discrete symmetries and CP violation*. Oxford University Press, 2008. ISBN 978-0-19-929666-8.

Equations (3.4, 3.5) allow finding the parity of systems with arbitrary number of particles by induction.

In 1925, Wolfgang Pauli formulated **the law of parity conservation** for the micro particles systems stating that the total parity of the system is the same before and after particle transformations. It can also be stated that, in accordance with this law, the mirror reflection of any physical process must proceed in the same way as it would be in the case of the mirror absence and we should observe it as a real physical process but not as the "beyond the mirror" process. The law of parity conservation corresponds well to the intuitive assumption of scientists that nature does not favor the right over the left, or vice versa.

The problem of mirror symmetry has always attracted the attention of physicists because the internal parity conservation in the processes of micro particle conversions is considered as an indicator of isotropy and homogeneity of the physical space in the microcosm, which is a fundamental property of space and the basis of all quantum physics, supporting the unshakable background of the most important laws of conservation.

However, in the late 1940s strange K-mesons were discovered in the cosmic rays, which quickly decayed due to the weak interaction into ether the three pi-mesons, preserving the original negative parity of K-meson, or into two pi-mesons with total positive parity, clearly demonstrating the blatant violation hitherto seemingly immutable law of conservation of parity in the micro particles world. The physicist community called this surprising behavior of K-mesons with the unusual name "Mystery of Tau-Theta".

In the mid-1950s, two American physicists Tsung Dao Lee and Zheng Ning Yang put forward a simple assumption that in the decay processes, caused, as in the case of K-meson, by the weak interaction, the intrinsic parity of micro particles actually is not preserved. Several ingenious experiments have confirmed their bold assumption and, indeed, it later turned out that the weak interaction has a very pronounced tendency to disturb the balance of internal parity in the systems of micro particles. The works of Lee and Yang were rewarded in 1957 by the Nobel Prize in Physics.

The violation of parity conservation law in weak interactions undermined the confidence in the hypothesis of mirror symmetry of the space, and the internal parity was considered as a "weak" quantum number. Many physicists thought that the idea of mirror symmetry of the microcosm would be, at least partially, preserved if the "combined CP-parity" in the processes of particle transformations strictly conserved.

The CP-transformation is a combination of the above mentioned mirror transformation P and the "charge conjugation" C, that is, the replacement of particles with anti-particles. It seemed during at least seven years that the lost confidence in the mirror symmetry of microcosm was partially recovered. However, in 1964, James Cronin and Val Fitch discovered the decay of the long-living K_L^0 meson, with negative value of CP-parity into two pions – a system with positive CP-parity. For over 15 years the physicists could not come to his senses after such "mirror shock", but in spite of this James Cronin and Val Fitch were in 1980 awarded the Nobel Prize in Physics for their discovery.

It should be noted that the violation of CP-parity conservation law could be directly related to the origin and characteristics of the Universe. One of still unsolved mysteries in cosmology is the lack of any traces of anti-particles and anti-matter in the Universe. All of the "hot" models of the Universe's birth predict the origin of the equal numbers of particles and anti-particles, but in this case, the cascade processes of annihilation of particles and anti-particles would soon lead to the formation of a vast ocean of radiation without any traces of matter in the Universe. One of the possible explanations of the absence of anti-matter is the so called "Sakharov conditions" where the violation of the CP-parity conservation law at the early stages of the Universe evolution plays an important role.

The ruins of the hypothesis about the mirror symmetry in the Micro World, decorated with two Nobel Prizes, certainly deserve the continuation of their study. In order to provide serious violation of mirror symmetry in so numerous processes of micro particle conversions there must be some yet undiscovered global mirror-asymmetrical factor.

An asymmetric object and the micro particle in particular, with a definite value of spatial parity is always the product of some dynamic process, in which there is already possible to detect certain violations of dynamic symmetry. Physical irreversible time is the global asymmetric factor, firstly, because of the asymmetrical “Arrow of time”, directed from the past to the future, and, secondly, because of the physical time spirality, which is characterized by only one type of symmetry in our Universe (see sections “Irreversible-Time Physics” and “Antitime and Antispace” in this site and [16]). Therefore, **some natural processes, developing in an asymmetric irreversible physical time, and material objects that are formed as results of these processes may demonstrate some type of asymmetry.**

In 2002, the author of this article put forward an idea to estimate the mirror asymmetry of all the elementary particles and resonances, which had already been discovered by that time just as we evaluate the asymmetry of left- and right-handers in the population of the Earth. **Analysis of the characteristics of almost a hundred and fifty known elementary particles and resonances showed that with the at least 95 % confidence their mirror asymmetry is negative and the number of particles with negative intrinsic parity is about 10% greater than that of the particles with a positive intrinsic parity** (Taganov 2003 [21, 22]).

Later it turned out that the analysis of the statistical properties of the micro particles can prove **the general negative mirror asymmetry of the whole set of elementary particles** almost like a mathematical theorem (Taganov, 2010 [15]). In this study the analysis of the intrinsic parity of the particles in the basic state, that is, with zero orbital angular momentum ($L=0$ in 3.5), plays a decisive role. Resonances, being the products of orbital and radial excitations of the particle quark structures, can have spins and intrinsic parity different from the initial parent particles.

Let us consider the internal parity formation for all groups of elementary particles in their basic states.

I. Leptons (l) and baryons (b) being fermions, i.e. having a half-integer spin and forming Fermi statistics, have positive internal parity $P(f)=+1$. Their anti-partners $\bar{l}$ and $\bar{b}$ instead, have negative parity $P(\bar{f})=-1$ due to the relation: $P(f)P(\bar{f})=-1$. The total internal parity of this class of particles is zero, because all leptons and baryons have their anti-partners:

$$l-\bar{l}+b-\bar{b}=0 \quad (3.6)$$

In this and subsequent equations numbers of particles of different groups have signs, corresponding to signs of their internal parities.

II. Mesons (m) do not possess the baryonic charge and have integer or zero spin, i.e. they have statistical properties of bosons. To study their internal parity the model of their quark structure is used, according to which they consist of pairs “quark – anti-quark”. The quark spins are equal to $1/2$, so they are fermions with negative internal parity of the “quark – anti-quark” pairs and, therefore, the parity of all mesons and anti-mesons ($\bar{m}$) is always negative in the basic state. The class of mesons also contains the group of the “true neutral mesons” (m_0), which do not have corresponding anti-partners, and also have negative internal parities. Therefore, the total internal parity of all mesons and anti-mesons is negative:

$$-m-\bar{m}-m_0<0 \quad (3.7)$$

The relations (3.6, 3.7) demonstrate that there is an excess of particles with negative parity in the Micro World due to numerous class of mesons and their anti-partners (3.7). The value of mirror asymmetry A of the whole population $N=R+L$ of micro particles is determined by the deviation of total parity of the particles with negative (“left” particles L) and positive (“right” particles R) internal parities:

$$A = (R - L)/(R + L) = (N - 2L)/N \quad \sigma_A \sim 1/\sqrt{N} \quad (3.8)$$

As it follows from (3.6, 3.7) this relation can be transformed to the inequality:

$$A = [N - 2(m + \bar{m} + m_0) - 2(\bar{l} + \bar{b})]/N = -(2m + m_0)/N < 0 \quad (3.9)$$

and $A = (1 - 2N_m/N) \pm N^{-1/2}$ (3.10)

In (3.10) N_m is the quantity of mesons and anti-mesons and *N* is the whole population of micro particles.

Therefore, the Micro World has total permanent negative mirror asymmetry of the integral internal spatial parity of the particles in their basic states, which is determined by the mesons and their anti-partners with negative spatial parity.

It is important that the negative mirror asymmetry of the Micro World will be conserved regardless of how many new particles will be discovered because the total parity of leptons and baryons (3.6) will always be zero, and the discovery of new mesons will only increase the negative total mirror asymmetry of the microcosm. For example, prior to the discovery of heavy gauge bosons in 1983, the negative parity have 56 mesons and anti-mesons from the total number of already studied particles and anti-particles $N = 82$. These numbers according to (3.8–3.10) define the following negative mirror asymmetry of the Micro World: $A = [82 - (2 \cdot 56)]/82 = -0.36 \pm 0.11$.

Literature

1. Antoniou, I., Perivolaropoulos, L. Searching for a Cosmological Preferred Axis: Union 2 Data Analysis and Comparison with Other Probes // Preprint arXiv:1007.4347v1[astro-ph.CO] 7 Dec 2010.

2. Baurov, Yu.A. Space magnetic anisotropy and a new interaction in nature // Phys. Lett. A (1993) 181; 283.

3. Bielewicz, P., Gorski, K.M., Banday, A.J. Low-order multipole maps of cosmic microwave background anisotropy derived from WMAP // Mon. Not. Royal Astr. Soc. (2004) 355; 1283. Preprint arXiv:astro-ph/0405007.

4. Hudson, M.J., Smith, R.J., Lucey, J.R., Schlegel, D.J., Davies, R.L. Are Recent Peculiar Velocity Surveys Consistent? // Preprint arXiv:astro-ph/9909307v1 17 Sep 1999.

5. Hutsemekers, D., Cabanac, R., Lamy, H., Sluse, D. Mapping extreme-scale alignments of quasar polarization vectors // Astr. & Astroph. (2005) 441; 915. Preprint arXiv:astro-ph/0507274v1 12 Jul 2005.

6. Iye, M., Sugai, H. // ApJ (1991) 374; 112.

7. Kashlinsky, A., Atrio-Barandela, F., Ebeling, H., Edge, A., Kocevski, D. A new measurement of the bulk flow of X-ray luminous clusters of galaxies // Preprint arXiv:0910.4958v3[astro-ph.CO] 11 Mar 2010.

8. Land, K. et al. // Mon. Not. Royal Astr. Soc. (2008) 388; 1686.

9. Lineweaver, C.H., Tenorio, G.F., Smoot, P. et al. The Dipole Observed in the *COBE DMR* Four-Year Data // ApJ (1996) 470; 38. Preprint arXiv: astro-ph/9601151.

10. Longo, M.J. Evidence for a Preferred Handedness of Spiral Galaxies // Preprint arXiv:0904.2529 [astro-ph.CO] 15 Apr 2009.

11. Perlmutter S., Aldering G., Goldhaber G. et al. Measurments of Omega and Lambda from 42 High-Redshift Supernovae // Astrophys. J., 517, 565-586 (1999).

12. Ralston, J.P., Jain, P. // Int. J. Mod. Phys. (2004) 13; 1857.

13. Riess, A.G., Filippenko, A.V., Challis, P. et al. Observational Evidence from Supernovae for Accelerating Universe and a Cosmological Constant // Astron. J. (1998) 116; 1009-1038.

14. Swenson, L.S. *Ethereal Aether: A History of the Michelson-Morley-Miller Aether-Drift Experiments 1880-1930*. Univ. of Texas Press, 1972. ISBN 978-0292720008.

15. Taganov, I. Die Asymmetrie in der Natur: Neue Phänomene // Nachrichten der Olbers-Gesellschaft Bremen (April 2010) 229; 4-9.

16. Taganov, Igor N. *Irreversible-Time Physics*. Saint Petersburg: TIN, 2013. ISBN 978-5-902632-12-2. Kindl Edition (English) ASIN: B00I214VIG. http://www.amazon.com/books. *"Physics of irreversible time: The new natural phenomena"*. ISBN-13: 978-3659513541. ISBN-10: 3659513547. LAP LAMBERT Academic Publishing. https://www.lap-publishing.com. *«Физика необратимого времени. Новые явления природы»*. ISBN-13: 978-3659286674. ISBN-10: 3659286672. LAP LAMBERT Academic Publishing. https://www.lap-publishing.com.

17. Watkins, R., Feldman, H.A., Hudson, M.J. Consistently Large Cosmic Flows on Scales of $100h^{-1}$ Mpc: a Challenge for the Standard ΛCDM Cosmology // Preprint arXiv:0809.4041[astro-ph] 27 Nov 2008.

18. Бауров Ю.А. *Структура физического пространства и новый способ получения энергии*. М., 1998.

19. *Библия. Современный русский перевод*. М.: Рос. Библейское о-во, 2011.

20. Воронцов-Вельяминов Б.А., Красногорская А.А. *Морфологический каталог галактик*. ТТ. 1–5. М.: Изд. МГУ, 1961–1974.

21. Таганов И.Н. *Спираль Времени. Космологическое замедление хода времени*. СПб.: ГеоГраф, 2003. ISBN 5-902211-02-6

22. Таганов И.Н. *Спираль Времени. Космологическое замедление хода времени*. Изд. 2-е испр. и доп. СПб.: ТИН, 2004. ISBN 5-902632-01-3

23. *Эфирный ветер*. Сб. статей под ред. В.А. Ацюковского. М., 1993. ISBN 5-283-04990-6