АКАДЕМИЯ НАУК АРМЯНСКОЙ ССР

АСТРОФИЗИКА

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A SET OF WORKING HYPOTHESES TOWARDS A UNIFIED VIEW OF THE UNIVERSE

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Some observational evidence (anisotropy and inhomogeneity of the Hubble constant, abnormal redshifts) led the authors to formulate working hypotheses compatible with these observations. The logics of these hypotheses led to consider the universe as a "hierarchical" universe similar to Charlier's, and to find the cause of the apparent expansion in the interactions affecting the path of the photons. As, in some cases, intrinsic redshifts are very important (QSS, ...) this reduces the distance of the considered objects and their absolute luminosity, and forces us to link them with ordinary galaxies; a scheme of evolution of extragalactic objects is suggested, to account for the geometrical location of abnormal objects, and for some aspects of their morphology (double radio sources, etc...). From this set of working hypotheses, the authors feel, of course, that much work has to be done; but a coherent picture of the universe might emerge from the suggested studies.

In the course of the last two years, the authors have published a number of papers (see bibliography [1—17]) in which they gave examples of "abnormal redshifts", either within our Galaxy, or outside the Galaxy. We have considered as "abnormal" the redshifts displayed by objects which have different redshifts than objects located at the same distance from the Earth (or suspected to be so) and different when they are themselves (due to the solar motion, or to their own motion) located at different distances from some important radiating mass, such as the Sun.

Our first working hypothesis is:

"Most of the redshifts considered as abnormal are *real*, and not spurious". (WH 1).

The second working hypothesis is:

"The abnormal redshifts, considered as real, are due to causes that are not well known at present, i. e. they are neither due to the expansion of the Universe, nor to the Doppler effect of mass motions, nor to Compton effects." (WH 2).

The third working hypothesis, even if the two first WH are accepted by several scientists, is more difficult to accept: "The observed abnormal redshifts, detected in objects passing behind the solar corona, on the solar limb spectrum itself, in double stars, in extragalactic compact objects, and, in *most* of the cases, are due to a *single* physical cause (this physical cause will be labelled $\mathcal{D}$)". (WH 3).

We should say, in order to give weight to this WH, that it came to us as a very promising one, when we found that a semi-empirical formula used by us in our first papers was indeed fitting rather well practically in all cases. It could have been of course just good luck; and several authors, in practically all cases, have given seperate interpretations (some of them just as hazardous as ours!) which could, qualitatively at least, at this stage, interpret the observations (Sun: either no effect—Brault, Snider—or effect of microturbulent transfer—Magnan and Schatzman; eclipses by the solar corona: either no effect—Shapiro, against his own evidence, —; or influence of transfer in the homogeneous coronal plasma—Heyvaerts and Chastel; peculiar galaxies: either unsatisfactory data,—or real motions of objects; ...)*.

The rest of our "system" is deduced from these three hypotheses. It leads to "derived working hypotheses" linked on one side with the nature of quasars, the explication of phenomenon $\mathcal{D}$, the universal redshift interpretation, the hierarchical universe, and on the other side, by another line of reasoning, with the evolutionary links between various extragalactic species.

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* But we should remember an argument, often used by the statisticians. We quote it from Darrell Huff, "How to take a chance, a popular book on statistics and probabilities", but the test was indeed suggested by Ronald Fisher: "A lady, British of course, remarks that she can tell by taste whether the milk has been added to the tea or the tea to milk. A sceptic presents her with four cups of tea of one sort and four of the other. She tastes, and identifies them all correctly. What can this mean ? First, it may be that she really can tell tea and milk from milk and tea by taste" (we claim our formula helps us to be as good in redshift tasting as this lady). "Of course, she may have made a series of lucky guesses, a one chance in seventy long shot" (we do believe, indeed, this figure to show only that our series of papers is putting the odds on our side). But Huff says: "This is so unlikely that it would be more reasonable to credit the lady's claims". (Thank God !)" But wait. Perhaps the sceptic has arranged the cups in some simple pattern, probably without thinking about it, an alternation, perhaps, and the lady has chosen the same common pattern; this could greatly reduce the odds against a series of hits being made, even if taste is no clue". (Yes, but in our case, we do not believe that the cosmogonic demon has been so nasty as to do such a thing to us... Would you, indeed ?)

Let us make clear at this point that we never claimed to be the first ones to discover and emphasize abnormal redshifts, and to consider them as such, or to doubt the classical views on the universe. Arp, for example, has certainly to be credited for the importance given to abnormal redshifts; de Vaucouleurs has (after Charlier, Fournier d'Albe, and others) advocated the hierarchical universe; Zwicky had many arguments against the expansion itself, from observations; Treder, or Segal, had some others, from relativistic theory; compactness has been recognized as essential by many; Oort recognized the evolutive role of the galactic nuclei; Ambartsumian has been strongly advocating explosive processes from hyperdense matter; Kristian has discovered the fact that an association between a quasar and an "underlying" galaxy is general; Hoyle, Gold, Bondi and Lyttleton have been developing the steady state universe, — for years; Thomas, for thermodynamical reasons, and contrarily to Prigogine, does think that no equilibrium state can exist before the present strongly-non-equilibrium state of the Universe: hence he disregards expanding universes starting from successive condensed equilibrium states. And we should here quote a very long list of papers indeed!...

In this first section of this paper, and without entering into too many details in what we, or others, have been publishing elsewhere, we shall give a view of the Universe which seems more coherent than any previously published, — except the classical expanding Universe. In the second section, we underline the weaknesses of our analysis; and in the third one, we delineate the directions in which we feel that further studies are now necessary.

1. *The model.* According to our WH 1, 2, 3, one can say: there are abnormal redshifts due to some physical cause. If so, taking into consideration the enormously large redshifts of QSS, their too large energy output (if assumed at cosmological distance) and their secular angular distribution on the sky, we are led to apply to them this idea: their redshift is considered as essentially due to the physical cause $\mathcal{D}$. Application of that idea to a set of QSS's led us to a coherent description of their space location. Most of them are found indeed not to be at cosmological distances but a hundred times nearer. From this, we are led to two types of considerations.

A. *The Universe at large.* Clearly, objects that are intrinsically redshifted, due to some physical cause $\mathcal{D}$, seem to be the more *compact* ones; those which are redshifted during their passage near the solar disk, are so because the photons from the source interact with the solar field (particles of some sort, associated with the Sun). In both cases, the photons from the source are undergoing more interactions than from a) less compact objects, b) objects whose light does not cross closely the field of any star.

But the fact that compactness introduces some kind of additional intrinsic shift does not necessarly rule out some redshift due to expansion. However, and it may be here our WH 4, we shall assume that two different sources cannot really compete in giving one single phenomenon: "the Hubble shift, as measured in the spectrum of any galaxy, is due to the same cause as the redshift of compact objects".

In other terms, the Hubble law which can be expressed as usual:

$$z_i = (\Delta\lambda/\lambda)_i = HL_i/c \qquad (1)$$

is indeed a complex expression containing essentially three terms (fig. 1):

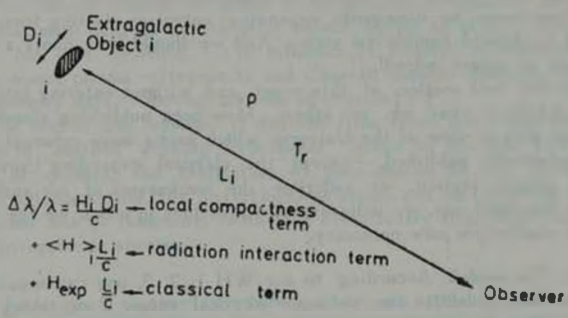

Fig. 1.

$$1 + z_{obs} = (1 + z_1)(1 + z_2)(1 + z_3) \text{ where} \qquad (2)$$

$$z_1 = H_i D_i \frac{1}{c} \qquad (3)$$

$$z_2 = \langle H \rangle_i L_i \frac{1}{c} \qquad (4)$$

$$z_3 = H_{exp} L_i \frac{1}{c} \qquad (5)$$

(the index *i* designates the observed extragalactic object, L_i its distance).

The third term, due to expansion, may be assumed negligible; the second one is due to all interactions encountered by the photons coming from the source along their path; the first one is due to compacity of sources. For compact objects, the first term alone dominates; for galaxies of the ordinary type, the second term is the only one which counts (fig. 2).

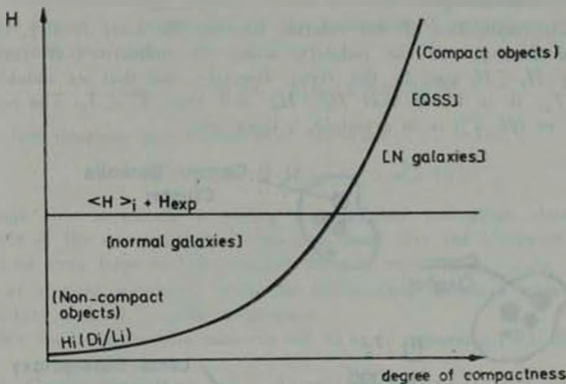

Fig. 2.

If compactness is associated with the effect, it means that the redshift is proportional to some function of the density of matter. We assume that there is, at large, a strong correlation between the density of matter and the density of the radiation (this is not a WH — it is indeed pretty obvious in the Universe). Hence the Hubble law, for ordinary rather close-by galaxies, can be written:

$$z_i = (\Delta\lambda/\lambda)_i = \int_0^{L_i} H(T_r(l))\, dl \tag{6}$$

where T_r is the *local* radiation temperature at any point in the Universe. Whatever the theory of the Universe may be, measures of H_0 and T_0 (value of T_r at the Earth) can be done. One obtains $T_0 = 2.65°$; and H between 50 and 100, — but with strong indications for some anisotropy and inhomogeneity; the analysis (with the law (6) in mind) of the observations we had under hand (and they may be criticable!) led us write:

— Our Galaxy (or our local cluster)	$T_0 = 2.65$ K	$H_0 = ?$ (motions in local cluster makes determination impossible)
— Our Supergalaxy	$T_1 = ?$	$H_1 = 100$
— Outside the Supergalaxy	$T_2 = ?$	$H_2 = 50$

The implication of the relation between the mass density, the radiation density, and the redshift, seems to indicate that the inequality $H_2 < H_1$ goes in the right direction, and that we should find $T_2 < T_1$. It is likely that $H_0 > H_1$: and that $T_1 < T_0$. The relation (H, ρ) or (H, T^4) is in principle, a linear one.

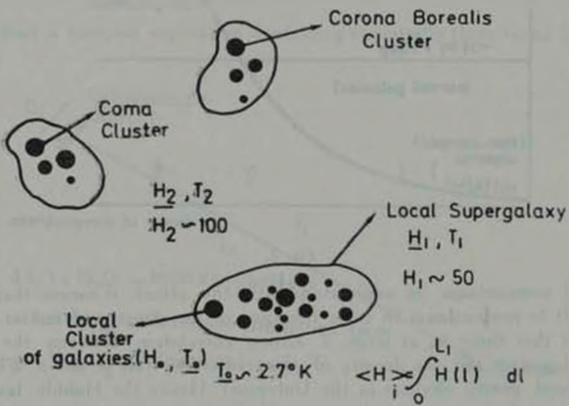

Fig. 3.

We do not know much from observations about clustering at a degree higher than the simple clustering of galaxies; Zwicky denies it, but modern authors (de Vaucouleurs for example) feel that the odds are in favor of such a clustering. A clustering at a larger scale would be undetectable. It is a well known law of hierarchical universes (fig. 3) such as the one we imply, that the average density decreases for larger and larger objects. This is what has been found. The exponent of the relation $\langle \rho \rangle = R^n$ can even be determined (in order of magnitude) from the data:

$$\log\rho = -21.7 - 1.5(\log R - 21.7) \qquad (7)$$

where ρ is expressed in g/cm^{-3} and R in cm.

Applying to such a universe the Relativity theory brings a problem. If we designate by R the radius of that universe, there is a relation between R and the average density in the corresponding volume. This relation is known but is function of the cosmological parameters. Very crudely, one has then $\langle\rho\rangle = R^{-2}$ or:

$$\log\rho = -21.95 - 2\log(R/3.09\cdot10^{24}) \qquad (8)$$

These two relations give a solution of the order $\langle\rho\rangle = 10^{-38}$;

$$R = 10^{32.5}\ cm \sim 10^{8}\ M\cdot pc\ (\text{or } z \cong 3\cdot10^{4}).$$

Although this is merely a strong extrapolated indication about the principle of the computation, it shows at least that the Universe might indeed be very large and its average density very small.

Let us note, incidently, that the hierarchical universe solves in a satisfactory manner the Olbers paradox.

We shall assume this universe not to be in expansion (WH 5).

B. *Compacity and evolution of extragalactic objects.* All compact objects, according to our scheme, have an intrinsic redshift; their "cosmological" distance is wrong; hence their brightness is usually overestimated by large factors, and their size as deduced from apparent diameters is overestimated. Hence, their apparent degree of compactness might not be too misleading, both effects compensating each other, at least in part.

Assuming all compact objects to be cosmological ones (the classical view), one can draw an "absolute magnitude-compactness" diagram, based on few measurements of the magnitude difference between the compact object (nucleus) and its quasi-galactic envelope. It appears on fig. 4. Three categories of objects can be drawn on this diagram. We suggest that further study of various objects will help considerably to draw a better diagram. The authors gratefully acknowledge blackboard discussions with Professor Ambartsumian, who is essentially responsible for the main aspects of this classification.

In each of the three category of objects, the radioemitters appear at the top first magnitudes of the representative column. This is due to the fact that radioemission is likely to be proportional to volume, and brightness only to surface, provided the opacity in the radio wavelengths of the whole object does not exceed unity.

Clearly, this figure leads to some difficulties. We should understand why the nucleus of an N-galaxy is so much less bright than a QSS, when many observers point out towards a great similarity between these two types of objects. Moreover, the cosmological hypothesis applied to QSS gives them a lifetime which appears to be very short ~ 10^5 years. Is this not difficult to reconcile with the fact that we observe QSS at many redshifts, hence at all distances, hence formed at almost any time since the Big Bang? The claimed association of some of them with some clusters of galaxies, mean thus that QSS could be a phase in galaxy life... But the flash would be of 5 magnitudes: the usual theories of nuclear reactions fail to explain that; and the matter-anti-matter theories do not apply to such unstabilities as can be produced in a single galaxy, giving place to the QSS phenomena...

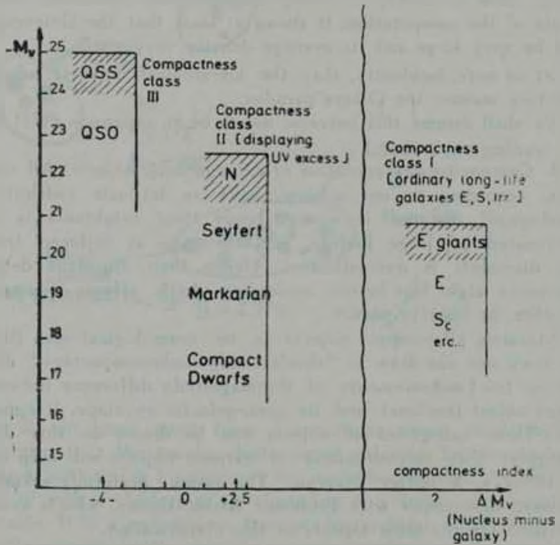

Fig. 4.

On the contrary, the hypothesis that QSS are local, that their redshift is intrinsic in general, does not meet with serious difficulties. If we reduce by a factor 100 the distance, hence the brightness by a factor 10^4, we increase the magnitude by 10; a factor 50 would give 8.5 magnitudes; hence we can bring the magnitude for the brightest QSS from -25 to a value of -16.5 to -15. This would give the maximum brightness of a quasar. The difference of magnitude between the nucleus of a N-galaxy and its galactic envelope is of the order of 2.5 mag. Putting the nucleus of the N-galaxy at about -15 magnitudes (maximum brightness), it gives for the galaxy itself -17.5. Hence, we reach a diagram such as the one of fig. 5.

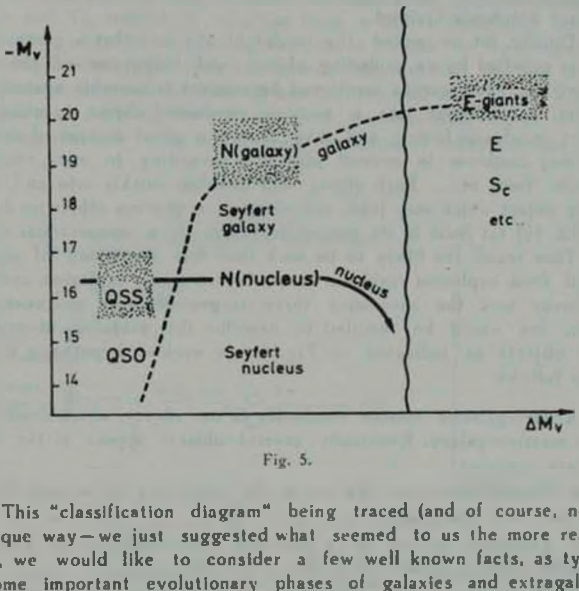

Fig. 5.

This "classification diagram" being traced (and of course, not in a unique way — we just suggested what seemed to us the more reasonable), we would like to consider a few well known facts, as typical of some important evolutionary phases of galaxies and extragalactic objects of compact nature.

First, let us remind the reader of the very large number of galaxies that are symmetrically completed by radiosources, generally at large distances, and in polar directions, this suggesting that an ejection has been taking place, by whatever mechanism it may be. In severa cases, one can note that, if put at cosmological distances, some absurl dities occur: 3C 279, for example, is composed of two sources, and interferometric studies seem to show a velocity of each component relative to the other of 10c; some authors mention objects where the distance between the two radiosources is, if assumed at cosmological distance, of about 50 *Mpc* (this implying that, at only the velocity c/10, the time necessary since the explosion is of the order of $4 \cdot 10^{9}$ years: this is in contradiction with the life-time deduced from counting the radiosources...).

Second, let us remind the reader of such rare but remarkable cases as the association of NGC 7331, and two almost symmetrical groups of odd and small galaxies, one of this group being the very compact Stephan's Quintet.

Thirdly, let us remind the reader of the fact that a gaseous mas such as expelled by an exploding object (and being one of the two symmetrical radiosources mentioned hereabove) is unstable against gravitation; it condenses into a massive condensed object, in which the nucleus condenses faster, and may radiate a great amount of energy; or it may condense in several objects — according to mass, rotation, magnetic field etc... Each object will develop quickly into an UV radiating object which may lead, according to a process otherwise described [10, 11] (at least in its general features), to a symmetrical explosion. Time scales are likely to be such that this dispersion of objects formed from explosion residuals occurs before a new explosion, and that one never sees the successive three stages of such an evolution. Hence, one would be tempted to describe the evolution of extragalactic objects as indicated on Fig. 6 (our working hypothesis WH 6) and as follows:

A. Intergalactic matter condenses in one object, which condenses into a massive galaxy. Eventually several objects appear in the same gas mass.

B. Nucleation occurs. We are in the stage of a (or several) N-Galaxy, shortlived (unstable).

C. Explosion occurs: for a relatively short time (but 10^{8} years is a possible value) a flash occurs: this is the QSS phase.

D. Residuals of the explosion: (a) two radio-radiating gaseous masses — Back to A. (b) one "tired galaxy" which goes back to equilibrium with a small nucleus — a normal galaxy, with long life expectation...

Processes A B C D repeat indefinitely; masses are getting smaller and smaller, the objects formed being lower and lower on the three columns of diagram 5. Eventually, expulsion of matter will end the life of the evolving matter; it will be distributed in the IGM (intergalactic medium), together with dying galaxies. These normal galaxies (including ours) have a chemical composition influenced by nucleosynthesis therein followed by supernova-type dissemination of heavy elements. Helium and deuterium are essentially as abundant as in the gas condensing in A. As time evolves, matter disintegrates; at the long range, an equilibrium abundance should exist in the universe, resulting from the ^4He and ^2D formation in hot points, and their very slow destruction in 10^n years (n being very large — in some cases 100 or more!). The present abundance of ^4He and ^2D, instead of resulting from a choice (somewhat ad hoc) of the time when an expanding universe is "frozen" in its composition (considered as protogalactic), results from the idea that the ^4He and ^2D abundance must result from an ad hoc (not more ad hoc than in expanding universe models!) determination of the maximum degree of concentrating reached before the average explosion of supernova-like character...

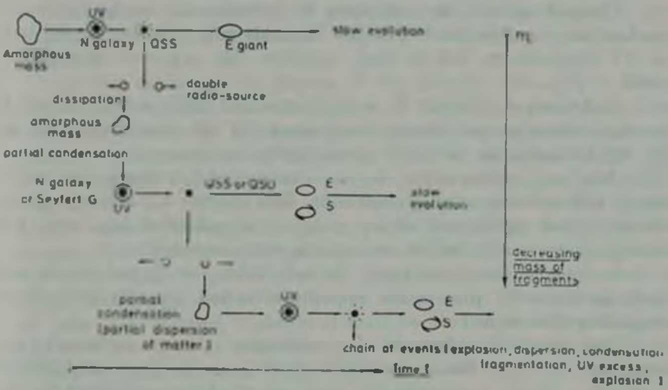

Fig. 6.

2. *Weaknesses of the model.* These are certainly obvious to anyone! Although we claim to account for the relation (H, T) and for the actual chemical composition, none of these relations is quantitative, unless we put forward good theories for (a) the natural decay of stable elements in the universe, and (b) a photon-field interaction theory.

We have not attempted the first except by claiming that our model is no more "ad hoc" in this respect than expanding universe models. We have attempted the second by putting forward successively three possible mechanisms, which do still meet considerable difficulties, in that it is hard to find a strong photon-field cross-section, which at the same time would not imply a large angle of scattering. We have replied to this argument, — but in a way which does not seem to have convinced every one.

The exploding processes which link various types of objects according to our classification-evolution scheme would need to rest on a detailed theory of the instability processes; in particular, our elementary theory of the UV explosion does not take properly into account optical depth effects or drag forces. Although it accounts for some phenomena observed in the Galaxy (metallic-poor halo; Dieter's ring and Oort's clouds), it can by no means be considered as safe; drag forces in particular considerably slow down the process; some authors think that it is unefficient at a time scale of the order of 10^{10} years.

Quasars spectra do not seem to corroborate our model in any obvious way; nor do the N-galaxies. But this might be due to the lack of UV observations, and we shall consider this argument as probably weak.

Links between normal E or S galaxies and QSS and QSO, which we have taken as our strongest argument for the local hypothesis on the QSS localisation in space, seems highly controversial.

Also very controversial is the observational evidence for anisotropy and inhomogeneity of expansion. This matter is far from settled, the statistical significance of any given set of published data being not always obvious, and the causes for bias being manyfold.

In front of this uncertainty, the safe value for T_0 and its obvious isotropy seems to plea in the opposite direction, strongly towards an expanding Universe.

The observed existence of cosmological quasars (although they seem not to have the same radio spectrum as do the local QSS) is certainly a strong argument for their spectra being redshifted by the same cause, and with the same amount, as the neighbouring galaxies... But maybe they are not exceedingly compact? Only dwarfs? In any case, this is an important argument...

3. *Tests to be done.* Both on the observational and theoretical sides, there are some experiments that may be critically conclusive in favor of one model or another.

a) The direct measurement of the expansion.

It is known that this test has been proposed, mostly by the northern and southern radioastronomers, to deduce, from radiosources counts, the density of the Universe, in places where $z \sim 1$ to 4. However this test, if positive, is of some value (as claimed by Ryle). If negative (as claimed by the Australian radioastronomers, notably Bolton), it does not mean so much, the counted objects being in our views definitely close-by objects.

This test could be valid if performed on bona fide galaxies, of the type, let us say, Sc or E, that fit the Hubble's law at moderately large distances, being well calibrated in distance through measurements of various distance indicators.

b) A re-discussion of distance indicators, and of distances of various groups. This is by no means unnecessary, in view of the present controversy about inhomogeneity or anisotropy of H. The statistical arguments in favor or against the claims of various observers, should be carefully rediscussed; it is remarkable that biases are almost never well discussed: the meaning of probable errors, or the degree of probability of certain distributions, etc. are rarely properly defined and computed.

In this question, the physics of the distance indicators is seldom studied. For example, the dimensions of the H II regions have often been used, notably by Sandage. But such dimensions depend critically upon two parameters, even assuming that the H II regions are ionization-bounded: the density of hydrogen in the medium, and the brightness, in the far UV, of the illuminating hot stars. Nothing is safe in this matter. Density in a galaxy varies from center to peripherical regions, from young to old galaxies are likely to be more peripherical than in the close-by galaxies, where they can be more easily seen on the general background of the galaxy under study. Hence, how should we take this scaling? It should at least be studied in more detail, and lead to a new type of calibration... A "degradation" of the photographs of close-by galaxies, used for calibration, could be a suitable method; a physical discussion is, in any case, necessary.

c) Abnormal objects.

Observations of abnormal objects should be multiplied; spectra, or even pictures of chains of galaxies, of bridges between objects, etc... in the radio, in the visible spectrum in the UV, are necessary. Radial velocity of double radio-sources, in the radio range, should be measured. Inside the Galaxy, systematic study of some double stars (of which a component is a hot star) should be done, and the atmospheric motions should be separately determined: only the residual could be due to abnormal redshift. In the solar vicinity, new determinations of the wavelength of the Fraunhofer lines near the limb, but on the disk, should be attempted, and if possible with an even better accuracy than Roddier, Snider and Brault. Eclipses of sounding rockets by the corona should be studied, and the accuracy in the frequency shift should reach a fraction of a Hertz, if one wants not only to measure a redshift, but to distinguish between a redshift depending upon the distance to the center of the solar sphere, either as $1/d^2$, or as the solid angle under which the solar disk is seen.

d) On the theoretical side, a better study, taking into account not only differential radiation pressure, but also drag forces, and optical depth effect, should be performed of the motion of test particles within and outside a galaxy, or an extragalactic object of any given nature. The confinement of expelled gas by magnetic field, its ionisation, its radio emission should be calculated, and compared to observations. The possibility of condensation, nucleations, within such a mass, should be carefully discussed, and the relaxation of a galaxy after the explosion of matter should be also studied from the point of view of the physics of the nucleus, and structure of the overall galaxy. We certainly have a very long way to ride before reaching the aims...

Naturally all attempts to solve the cosmological problem other than the classical, i. e. implying either a succession of non-equilibrium states, or a statistical uniformity, fluctuations being only local, — the cosmological problem in a non-homogenuous medium, — should be actively developed, such as recently by Segal (chronogeometry) or, not so recently, by Heckmann and Schueking. The explanation of He, D, abundance in a non-expanding infinitely lasting universe, linked with the equilibrium construction-destruction of so-called stable species (of which the life-time is only very long), should be worked out in great detail.

The transfer of radiation, affected by very directive successive scatterings, should be treated in the whole universe. The explanation of the 2.7° radiation, locally, by the interaction of some photons with the interacting medium surrounding the local masses, should be a part of this study. The correlation matter density — radiation density is obviously another by-product of such developments.

e) Physics of the possible physical cause for redshifts (phenomenon $\mathcal{D}$).

Laboratory measurements should study all types of interactions of photons with whatever particles can be introduced in the experiment.

All proposed causes for redshift, in various cases (interaction with coronal plasmas, microturbulent redshifts, etc...) should be studied quantitatively, and the results applied directly to the observed cases.

Clearly, many problems (and we should certainly enlarge our list!) are to be accurately solved before our working hypotheses might be considered as the backbone of a bona fide theory. However, we have the feeling that the expanding Universe needs about as much work to be confirmed. Many arguments lead us to think that we are on the right way, but still far from the goal. Years to come now, possibly decades, may be necessary to reach a final conclusion in this matter, which is obviously of paramount importance, — possibly the most important problem of the present day astronomy.

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РАБОЧИЕ ГИПОТЕЗЫ К ЕДИНОЙ КАРТИНЕ ВСЕЛЕННОЙ

Ж. К. ПЕКЕР, Ж. П. ВИГЕ

Некоторые наблюдательные данные (анизотропия и неравномерность постоянной Хаббла, аномальные красные смещения) позволили авторам сформулировать рабочие гипотезы, согласующиеся с этими наблюдениями. Логика этих гипотез позволяет рассматривать Вселенную как «иерархическую», подобную Вселенной Шарлье, и определить причину видимого расширения во взаимодействиях, воздействующих на пути фотонов. Поскольку, как в некоторых случаях, собственные красные смещения весьма важны (КЗИ,...), это уменьшает расстояния рассматриваемых объектов и их абсолютную светимость и заставляет нас связать их с обычными галактиками: предложена схема эволюции внегалактических объектов, объясняющая геометрическое расположение аномальных объектов и, с некоторой точки зрения, их морфологию (двойные радиоисточники и т. д.). Исходя из этих рабочих гипотез, авторы чувствуют, конечно, что многое еще должно быть сделано, однако предложенная программа исследований может привести к когерентной картине Вселенной.

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