Apparent discordant redshift QSO-galaxy associations

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ABSTRACT

An “exotic” idea proposed by Viktor Ambartsumian was that new galaxies are formed through the ejection from older active galaxies. Galaxies beget galaxies, instead of the standard scenario in which galaxies stem from the evolution of the seeds derived from fluctuations in the initial density field. This idea is in some way contained in the speculative proposal that some or all QSOs might be objects ejected by nearby galaxies, and that their redshift is not cosmological (Arp, G./M. Burbidge and others).

I will discuss some of the arguments for and against this scenario; in particular, I shall talk about the existence of real physical connections in apparently discordant QSO-galaxy redshift associations. On the one hand, there are many statistical correlations of high-redshift QSOs and nearby galaxies that cannot yet be explained in terms of gravitational lensing, biases, or selection effects; and some particular configurations have very low probabilities of being a projection of background objects. Our understanding of QSOs in general is also far from complete. On the other hand, some cases which were claimed to be anomalous in the past have found an explanation in standard terms. As an example, I will show some cases of our own research into this type: statistics of ULXs around nearby galaxies, and the Flesch & Hardcastle candidate QSOs catalog analysis. My own conclusion is neutral.

1 The problem and the observations that give rise to it

Viktor A. Ambartsumian suggested the idea that new galaxies are formed through ejection from older active galaxies (Ambartsumian 1958). This idea has had a certain continuity in the research carried out over the last 40 years based on the hypothesis that some extragalactic objects, and in particular high redshift QSOs, might be associated with low redshift galaxies, thus providing a non-cosmological explanation for the redshift in QSOs (e.g., Arp 1987, 2003; Narlikar 1989; Burbidge 2001; Bell 2002a,b, 2006, 2007; López-Corredoira & Gutiérrez 2006a); that is, a redshift produced by a mechanism different...
from the expansion of the Universe or the Doppler effect. Ambarsumian never accepted the idea of non-cosmological redshifts; however, the scenario of QSOs ejected by galaxies is a common theme of the Armenian astrophysicist and in proposals of discordant QSO-galaxy redshift associations.

There are plenty of statistical analyses (e.g., Chu et al. 1984; Zhu & Chu 1995; Burbidge et al. 1985; Burbidge 1996, 2001; Harutyunian & Nikogossian 2000; Benítez et al. 2001; Gaztañaga 2003; Nollenberg & Williams 2005; Bukhmastova 2007) showing an excess of high redshift sources near low redshift galaxies, positive and very significant cross-correlations between surveys of galaxies and QSOs, an excess of pairs of QSOs with very different redshifts, etc. An excess of QSOs near the minor axes of nearby parent galaxies has also been observed (López-Corredoira & Gutiérrez 2007); however, the discovered excess for position angles lower than 45 degrees is significant only at the 3.5-σ level (3.9-σ for $z_{QSO} > 0.5$) with the QSOs of the SDSS-3rd release (López-Corredoira & Gutiérrez 2007) and somewhat lower [2.2-σ (2.5-σ for $z_{QSO} > 0.5$)] with the SDSS-5th release.

There are plenty of individual cases of galaxies with an excess of QSOs with high redshifts near the center of nearby galaxies, mostly AGN. In some cases, the QSOs are only a few arcseconds away from the center of the galaxies. Examples are NGC 613, NGC 1068, NGC 1097, NGC 3079, NGC 3842, NGC 6212, NGC 7319 (separation galaxy/QSO: 8''), 2237+0305 (separation galaxy/QSO 0.3''), 3C 343.1 (separation galaxy/QSO: 0.25''), NEQ3 (see Fig. 1/left; a QSO-“narrow emission line galaxy” pair separated 2.8'' from another emission line galaxy with a second redshift, and all of them lying along the minor axis of an apparently distorted lenticular galaxy at ~17'' with a third redshift), etc. In some cases there are even filaments/bridges/arms apparently connecting objects with different redshift: in NGC 4319+Mrk 205, Mrk273, QSO1327-206, NGC 3067+3C232 (in the radio), NGC 622, NGC 3628 (in X-ray and radio), NEQ3 (Fig. 1/left), etc. The probability of chance projections of background/foreground objects within a short distance of a galaxy or onto the filament is as low as $10^{-8}$, or even lower. The alignment of sources with different redshifts also suggests that they may have a common origin, and that the direction of alignment is the direction of ejection. This happens with some configurations of QSOs around 1130+106, 3C212, NGC 4258, NGC 2639, NGC 4235, NGC 5985, GC 0248+430 (Fig. 1/right), etc. Other proofs presented in favor of the QSO/galaxies association with different redshift is that no absorption lines were found in QSOs corresponding to foreground galaxies (e.g. PKS 0454+036, PHL 1226), or distortions in the morphology of isolated galaxies.

The non-cosmological redshift hypothesis also affects galaxies differently from QSOs. Cases such as NGC 7603, AM 2004-295, AM 2052-221, NGC 1232, VV172, NEQ3, NGC 450/UGC 807, etc. present statistical anomalies also suggesting that the redshift of some galaxies different from QSOs might have non-cosmological redshifts. Not all supporters of the non-cosmological redshift agree with this idea; for instance, Arp claims that galaxies might have non-cosmological redshift because they derive from an evolution of ejected QSOs, while G. Burbidge only defends the non-cosmological redshifts in QSOs. In this paper, except for this paragraph, I shall talk only about anomalies in QSOs.
2 Probabilities of being background QSOs

There are two possible interpretations of these data: either QSOs with different redshifts are objects with different distances and the configurations are due to chance, or there are non-cosmological redshifts, and QSOs with different redshifts are at the same distance. The first position, the standard one, defends the hypothesis that in all cases the main galaxy is surrounded by background QSOs. The idea is quite straightforward. The position of anomalous redshifts is not naive enough to deny this possibility, and this might be the case in some examples. However, the question is not whether such a fortuitous projection is “possible” but whether it is “probable”.

For the calculation of this probability $P$, it is normally assumed that the background/foreground objects in a small area are distributed according to a Poissonian distribution with the average density in any line of sight. There may be some clustering of QSOs, but this does not essentially affect the numbers. A conspiracy in which a given line of sight crosses several clusters of QSOs at different redshifts is not justified because the increase in probability due to the increase in density along lines of sight with clusters is compensated for by the additional factor to be multiplied by the present amount $P$ to take into account the probability of finding clusters in the line of sight. On average, in any arbitrary line of sight in the sky, the probability will be given anyway by the Poissonian calculation of $P$ with the average density of QSOs in the sky (see further details in subsection 5.3.1 of López-Corredoira & Gutiérrez 2004).

A much more important matter concerns the consideration of the number of events in the whole sky. Of course, there may be many objects that are quite peculiar but we must consider the global probability in the whole sky multiplying by the number of galaxies or QSOs as in the anomalous case. For instance, if
we found an NGC galaxy of magnitude $m_g$ with a very low probability $P_0$ of being surrounded by $N$ QSOs up to some magnitude and angular distance, we must calculate the global probability $P$, multiplying it by the number of NGC galaxies (around eight thousand; or somewhat larger if we considered the southern hemisphere), or at least the galaxies in the whole sky up to magnitude $m_g$.

It is said that one should not carry out a calculation of the probability for a configuration of objects known a priori (for instance, that they form a certain geometrical figure) because, in some way, all possible configurations are peculiar and unique. That is right so long as we speak about random configurations that do not indicate anything special. For example, if the Orion constellation is observed and we want to calculate the chance of its stars being projected in that exact configuration, we will get a null probability (tending towards zero as the allowed error in the position of the stars with respect the given configuration goes to zero), but the calculation of this probability is worthless because we have selected a particular configuration observed a priori. Therefore, the statistics to be carried out should not be about the geometrical figure drawn by the sources, unless that geometrical configuration is representative of a physical process in an alternative theory (for instance, aligned sources might be representative of the ejection of sources by a parent source).

In this last sense, I think that much of the statistics already published is valid and indicates the reality of some kind of statistical anomaly. It would be useful to look out for physical representations indicating peculiarities beyond mere uniqueness. I disagree with the claim that all attempts to calculate probabilities of unexpected anomalies are a posteriori and whose validity may therefore be rejected. Some astrophysicists, when looking at the images of the controversial objects, argue along the lines that the anomalous distributions of QSOs are curious, but that since they were observed their probability is 1 and there is therefore nothing special about them. According to this argument, everything is possible in a Poissonian distribution and nothing should surprise us. But I believe that statistics is something more serious than the postmodern rebuff that anything is possible.

We think that this anti-statistical position, this way of rejecting the validity of the calculated probabilities, is equivalent to the scepticism that those unfamiliar with mathematics express when we discuss the low probability of winning the lottery. They continue to bet regardless with hope that, however low the probability, somebody is sure to win so why not me. Typically they are unaware of how low some probabilities are and make no distinction between a case such as $P \sim 10^{-2}$, which is a low but certainly makes a win possible from time to time, and the case $P \sim 10^{-7}$, which virtually ensures no wins during seven lifetimes of daily betting. Small numbers, like the huge numbers prevalent in astronomy, are not easily assimilated. Of course, somebody wins the lottery but this is because the number of players multiplied by the probability of winning of each player is a number not much lower than one; otherwise, nobody would ever be likely to win.

Even worse, imagine that a person wins the lottery four consecutive times with only one bet each time. If we did not believe in miracles, we might think that this person had cheated. We might carry out some statistical calculations and show how improbable it was that he/she could have won by chance. Somebody might say about these calculations that they are not valid because they were carried out a
posteriori (after the person won the lottery four consecutive times). We would not agree because there is an alternative explanation (he/she is cheating; and this explanation could be thought of before the facts) and the event of winning the lottery four consecutive times, apart from being very peculiar among the random possibilities, would be an indication to support this hypothesis.

For our cases, we have facts (higher concentration of QSOs, alignments, QSOs projected onto filaments) which suggest that an alternative (a priori) theory claiming that galaxies/QSOs may be ejected by galaxies better represents the observations. The measured probabilities are not to form triangles or any shape observed a priori only because it was observed. The peculiarity that is analysed is not comparable with the previous example of Orion because we have in mind a physical representation rather than a given distribution of sources. The difference from the Orion problem is that the peculiarity of Orion is not associated with any peculiar physical representation to be explained by an alternative theory. The question is as follows: what is the probability, $P$, that the apparent fact be the fruit of a random projection of sources at different distances? In other words, what is the probability, $P$, that the standard theory can explain the observed facts without aiming at alternative scenarios?

There is some a posteriori information used normally in the calculations: for instance the maximum magnitude or distance of the QSOs according to what we have observed in our particular case. It is in this sense an a posteriori calculation, we are calculating the most pessimistic case (the lowest probability). Because of this, the values of $P$ might be slightly underestimated (by a factor not higher than 10-100) with respect to an a priori calculation without any information on magnitudes or radii, but values of $P$ lower than $\sim 10^{-4}$ should in any case be considered as statistically anomalous. In order to make a fairer estimate of the probability, we could calculate $P^* = 2^n P$, where $n$ is the number of parameters on which $P$ depends. For instance, when we observe a source with magnitude 19 and we calculate $P(m < 19)$ we are putting the limiting magnitude exactly at the observed number; a fairer calculation would be $P^*(m < (19 + x))$ such that a source with magnitude 19 is a typical average source in the range $m < (19 + x)$, i.e. roughly that half of the sources with $m < (19 + x)$ have $m < 19$ and the other half have $19 < m < (19 + x)$. This is equivalent to calculating $P^*(m < (19 + x)) = 2P(m < 19)$ and for the correction we can multiply by a factor two for any independent parameter. Values of $P^*$ lower than around $10^{-3}$ should be considered as statistically anomalous.

3 Gravitational lensing

An explanation for anomalous redshift systems might be found in principle if we considered some kind of gravitational lensing by the foreground object. However, the effect on the enhancement of the probability produced by an individual galaxy is small. In order to increase by at least an order of magnitude in $P$ per object, i.e. an average enhancement of $\sim 10$ in density for each of the QSOs, we would need an average magnification of around 20,000 (López-Corredoira & Gutiérrez 2004, sect. 5.3.2). This is so because the enhancement in the source counts increases because of the flux increase of each source but decreases owing to the area distortion, which reduces the number counts by losing the sources within
A magnification of $2 \times 10^4$ is extremely high and impossible to achieve by a galaxy lens. The highest known values are up to a factor $\sim 30$ (Ellis et al. 2001) for background objects apparently close to the central parts of massive clusters. Moreover, a single galaxy would only produce a significant magnification at very close distances (a few arcseconds) from the center. The possibility of multiple gravitational microlenses within the galaxy (Paczynski 1986) does not work either (Burbidge et al. 2005, sect. 5; López-Corredoira & Gutiérrez 2006, sect. 8).

Weak gravitational lensing by dark matter has also been proposed as the cause of the statistical correlations between low and high redshift objects, but this seems to be insufficient to explain them (Kovner 1989; Zhu et al. 1997; Burbidge et al. 1997; Burbidge 2001; Benítez et al. 2001; Gaztañaga 2003; Jain et al. 2003; Nollenberg & Williams 2005; Tang & Zhang 2005) and cannot work at all for the correlations with the brightest and nearest galaxies; López-Corredoira & Gutiérrez (2007) have shown that gravitational lensing is not the solution for the possible minor axis excess of QSOs. Scranton et al. (2005) have claimed that the small amplitude correlation between QSOs and galaxies from the SDSS survey is due to weak gravitational lensing but this does not explain the most general case with bright nearby galaxies. Komberg & Pilipenko (2008) suggested the existence of a large number of globular or proto-globular clusters in the intergalactic medium of clusters of galaxies as an explanation of the correlations, a hypothesis which is awaiting testing. In principle, it seems there are many field galaxies with an excess of surrounding QSOs. Further research is in any case necessary in some of these aspects.

4 Are all QSOs with anomalies really QSOs?

Even more important than thinking about gravitational lensing or discussing the probabilities of background projections is being sure that the identification of QSOs and their redshifts is correct. For instance, cases like 3C 343.1 (Arp et al. 2004a), if we believe that they are indeed a radio galaxy at $z=0.34$ and a radio QSO at $z=0.75$ separated by 0.25", are really spectacular, but are we sure of the correct identification of the sources?

An example: Burbidge et al. (2003) suggested that many of the ultraluminous compact X-ray sources (ULXs) found in the main bodies of galaxies are “local” QSOs, or BL Lac objects, with high intrinsic redshifts in the process of being ejected from those galaxies. Certainly, there is an overdensity of these X-ray sources near galaxies but, before claiming a case of anomalous redshift, we have to be sure that they are indeed QSOs with different redshifts. Arp et al. (2004b) took some spectra of ULXs and saw that some of them are QSOs but others were not. López-Corredoira & Gutiérrez (2006b) have shown that $>50\%$ of ULXs are effectively QSOs but, except for few cases which are anomalous for other reasons (e.g., NGC 3628, NGC 4319), the probability of these QSOs being background objects is significant, while the cases with ULXs over the expected background were not QSOs. Therefore, there are not enough statistical anomalies to claim that some ULXs are non-cosmological redshift QSOs.

Another example: Flesch & Hardcastle (2004) published a catalog of candidate QSOs (with a probability $>40\%$ of being QSOs) derived from the correlation of radio and X-ray sources with blue point-like
optical objects. In this catalog, there is an overdensity of QSO candidates in fields near galaxies and for bright sources. However, López-Corredoira et al. (2008) showed that the probabilities of being QSOs were overestimated for bright objects and near galaxies. Therefore, again, there are in principle no reasons to think about statistical anomalies in this catalog.

5 Discussion

Some of the examples of apparent associations of QSOs and galaxies with different redshifts may be just fortuitous cases in which background objects are close to the main galaxy, although the statistical mean correlations remain to be explained, and some lone objects have a very low probability of being a projection of background objects. Nevertheless, these very low probabilities (down to $10^{-8}$ or even lower, assuming correct calculations) are not extremely low and, if the anomaly is real, one wonders why we do not find very clear anomalous cases with probabilities as low as $10^{-20}$. Gravitational lensing seems not to be a solution yet, although further research is required, and the aim that the probabilities be calculated a posteriori is not in general an appropriate answer for avoiding or forgetting the problem.

There are also other aspects of QSOs that are not well understood within the cosmological redshift assumption, and which could find an explanation within a non-cosmological redshift hypothesis (López-Corredoira & Gutiérrez 2006a, sect. 9): the extremely high luminosity of QSOs at high redshift and the absence of bright QSOs at low redshift, periodicity of redshifts, their age and metallicity and the lack of evolution signs, superluminal motions, spectral features in the emission and absorption lines that are not well understood, the mechanism of triggering activity, the fact that Faraday rotation does not increase with redshift, etc.

There are two possibilities: either all cases of associations are lucky coincidences with a higher probability than expected for some still unknown reason, or there are at least some few cases of non-cosmological redshifts. If we accepted that some objects (maybe not all of them) with different redshifts had the distance of the main galaxy, there might be some truth in those models (Burbidge 1999; Arp 1999a,b, 2001; Bell 2002a,b) in which QSOs and other types of galaxies are ejected by a parent galaxy, as proposed by Ambartsumian (1958). In these models, galaxies beget galaxies, not all the galaxies would be made from initial density fluctuations in a Big Bang Universe. For the explanation of the intrinsic redshift, there are several alternative hypotheses (reviews at Narlikar 1989; López-Corredoira 2003, sect. 2.1; 2006).

In my opinion, we must consider the question as an open problem to be solved. I maintain a neutral position, neither in favor of nor against non-cosmological redshifts. The debate has lasted a very long time, around 40 years, and it would be time to consider making a last effort to finish with the problem. However, the scientific community does not seem very interested in solving the problem because most researchers consider it already solved. Supporters of the standard dogma of all redshifts being cosmological do not want to discuss the problem. Every time it is mentioned they just smile or talk about "a posteriori" calculations, manipulations of data, crackpot ideas, without even reading any paper on the theme. The Arp-Burbidge hypothesis has become a topic in which everybody has an opinion without having read the
papers or knowing the details of the problem, because some leading cosmologists have said it is bogus. This means that it is very difficult to make any progress in this field, as is usual when a researcher is away from the mainstream (López-Corredoira & Castro-Perelman, eds., 2008). On the other hand, the main supporters of the hypothesis of non-cosmological redshifts continue to produce tens of analyses of cases in favor of their ideas without too much care, pictures without rigorous statistical calculations in many cases, or with wrong identifications, underestimated probabilities, biases, use of incomplete surveys for statistics, etc., in many other cases. There are, however, many papers in which no objections are found in the arguments and they present quite controversial objects, but due to the bad reputation of the topic, the community simply ignores them. In this panorama, it would be difficult for the problem to be solved soon. Mainstream cosmologists are waiting for the death of the main leaders of the heterodox idea (mainly Arp and the couple Burbidge) to declare the idea as definitively dead. However, as in the case of Ambartsumian, some challenging ideas could survive or even be revived after some time if we leave open problems without a clear solution. Therefore, I would recommend that the community either finds good arguments against the Arp-Burbidge hypothesis, or that it allows their ideas to cohabit within the possible speculative hypotheses in cosmological scenarios.

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References

[1] Ambartsumian, V. A. 1958, Onzieme Conseil de Physique Solvay, ed. R. Stoops, Bruxelles
[2] Arp, H. C. 1987, QSOs, Redshifts and Controversies, Interstellar Media, Berkeley
[3] Arp, H. C. 1999a, ApJ, 525, 594
[4] Arp, H. C. 1999b, in: Active Galactic Nuclei and Related Phenomena, Y. Terzian, E. Khachikian, D. Weedman, eds., Astron. Soc. of the Pacific, S. Francisco, p. 347
[5] Arp, H. C. 2003, Catalogue of discordant redshift associations, Apeiron, Montreal
[6] Arp, H. C., Burbidge, E. M., & Burbidge, G. 2004a, A&A, 414, L37
[7] Arp, H. C., Gutiérrez, C. M., López-Corredoira, M. 2004b, A&A, 418, 877
[8] Bell, M. B. 2002a, ApJ 566, 705
[9] Bell, M. B. 2002b, ApJ, 567, 801
[10] Bell, M. B. 2006, astro-ph/0602242
[11] Bell, M. B. 2007, ApJ, 667, L129
[12] Benítez, N., Sanz, J. L., & Martínez-González, E. 2001, MNRAS, 320, 241
[13] Bukhmastova, Yu. L. 2007, Astronomy Letters, 33(6), 355. Translated from: 2007, Pi’sma v Astronomicheckii Zhurnal, 33(6), 403

[14] Burbidge, E. M., Burbidge, G. R., Arp, H. C., & Napier, W. M. 2005, astro-ph/0510815

[15] Burbidge, G. R. 1996, A&A, 309, 9

[16] Burbidge, G. R. 1999, in: Cosmological Parameters and the Evolution of the Universe, K. Sato, ed., Kluwer, Dordrecht, p. 286

[17] Burbidge, G. R. 2001, PASP, 113, 899

[18] Burbidge, G. R., Burbidge, E. M., & Arp, H. 2003, A&A, 400, L17

[19] Burbidge, G. R., Hoyle, F., & Schneider, P. 1997, A&A, 320, 8

[20] Burbidge, G. R., Narlikar, J. V., & Hewitt, A. 1985, Nature 317, 413

[21] Chu, Y., Zhu, X., Burbidge, G., & Hewitt, A. 1984, A&A, 138, 408

[22] Ellis, R., Santos, M. R., Kneib, J. P., & Kuijken, K. 2001, ApJ, 560, L19

[23] Flesch, E., & Hardcastle, M. J. 2004, A&A, 427, 387

[24] Gaztañaga, E. 2003, ApJ, 589, 82

[25] Gutiérrez, C. M., & López-Corredoira, M. 2004, ApJ, 605, L5

[26] Harutyunian, H. A., Nikogossian, E. H. 2000, Astrophysics 43, 4

[27] Jain, B., Scranton, R., & Sheth, R. K. 2003, MNRAS, 345, 62

[28] Komberg, B. V., & Pilipenko, S. V. 2008, Astron. Reports, 52(7), 517

[29] Kovner, I. 1989, ApJ, 341, L1

[30] López-Corredoira, M. 2003, in: Recent Research Developments in Astronomy and Astrophysics I, ed. S. G. Pandalai, Research Signpost, Kerala, p. 561 [astro-ph/0310214]

[31] López-Corredoira, M. 2006, Apeiron, NewsWire/2006 [astro-ph/0701061]

[32] López-Corredoira, M., & Castro-Perelman, C., eds., 2008, Against the Tide. A Critical Review by Scientists of How Physics and Astronomy Get Done, Universal Publ., Boca Raton (Florida)

[33] López-Corredoira, M., & Gutiérrez, C. M. 2004, A&A, 421, 407

[34] López-Corredoira, M., & Gutiérrez, C. M. 2006a, in: First Crisis in Cosmology Conference (AIP Conf. Proc. 822), E. J. Lerner, J. B. Almeida., Eds., AIP, Melville (New York), p. 75

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1Book censored by arXiv.org; free copy available at: http://www.archiefreedom.org/tide.htm
[35] López-Corredoira, M., & Gutiérrez, C. M. 2006b, A&A, 454, 77

[36] López-Corredoira, M., & Gutiérrez, C. M. 2007, A&A, 461, 59

[37] López-Corredoira, M., Gutiérrez, C. M., Mohan, V., Gunthardt, G. I., & Alonso, M. S. 2008, A&A, 480, 61

[38] Narlikar, J. V. 1989, Space Science Reviews, 50, 523

[39] Nollenberg, J. G., & Williams, L. R. 2005, ApJ, 634, 793

[40] Paczynski, B. 1986, ApJ, 304, 1

[41] Scranton, R., Ménard, B., Richards, G. T., et al. 2005, ApJ, 633, 589

[42] Tang, S. M., & Zhang, S. N. 2005, Chin. J. Astron. Astrophys., 5, 147

[43] Wu, X. P. 1996, Fund. Cosmic Phys., 17, 1

[44] Zhu, X. F., Chu, Y. Q. 1995, A&A, 297, 300

[45] Zhu, Z. H., Wu, X.-P., & Fang, L. Z. 1997, ApJ, 490, 31