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θ-z test for QSO-galaxy physical association

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Abstract. The θ-z test devised by Burbidge et al, (1972, 1990) may serve as a powerful test to decide the reality or otherwise of the physical association hypothesis for the *QSO*-bright galaxy close pairs with discrepant redshifts. Recently, Burbidge (1996) has published a sample of 33 QSO-bright galaxy close pairs with discrepant redshifts as the best candidates for the physical association. In this paper, we have subjected this sample of 33 pairs to the θ-z test with a view to test the reality of the physical association of these pairs.

1. Introduction

If θ is the angular separation between the two members of a QSO-bright galaxy close pairs and z is the redshift of the galaxy (lying at cosmological distance implied by its redshift) belonging to that pair then for a sample of such close pairs $\theta \propto z^{-1}$ provided that each QSO is physically associated with the galaxy belonging to its close pair with fixed metric distance D projected perpendicular to the line of sight. If the QSO redshifts are cosmological ($z_{QSO} \gg z$), such a relation cannot exist (Burbidge et al, 1990). Such accidental results would be wiped out with the discoveries of larger and larger samples of such close pairs. Thus, such a θ-z test can serve as a powerful test for reality or otherwise of the physical association hypothesis for the QSO-galaxy close pairs with discrepant redshifts. Such a test can then also throw light on whether the redshifts of such QSOs are cosmological or not.

2. The data, analysis and results

Recently, Burbidge (1996, Table 1) has published a sample of 46 QSO-bright galaxy close pairs with discrepant redshifts as the best candidates for physical associations. Out of this we have found a sample of 33 pairs for which $\theta \leq 180''$, $m_{gal} \leq 15.5$ and galaxy redshifts z are available. In this paper we have subjected this sample of 33 pairs to the θ-z test with a view to test the reality of the physical associations of these pairs.

The least squares linear fit to the (logθ, logz) pairs for this sample (Figure 1.) should yield a slope of −1.0 if they are physically associated and if $< \log D >$ for the sample is approximately constant. However, we find that the slope is −0.186 ± 0.101 and is not statistically significant with the expected slope of −1.0 at 95% confidence level. The correlation coefficient for data pairs is −0.313 and is not statistically significant at 99% confidence level. For this sample

< logD_{kpc}> ≈ 1.4 ± 0.4 (obtained for an assumed slope of −1.0). Our results, therefore, suggest that the *QSO*'s in this sample do not satisfy the θ-z test for their physical association with their neighbouring galaxies implying that the *QSO*-galaxy pairs of this sample are close to each other by chance. Our results also suggest that the redshifts of these QSOs are, therefore, cosmological in nature.

On the other hand, a sample of QSO-galaxy pairs with similar redshifts must satisfy the θ-z test yielding a slope close to −1.0 because there is no controversy that they are physically associated and hence that the redshifts of such QSOs are cosmological in nature. A similar analysis carried out for the largest available sample of 24 QSO-galaxy pairs with similar redshifts ($|Z_{QSO} - Z| < 1000$ kms^{-1}) and $\theta \leq 180°$, drawn from the catalogue of Burbidge et al, (1990), yields a slope of -1.851 ± 0.482 (Figure 1) which is statistically consistent, at 95% confidence level, with the expected slope of −1.0. The correlation coefficient for the data pairs is −0.625 and is statistically significant at 95% confidence level and <logD_{kpc}> ≈ 2.0 ± 0.5 for this sample. Thus, it is interesting to find that this sample indeed satisfies the θ-z test for physical association, as it must, since it is known that these pairs are physically associated.

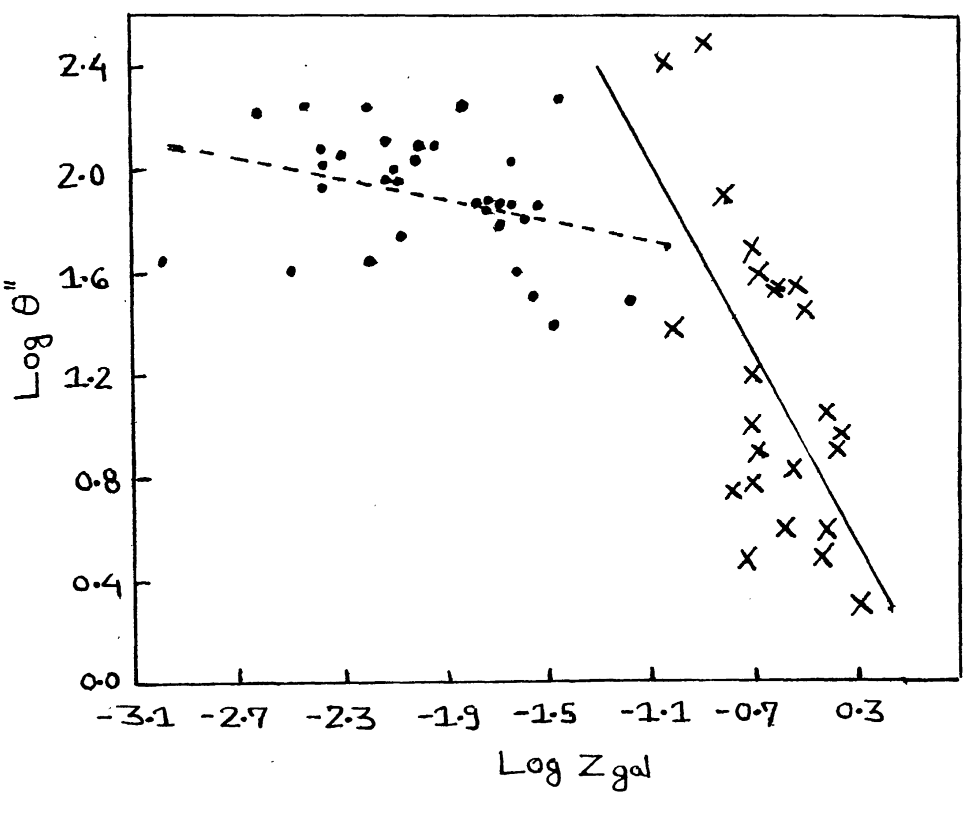

Figure 1. Plot of logθ against log z_{gal} for a sample of 33 *QSO*-galaxy close pairs with discrepant redshifts (filled circles). The broken line represents the least-squares linear fit to the data. Crosses show a sample of 24 *QSO*-galaxy pairs with similar redshifts. The continuous line depicts the linear fit to the data. This plot may be compared with a similar plot for 392 *QSO*-galaxy pairs in Burbidge et al, (1990).

3. Conclusion and discussion

The results obtained above suggest that the θ-z test devised by Burbidge et al, (1972) indeed serves as a powerful test to decide the reality or otherwise of the physical association hypothesis for the QSO-galaxy pairs with discrepant redshifts. It is also a powerful test to decide whether the redshifts of the QSOs belonging to such pairs have a large non-cosmological component or not. The θ-z test also serves to corroborate the reality of the physical association for the QSO-galaxy pairs with similar redshifts. However, Burbidge et al, (1990) have given an independent evidence that there is a large excess of *QSO*-galaxy pairs with $z_{QSO} \gg z_{gal}$ and with $\theta < 2'$ over the numbers expected if the configurations were accidental, thus suggesting that the pairs are physically associated. At present we do not have satisfactory explanation for this evidence. We only point out that there is no evidence for such large excess of pairs if $\theta > 2'$. We also find that our result for the sample of 33 QSO-galaxy pairs of Burbidge (1996) contradicts that for the sample of 392 QSO-galaxy pairs in Burbidge et al, (1990) because the latter includes the sample of QSO-galaxy pairs with similar redshifts. To sum up, it appears that the evidence of a large excess of QSO-galaxy pairs with discrepant redshifts and with $\theta < 2'$ is not decisive enough for their physical association. The θ-z test, on the other hand, appears to be more powerful to decide the reality of the physical association hypothesis for the QSO-galaxy close pairs.

4. References

Burbidge G. R., O' Dell S. L., Strittmatter P. A., 1972, Ap J, 175, 601.

Burbidge G. R., Narlikar J. V., Hewitt A., Das Gupta P., 1990, Ap J. Suppl., 74, 675.

Burbidge G. R., 1966, A&A, 309, 9.