growth. When the medium flows towards the sheet from a denuded region without uptake of critical nutrients, however, the effect of the increased velocity is enhanced.

This paper emphasises the role of the diffusion boundary layer in limiting the uptake of critical nutrients or growth factors from the medium. The barrier could, however, operate in the opposite way, by preventing the escape of inhibitory molecules released by the cells. On present evidence the two mechanisms cannot be distinguished.

The original suggestion that a diffusion barrier could account for many of the effects of cell density was based on experiments with opposed cell layers made by Rubin and Rein[10]. My data support this view and show that concentration changes in the microenvironment could account for the highly localised growth of 3T3 cells at the edge of wounds and presumably also at the circumferences of colonies[16]. On this basis the reduction in density-dependent inhibition of growth, or topoinhibition, by virus transformation can be explained by a lowering of nutritional requirements. Even in those variants which show a lowered requirement for serum growth factor while remaining sensitive to topoinhibition[17], another essential nutrient may be limiting.

It may be concluded that topoinhibition, as manifest at wound edges in 3T3 cells, is no longer evidence that contact between cells regulates their growth. The accompanying paper[18] reaches the same conclusion on different grounds.

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LETTERS TO NATURE

PHYSICAL SCIENCES

A Double Quasistellar Object

BECAUSE QSOs are rare[1,2] the discovery of close pairs with discordant redshifts is improbable if they are randomly distributed on the plane of the sky. But Stockton[3] has reported that Ton155 and Ton156 form a pair of 17 mag QSOs, with a separation of approximately 35 arc s. For QSOs randomly distributed on the plane of the sky he gives the probability for an accidental occurrence of this close pair as 6×10^{-3}.

Visually, 1548+115≡4C11.50 (ref. 4) is another close pair of blue stellar objects. The brighter object (1548+115a) is approximately 17 mag, and is followed 4.8 arc s east and 0.4 arc s south by the 19 mag object 1548+115b. The pair was first noted by Hazard and Jauncey (see ref. 5) in a programme of 4C identifications, and has also been noted by Murdoch and Hazard (unpublished) in a programme of identifications based on Molonglo radio positions. It had been found earlier[4] that 1548+115b was a QSO although its redshift had not been determined nor had the nature of 1548+115a been established. We report here that 1548+115a is also a QSO and give additional spectral information for both objects. In particular we note the very different redshifts of the objects; z=0.4359 for 1548+115a and z=1.901 for 1548+115b. The radio source is a 3C273 type double (Ekers and Fanaroff, private communication) with one component coincident with 1548+115a. There is a faint red wisp of otherwise unknown characteristics visible on the National Geographic Mount Palomar Sky Survey plates ~10 arc s south-west of 1548+115a.

On the nights of August 1, 3–6, and 24–25, 1973 (UT), 1548+115a,b were observed optically with the Cassegrain scanner[6] of the 120-inch (305-cm) telescope. At that time of year 1548+115 can only be observed early in the evening in the western sky. The astronomical seeing was generally good during the earlier observing period and small (~2 arc s) spectrograph entrance apertures were used to reduce the background illumination from the lights of nearby cities. On the nights of August 24–25 the conditions were much poorer and only 1548+115a was observed. The use of small apertures, especially in the presence of substantial atmospheric dispersion, prevented us from obtaining an accurate continuum flux calibration. For this reason we are uncertain of the spectral index of the continuum although the magnitude estimates obtained in August (m_V=16.8 and 18.8) are in good agreement with those obtained earlier[4]. Our best estimate for the spectral index of 1548+115a is $\alpha=0.8\pm0.5$ and for 1548+115b $\alpha=0.6\pm0.4$ where α is the index in the equation $f_\nu \sim \nu^{-\alpha}$. Because the objects are so close together scattered light is a potential problem, but measurements of the scattered light from a bright star set 5 arc s off the slit showed no significant effects.

Both objects show rich emission line spectra. The observed lines, their identifications, and equivalent widths are listed in Table 1. The adopted redshift for 1548+115a is z=0.4359 and for 1548+115b we adopt z=1.901. If both objects were at the cosmological distance corresponding to z=0.4359 their separation would be about 40 kpc (H_0=50 km s^{-1} Mpc^{-1}, q_0=1/2). Figure 1 shows the observed spectra of the two objects. They seem to be normal for QSOs. Also the objects seemed stellar in the television guiding monitor of the 120-inch telescope. If either object were discovered alone in the sky it

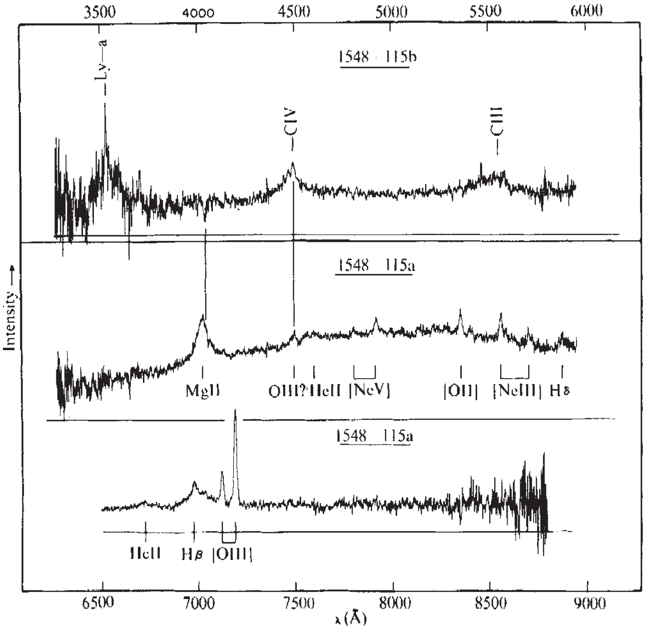

Fig. 1 Spectra of 1548+115a,b. Evidence of poor subtraction of the strong Hg night sky lines at λλ3650, 4047 may be seen in the spectra. But a close inspection of our data shows that the strong absorption feature seen at λ4038 in the spectrum of 1548+115b is not caused by incorrect subtraction of Hg λ4047. The two vertical lines show the correspondence between the λ4038 and λ4495 features in the spectra of 1548+115a,b.

would be classified as a normal QSO. In addition to the close proximity of the two objects to each other in the plane of the sky and the possible alignment of the optical and radio sources, there are several coincidences in the spectra of the two objects.

First, there is a strong absorption feature at λ4038 in the spectrum of 1548+115b that lies slightly to the red of the redshifted Mg II λ2800 emission peak in the spectrum of 1548+115a. The spectral data are not of high enough quality to decide conclusively if the feature is due to Mg^+ or to some other ion, such as C^{3+}. An accurate determination of the profile of the absorption line is hindered by the presence of a strong night sky line, Hg λ4047, in the red wing of the feature. But we were able to use the night sky line to determine the instrumental profile and to construct artificial profiles representing doublets with separations corresponding to C^{3+} and Mg^+. A comparison of these profiles with the observed profile is given in Fig. 2.

Table 1 Observed Lines in 1548+115a,b

Ion	Observed λ	Rest wavelength	Equivalent width (Å)	z
		1548+115a		
Mg II	4024	2800	70	0.4382
O III ?	4496	—	4	—
He II*	—	3203	9	—
[Ne V]	4801	3346	2	0.4348
[Ne V]	4916	3426	5	0.4345
[O II]	5350	3727	5	0.4352
[Ne III]	5556	3869	6	0.4360
[Ne III]+Hε	5696	3968+3970	4	0.4350
Hδ	5880:	4102	13	0.4335:
He II*	—	4686	21	—
Hβ	6982	4861	91	0.4361
[O III]	7123	4959	18	0.4364
[O III]	7193	5007	62	0.4366
		1548+115b		
Ly-α	3527	1216	224	1.901
Absorption	4038	—	12	—
C IV	4493	1549	83	1.901
C III]*	5555:	1909	65	1.910:

* Line not used to determine redshift.

Inspection shows that the absorption feature is probably due to C^{3+}.

Second, the presence of emission features close to λ4495 in the spectra of both objects led to speculation that the C IV $\lambda_0$1549 feature might be present in both objects at $z=1.901$. But the line of λ4496 in the spectrum of 1548+115a is very probably a blend of the O III λ3122, λ3133 Bowen fluorescence lines[7] in the $z=0.4359$ redshift system. The other lines in the O III cascade chain would be confused with the [Ne V] λ3346, λ3426 doublet and are possibly present at their expected strengths. Several other QSOs are known to have an emission line at a rest wavelength near λ3135. Ly-α at λ3527 does not appear in our spectrum of 1548+115a, a circumstance that strengthens the probability that the wavelength agreement between the λ4495 features is accidental.

Finally, we note that the wavelength ratio $(1+z)_a/(1+z)_b = 2.02$. Although the observational data are sufficiently accurate to exclude the possibility that the true ratio as determined from the emission lines in the two objects is exactly 2, it would be possible for the departure from 2 to be caused by small peculiar motions associated with one or both of the objects. This difference of almost exactly a factor of two in wavelength for these two (optically) associated objects is either an unfortunate coincidence or a profound mystery.

The discovery of surprising objects such as this tempts us to make statistical arguments. Arguments about rare single events are treacherous; the archives of science are filled with dead hypotheses, supported initially by overwhelming statistical claims. One must avoid the errors of either testing only a single hypothesis, or of selecting an *ad hoc* alternative and then confirming it on the basis of the same data.

Before the observation of double QSOs, the 'most likely' hypothesis was the cosmological hypothesis: Redshifts were cosmological in origin, with a small component due to peculiar velocities. In general QSOs were expected to be randomly distributed on the plane of the sky and any groups that did appear should agree in redshift. Another hypothesis, less definite but existing before these observations, was the local

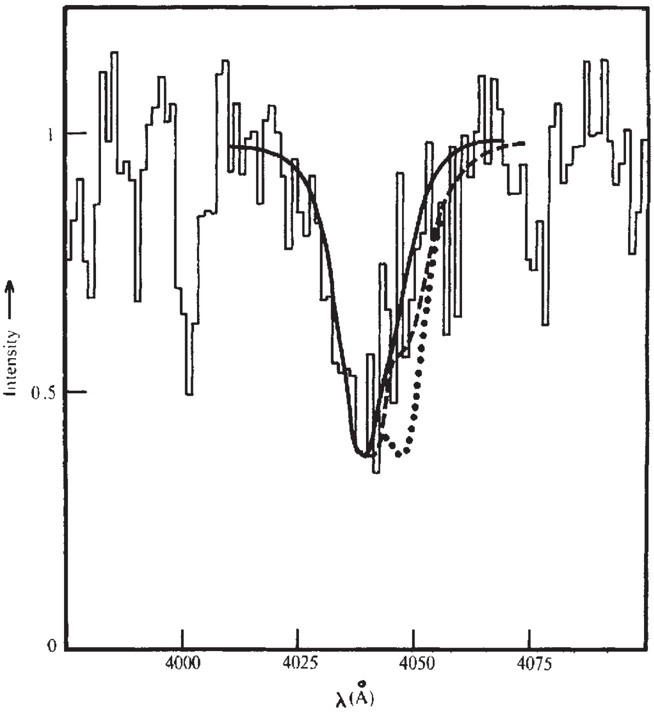

Fig. 2 The λ4038 absorption feature in 1548+115b. The curves are computed instrumental profiles for: ——, C IV $\lambda\lambda_0$1548.2, 1550.8 with a 1:1 intensity ratio; - - -, Mg II $\lambda\lambda_0$2795.5, 2802.7 with a 2:1 intensity ratio; and . . ., Mg II $\lambda\lambda_0$2795.5, 2802.7 with a 1:1 intensity ratio. The night sky line Hg λ4047 increases the uncertainty in the red wing of the QSO absorption line.

hypothesis. The observed redshifts were allowed a large, non-cosmological, component and groups of QSOs could now have discordant redshifts.

Our observation of a close pair of QSOs with discordant redshifts is unlikely under the cosmological hypothesis. Sandage and Luyten[1] estimate that there are five QSOs brighter than magnitude 19.4 per square degree. If this is true and if QSOs are randomly distributed in the sky the chance of finding a second QSO within 5 arc s of a given object is approximately 4×10^{-5}. The probability of finding such a pair among the 250 QSOs with known redshifts is about 1 in 100 if there were no observation selection effects. Present observational techniques certainly discriminate against finding close doubles since normally the search is stopped when one candidate from a group of stars is found to be a QSO.

A local hypothesis which puts 10% of the QSOs in pairs of galactic cluster dimensions, say one minute of arc, is at a statistical advantage by a factor of thirty or so. The radio alignment, when accurately measured, may provide additional evidence. The spectral peculiarities are fascinating but no pre-existing theory suggested them and these observations only raise them for future consideration.

We believe that these observations add support to non-cosmological theories of redshifts. Such theories will receive additional support if an interaction between the two components of a close pair can be shown. Alternatively, additional close pairs may be found. Since it is now known that some large redshift QSOs have neutral colours[8], a search for more QSO pairs should include all stars found near suspected or known QSOs.

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Discrepant Redshifts of QSOs in Clusters of Galaxies and a Close QSO Pair

ALTHOUGH it is the majority view that QSO redshifts are cosmological in origin and related to distance by Hubble's law, several workers[1–3] have proposed that QSOs may be more local objects. The strongest direct evidence for the conventional view is provided by observations of a number of QSOs which have been shown to have redshifts (z) which agree to within about 1% with the redshifts of apparently associated clusters of galaxies[4–8]. These QSO-cluster associations have all been found in searches restricted to QSOs with $z<0.36$ since on the cosmological hypothesis it is only for such low values of z that the associated galaxies would be readily visible. But, as Burbidge and O'Dell[9] have pointed out, by assuming at the outset that the redshifts are cosmological these investigations fail to test the non-cosmological hypothesis. For the past several years we have been attempting to carry out a study of QSOs in clusters or groups which would be free from this objection. Although our results are by no means complete, we present here some of our preliminary findings as they seem to be of relevance to the present controversy.

To avoid any assumptions as to the nature of the redshifts, two of us (D. J. and C. H.) started, not with a list of QSOs, but with a list of 280 radio sources selected from the 4C catalogue and for which we had measured improved positions. The fields around each of these sources were examined on the Palomar Sky Survey Prints for possible QSO identifications, an identification being suggested whenever a blue stellar object (BSO) brighter than 19 mag was found within the error rectangle of the radio position[10]. In searching for possible associations with clusters we adopted the view that a QSO is typically brighter than the brightest cluster galaxies by up to 2 or 3 mag. We therefore noted all cases in which three or more galaxies lay within 1 (arc min)^2 of the suggested QSO identification and which on the Palomar Sky Survey E print were approximately equal to it in brightness. We noted QSOs with less than three nearby galaxies only if these were brighter than 19 mag and lay within 10 arc s. This approach not only differs from that adopted in other QSO-cluster investigations but also differs significantly from that of Burbidge *et al.*[11] who looked for an association between QSOs and much brighter galaxies. It assumes that the QSOs are at cosmologically significant distances rather than very local ones but not necessarily at distances given by Hubble's law.

A search was also made for situations in which more than one BSO lay close to the radio position, a few examples of this type having already been noted[12]. It seemed possible that these might represent physical associations of QSOs the significance of which would be easier to establish than QSO-galaxy associations. They would therefore provide a more powerful method of investigating any possible non-cosmological contribution to the QSO redshifts, particularly if this non-cosmological component were present only in high redshift objects, say $z>1$.

A BSO or possible BSO was found within the search area of fifty-three of the 280 sources examined. Of these fifty-three, two (4C04.54 and 4C28.40) were found to be within 1 arc min of a second BSO, three (4C24.23, 4C11.45 and 4C26.48) lay close to one or more galaxies and the sixth (4C11.50) showed both a close pair of BSOs and a galaxy within the error rectangle. The latter four cases were considered to represent the most probable associations and to be worthy of further study, the remaining forty-nine have been published elsewhere[10]. The adopted radio positions of the four selected sources and their position relative to the nearby BSOs are given in Table 1 and enlargements of the fields around each of the sources are shown in Fig. 1.

The most convincing case for a QSO-cluster association is provided by 4C24.23; the BSO is seen clearly near the edge of a small compact group of five galaxies which may represent the brightest members of a cluster extending over a diameter of about 2 arc min. The BSO is the brightest member of the group, consistent with it being a QSO at the same distance. The BSO identified with 4C11.45 is also the brightest member of a small compact group but both the galaxies and the BSO are some 2 mag fainter than in the case of 4C24.23. A line of three brighter galaxies within 2 arc min may be members of the same cluster. 4C26.48 and 4C11.50, each with only a single galaxy within 10 arc s, are less convincing. 4C11.50 was, however, also of par-