1411+442: OPTICAL IMAGING OF A BAL QSO

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ABSTRACT

Results are presented of optical imaging of the low redshift BAL QSO 1411+442, in four colours. The host galaxy is revealed as an inclined spiral galaxy with a long arm which may be a tidal tail. There also appears to be connecting luminosity to two nearby objects. There is a straight blue feature emerging from the nucleus and Hα emission from an oppositely directed filament. [O III] appears to be enhanced in some outer regions. While the host galaxy is more exotic than usual for QSOs, it is not obvious how these properties are connected with the BAL phenomenon.

INTRODUCTION

The bright QSO 1411+442 is included in the Palomar Bright Quasar Survey of Schmidt and Green (1983), and has a redshift of $\sim$0.09. IUE spectra, first noted by Malkan and Green (private comm), show broad displaced absorption lines of C III, N V, Si IV, C IV, making this the lowest redshift BAL QSO presently known. Thus, this object offers our best opportunity to study the host galaxy for morphological or geometrical clues as to the origin of the BAL phenomenon. This work reports on such observations, which will be incorporated elsewhere with the UV and optical spectra, and VLA radio observations.

OBSERVATIONS AND DATA

Direct images of 1411+442 were recorded at the prime focus of the Canada-France-Hawaii telescope, on an RCA single density CCD. Broad-band B and R filters and medium band (700A) Corion filters centred at 5500 and 7000A were used. The latter two filters were chosen to separate line emitting regions of [O III] and Hα by comparison with the broad-band images, which are more dominated by continuum emission. The pixel size is 0.41 arcsec. The exposures were photometrically calibrated in B and R by frames of a standard field in the cluster NGC 2419.

Figure 1 shows some of the results. These include direct B and R images, sky-subtracted, and smoothed with a 1.3 pixel FW gaussian. The figure also shows differences between the 7000A and R band, and between the 5500A and B band images. There are significant areas of difference, which may be attributed to line emission of Hα and [O III] which have different spatial distributions from the continuum radiation. Since the narrow band images were not photometrically calibrated, and there is significant continuum radiation in them too, no attempt is made to derive line luminosities. Nevertheless, the differences very likely do delineate the areas of strong line emission in the images.

Luminosity profiles were generated by fitting elliptical contours to the images and

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also by azimuthally averaging them. These profiles were analysed similarly to the data of Hutchings, Crampton and Campbell (1984:HCC) to derive measures of the resolved and unresolved luminosity (host galaxy and nucleus) in all colours. These were corrected for differences in seeing, and image depth, and reduced to zero redshift as in HCC. Measures of scale length of the resolved light and its axis ratio were also made. Table 1 summarizes the measured quantities.

Table 1: 1411+442 imaging results

Colour	Seeing (")	Depth ($m.sec^{-2}$)	L_n/L_g	L_n/L_g (corr)	D25 (")	m	$-M_n$ (H_0=100)	$-M_g$	b/a	scl.l (Kpc)
R	1.1	25.0	4.4	2.4	24	14.9	21.9	21.1	0.54	4.0
B	1.3	24.8	18.5	6.5	17	15.1	21.9	20.4	0.56	2.3
5500	1.0	23.7	12.6	4.5	22	-	-	-	0.59	2.5
7000	1.7	24.7	11.4	2.5	21	-	-	-	0.6	2.7

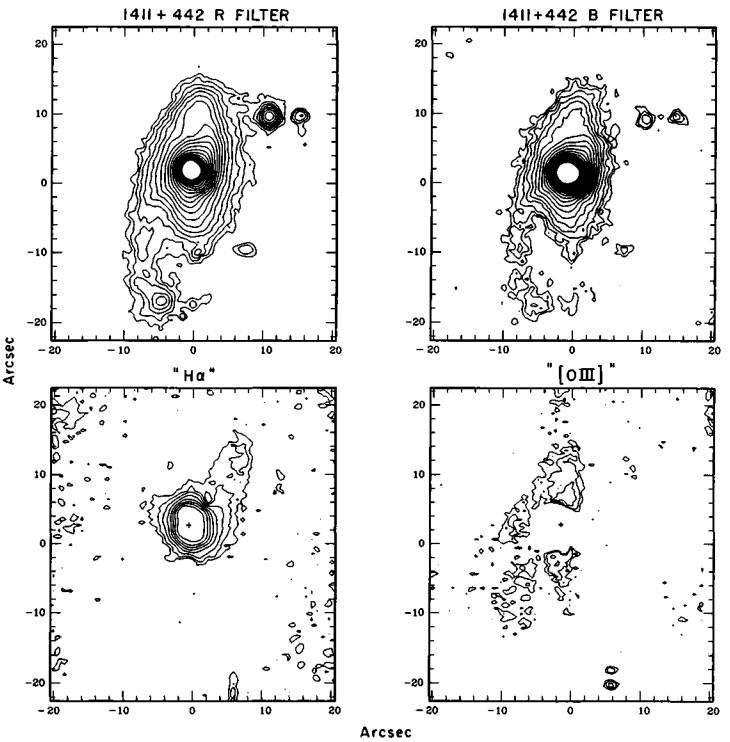

Figure 1. *Upper:* broad band images, showing large arm, inner spiral arms, companion objects, and inner linear feature to SE. *Lower:* differences between narrow and broad band images, showing areas of probable enhanced Hα and [O III] line emission.

DISCUSSION

The object is clearly extended and shows considerable structure. It is unusually elongated, but not as much as two other resolved QSOs at redshifts <0.1: 2130+099=II Zw 136, and 1059+730. Neither of those objects has broad absorption lines.

There are two clearly visible spiral arms emerging from the nucleus along the direction

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of elongation of the image, and there is an obvious outer arm to the South, with a blob near its end. In addition, there is a linear feature to the ESE, seen more clearly in B light, which emerges from the nucleus and becomes invisible as it merges with or crosses the outer arm. There is extended R light to the West, which envelopes two resolved faint objects to the NW. The inner of these two is brighter and considerably redder. The blob of light on the end of the large arm is also red. The absolute magnitudes of the nucleus and host galaxy are given in Table 1, and are not particularly unusual for objects of this redshift (see HCC). The scale lengths are larger than 'normal'.

It is not obvious how to interpret these results and comparisons, particularly in the sense of finding something that characterizes the BAL nature of the spectrum. It may be that the resolved objects to the NW are interacting objects, and that the long arm and blob are tidal results of an encounter. The linear blue feature may be a nuclear jet, or just another 'spiral' arm. To help assess these possibilities we looked at the galaxies in the paper of de Ruiter *et al* (1977) for similar morphologies. There are similarities in many instances: M81, M101, NGC 2403, 2903, 3359, 3718, 4088, 4258. All these galaxies have arms and/or axial ratios very similar to 1411+442. They have a mean colour (B-V) of 0.66 ± 0.12, and a long diameter of 26 ± 8 Kpc, to a luminosity level comparable with that in our 1411+442 data. The colours of 1411+442 are similar to these and the long diameter is $\sim$26 Kpc to 25 mag.arcsec^{-2}, for H_0=100. The long arm is also similar in length to those seen in several of these normal galaxies. The luminosity of 1411+442 galaxy is a little higher than the normal galaxies.

The host galaxy of 1411+442 is unusual (but not unique) in its degree of flattening, in the clarity of its spiral arms, and in its large scale length, compared with other QSO hosts. Compared with nearby non-QSO galaxies, it may be unusual in its linear blue 'jet', and the blob near the end of its arm, which is reminiscent of tidal tails (e.g Mkn 231: Hutchings and Neff 1986). However, the arm does seem to continue and bend around past the blob. The faint companions appear to be connected by red luminosity and may well be interacting companion bodies. The Hα and [O III] morphology suggest complex distribution of gas and ionising radiation, and the blue jet and Hα region both suggest association with the nucleus.

The nucleus is not particularly red, as might be expected if there were dust associated with the absorption line region in the spectrum. The Seyfert galaxy Mkn 231, by contrast, has high nuclear reddening, and BAL spectra in Na I, Ca II, He II, and possibly Hβ. Its UV spectrum contains no lines, but the nucleus is probably completely obscured. Thus, 1411+442 has a different absorbing medium from Mkn 231. If the galaxy is a circular disk, the axis ratio indicates an inclination of $\sim 57^o$, which is insufficient to obscure the nucleus by a normal disk. We note that the next closest known BAL QSO (1700+518 : z=0.29) has very high nuclear luminosity and is difficult to resolve at all (see e.g Hickson and Hutchings 1986), but it seems that 1700+518 is not flattened even to the extent that 1411+442 is. There is also no detected sign of a tidal interaction occuring in 1700+518. Overall, we conclude that the BAL phenomenon is not connected with a highly inclined disk system, or with nuclear extinction.

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