Optical imaging and spectroscopy of BL Lac objects.

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Abstract. High resolution images and spectroscopy of the close environment of several BL Lac objects are presented. The observations obtained with the NTT at ESO are part of an on-going programme aimed at studying the properties of the host galaxies and the immediate environments of BL Lac objects with different characteristics (radio vs X-ray selection, redshift, clustering of galaxies).

Introduction, observations and data analysis.

BL Lac objects are a special kind of AGN with extreme properties of non-thermal emission, polarization and strong and rapid flux variability. The basic current idea is that BL Lac objects are sources which have a relativistic jet closely aligned with the line of sight of the observer. This implies that there are objects intrinsically identical to BL Lacs but that have the jet pointing away from the observer's line of sight. From comparison of radio and optical properties it was proposed that radio galaxies of FR type I or a fraction of them (e.g. Ulrich 1989; Urry & Padovani 1995, and references therein) may represent these mis-aligned objects.

A direct test of this idea might come from the study of the host galaxies of BL Lacs and the environment properties as compared with those of parent objects. With subarcsec ground based imaging one is able to study the host properties up to z $\sim$ 0.5. Beyond z $\sim$ 0.5 imaging with HST capabilities is required and/or observing with excellent resolution in the IR band. At variance with the case of quasar hosts the study of BL Lacs hosts is hampered by the uncertainty of the redshift which is yet unknown or highly uncertain in many sources.

In the course of a program aimed at comparing the properties of host galaxies of BL Lacs at z $<$ 0.5 from different samples we have acquired subarcsec optical images and spectroscopy of the nebulosity for selected targets. We present here preliminary results for two sources: 0301-24 and 1101-23. The observations were obtained using the 3.5m NTT at ESO with the direct imaging system SUSI and a R filter. Spectroscopy of the nebulosity was secured with EMMI and low resolution grisms in the spectral range 4000 to 8500 Å. We performed a surface photometry down to $\mu_R \sim 26$ mag./arcsec^2 in order to derive the morphological and photometric properties of the host galaxies. The luminosity profile was then fitted with a model consisting of a point source plus a galaxy (elliptical or exponential disk) convolved with the proper PSF.

Results

0301–243 Our image (seeing = 0.8″ ; exp =20min) of this BL Lac object clearly shows an extended nebulosity (ellipticity $\varepsilon = 0.3$) with complex morphology and close companions (figure 1). The immediate region around the object is rich with faint galaxies and there is a marked enhancement of the galaxy density within ∼60 arcsec from the BL Lac object. Spectra of two galaxies (G1 and G2; see figure 1) at $\sim 6''$ and $20''$ from 0301-243 indicate that they are at $z = 0.263$ suggesting a cluster of galaxies of Abell richness class 0 might be associated with the BL Lac source at this redshift (Pesce Falomo & Treves 1995). The radial profile is adequately well represented by a point source plus the elliptical model while the fit with an exponential disk is not acceptable. Figure 1 (right panel) shows the field after subtraction of the BL Lac model that reveals the faint galaxy $\sim 3.5''$ South of the nucleus. The surrounding nebulosity is very well centered on the nucleus within an accuracy of 0.2″ . Optical spectra of the nebulosity (slit off the nucleus by 2″), that are still dominated by the signal from the non-thermal source, show only one weak emission line at $\lambda =$ 6303 Å. The most plausible identification is [O III] 5007 that yields a redshift of 0.26, identical to the redshift of the companion galaxies G1 and G2. At this redshift the absolute magnitude of the host galaxy is M_R = -24.2 (k-corrected and assuming H_0 = 50 km s^{-1} kpc^{-1} and $q_0 = 0$).

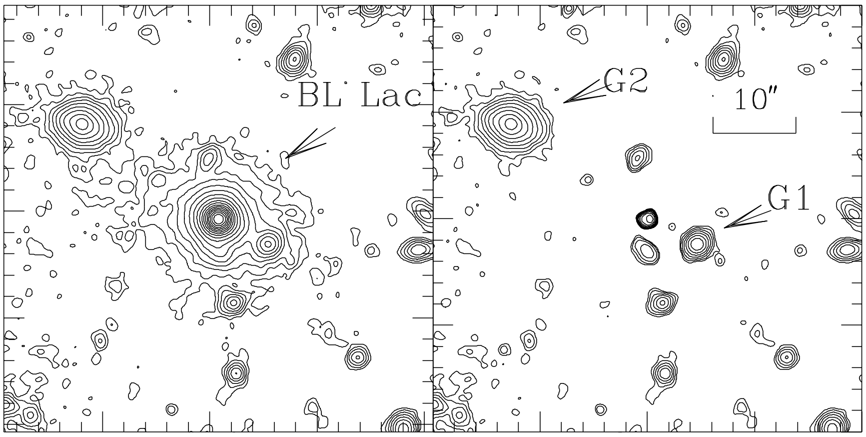

Fig. 1. Contour plot of the central part of 0301-24 before (left) and after (right) subtraction of the galaxy and nucleus. The spacing between isophotes is 0.5 magnitudes while faintest shown level is μ_R = 25.5 mag/□″ . Galaxies G1 and G2 are at redshift z = 0.26.

1101–232 This is a BL Lac discovered from X-ray survey and is surrounded by a conspicuous rather elongated nebulosity (see Fig 2) at the proposed $z =$

0.186 (Remillard et al. 1989). Our optical spectroscopy confirms this redshift from absorption lines of the galaxy. The radial brightness profile extends to 15 arcsec along the major axis a with the ellipticity increasing up to 0.45. We found that the luminosity profile is well fitted by an elliptical galaxy model plus a point source. The absolute magnitude of this host galaxy is $M_R = -24.3$. External isophotes are found to be substantially *boxy*, possibly due to merging (*e.g.* Bender et al. 1989). This is the only clear evidence of substantial *boxy* isophotes found in BL Lacs hosts.

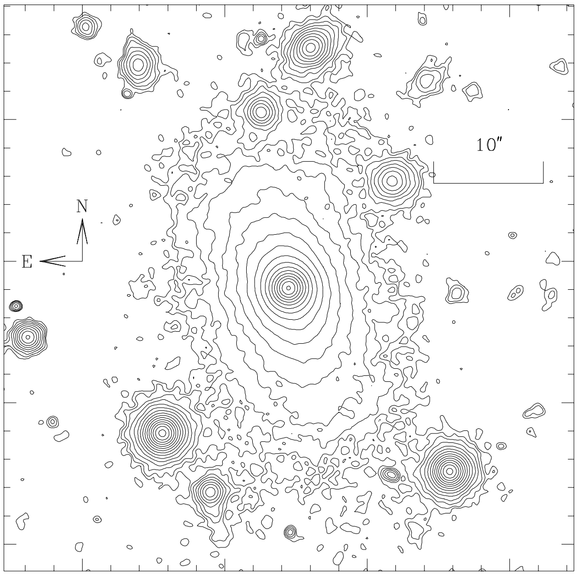

Fig. 2. Contour plot of the central part of the image of the 1101-23. The spacing between isophotes is 0.5 magnitudes while faintest shown level is $\mu_R = 25.5$ mag/□″ .

References

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