RevMexAA (Serie de Conferencias), **49**, 138–138 (2017)

XV Latin American Regional IAU Meeting (Cartagena de Indias, Colombia, 3-7 October 2016)
Editors: Mario Armando Higuera Garzón & Santiago Vargas Domínguez

REDSHIFT DETERMINATION OF BL LAC OBJECTS AS FROM DETECTION OF THEIR HOST GROUPS

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BL Lac objects are a subclass of blazars showing strong, non-thermal variable emission from radio to TeV energies. Their properties are usually attributed to beamed emission from a relativistic jet which is close to the line of sight. The lack of emission and/or absorption features in the optical spectra of these objects, makes the accurate determination of their redshifts very uncertain or even impossible. Since these sources are typically hosted by elliptical galaxies that are associated with groups or poor clusters, the detection of one of these structures in their close environment, serves as an estimator of their possible redshift. For this reason we perform a spectrophotometric study of the close environments of a sample of three BL Lac objects with unknown redshift: 3C 66A, PG 1553+113 and PKS 0332-403.

Considering the controversy about the redshift of these three objects, we have studied their environments using deep, two-colour photometry of galaxies present in fields centred on each BL Lac object, and spectra of a subsample of objects located in the proximity of each blazar, obtained with both Gemini (North & South) Telescopes and the Gemini Multi-Object Spectrographs (GMOS). Our goal is to look for both photometric and spectroscopic signatures of a group or cluster of galaxies hosting each BL Lac object, thus providing and independent and reliable determination of their redshifts.

Observations included g' and i' band images. We performed photometry on these images using SExtractor (Bertin & Arnouts 1996). The objects selected for photometric analysis within each field were those brighter than $g' = 24.5$ mag. Spectroscopic data were acquired in the multi-object (MOS) mode, making use of two diffraction gratings: B600 and R400. The spectroscopic data analysis allowed us to detect galaxy groups in the environment of each blazar: two groups in the field of 3C 66A at $\langle z \rangle = 0.020$ and $\langle z \rangle = 0.34$, two groups in the field of PG 1553+113 at $\langle z \rangle = 0.26$ and $\langle z \rangle = 0.43$, and two groups in the field of PKS 0332-403 at $\langle z \rangle = 0.101$ and $\langle z \rangle = 0.34$. To identify these groups as galaxy clusters, we proposed the reference *Cluster Red Sequence* (CRS), following the recommendations of López-Cruz et al. (2004). To detect the red sequences of clusters, we used a linear fit to the Virgo CRS (Chen et al. 2010), assuming that a similar relation is followed by the early type galaxies in these structures at different redshift.

We used this CRS shifted to z values of identified galaxy groups. Shifts in $g' - i'$ colour and g' magnitude were established using $K-$ and evolutionary corrections computed through the stellar population synthesis template galaxy models of Buzzoni (2005). The shifted Virgo CRS clearly coincides with the positions of spectroscopically identified early type galaxies, confirming the presence of galaxy clusters in the environment of each blazar.

We calculated the colour scatter $\sigma_{(g'-i')}$ of each detected red sequence, based on the spectroscopically identified members, to identify other candidate members of these clusters.

This study allowed us to detect host cluster candidates for each blazar with redshifts of 0.34, 0.43 and 0.34, respectively. Therefore, we propose that the host galaxy of 3C 66A belongs to a galaxy cluster at $z = 0.34$, that the redshift lower limit for PG 1553+113 is $z \gtrsim 0.43$, and that the redshift lower limit of PKS 0332-403 is $z \gtrsim 0.34$.

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