OGLE BLAZARS BEHIND MAGELLANIC CLOUDS

ŻYWUCKA-HEJZNER, N., GOYAL, A., JAMROZY, M., KOZŁOWSKI, S., OSTROWSKI, M., STAWARZ, Ł., Udalski, A.

ABSTRACT

We report blazar candidates behind the Large and Small Magellanic Clouds. Both Flat Spectrum Radio Quasar (FSRQ) and BL Lacreate (BL) objects are selected based on the long-term, multi-colour Optical Gravitational Lensing Experiment (OGLE) photometric data. We cross-correlate the optical catalogue of quasars behind the Magellanic Clouds with radio data at 6 frequencies from 0.8 to 20 GHz. Among the 1654 objects visible in optical range, we identify a sample of 44 blazar candidates, i.e. 27 FSRQs and 17 BLs. We examine selected objects with the respect to their radio, optical, and mid-infrared properties. Most of the selected sources are newly detected FSRQ and BL Lac blazar candidates.

INTRODUCTION

The OGLE experiment has observed few million stars in the area of both Magellanic Clouds (MCs). Quasars from the *Magellanic Quasars Survey* (MQS) catalogue (Kozłowski et al. 2013) were analized with a four-step selection process: mid-infrared properties, optical variability, ROSAT X-ray sources counterparts, and finally, optical spectroscopy study. The OGLE catalogue contains 758 quasars and around 10% of them should be radio loud quasars (Kellermann et al. 1989). Several of them may be FSRQ type blazars. The BL type of blazars were selected using separate list of *featureless spectra* objects (FS) consisting of 669 and 229 sources from the LMC and SMC fields, respectively.

We present the selection procedure of blazars among other AGN. Accordingly, we cross-matched the MQS catalogue and the FS list with four radio catalogues, the Sydney University Molonglo Sky Survey (SUMSS) at 0.843 GHz, the Australia Telescope 20 GHz (AT20G) at 5, 8, and 20 GHz, the Parkes-MIT-NRAO (PMN) at 4.85 GHz, and the Australia Telescope PMN follow-up (ATPMN) at 4.8 and 8.6 GHz, to disclose both aforementioned type blazars from the sample.

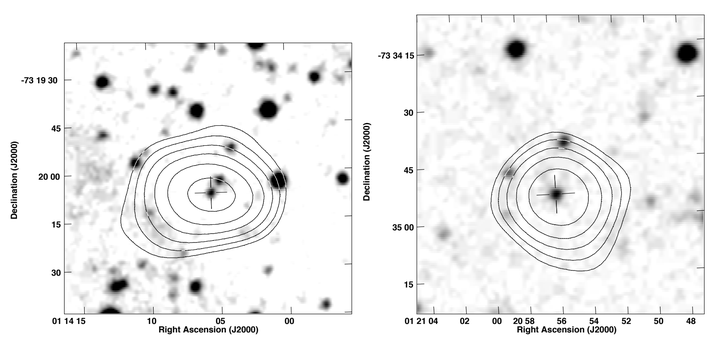
METHODS

The blazar candidates were selected from the MQS catalogue and the FS list using (i) the radio and optical positioning, (ii) the cross-matching procedure, and (iii) the parameters examination of identified objects.

(i) The positions of selected quasars from both, the MQS catalogue and FS list, were checked with positions from two radio catalogues: SUMSS at 0.84 GHz and ATCA at 4.8 and 8.6 GHz.

(ii) The cross-matching procedure was based on archival data from four sky surveys: SUMSS (Murphy et al. 2007), AT20G (Murphy et al. 2010), ATPMN (McConnell et al. 2012), and PMN (Condon et al. 1993).

(iii) The examination of selected objects was based on calculation of three parameters: radio loudness (R), radio spectral indexes (a_r), and mid-infrared spectral indexes (a_{IR}). Radio and optical data for calculating two first parameters were taken from earlier mentioned catalogues. Mid-infrared data were produced by IRAC and MIPS instruments onboard the Spitzer Space Telescope. The sources were observed at 3.6, 4.5, 5.8, and 8.0 microns.



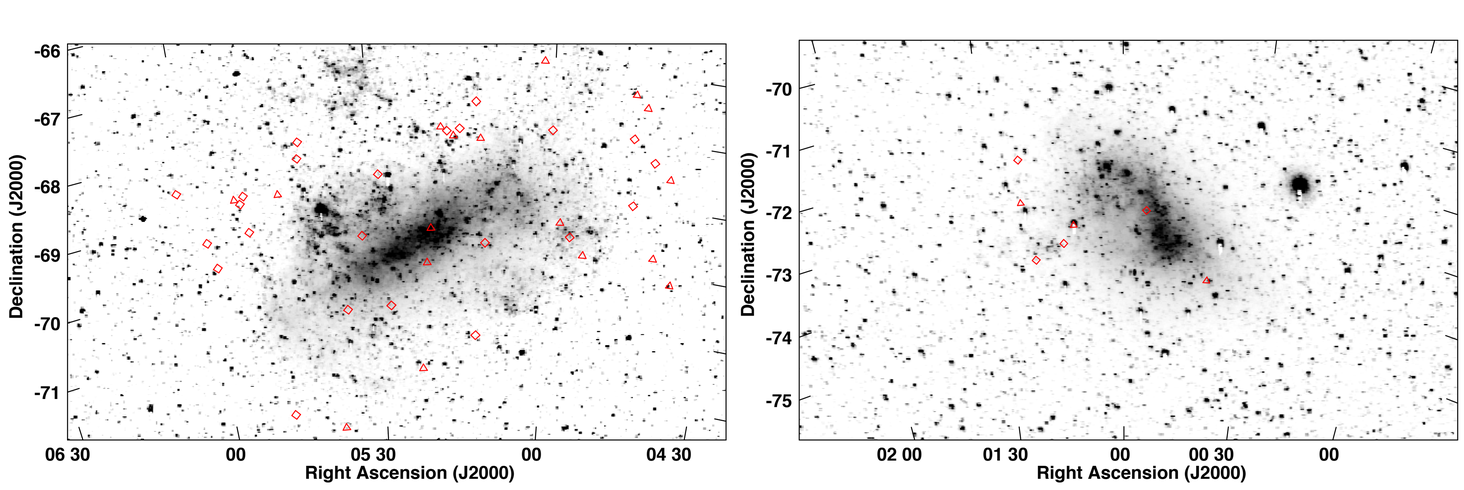
RESULTS

As a result, two lists of blazar candidates were produced: 27 FSRQ and 17 BL type blazars.

The radio spectra and indices were derived for the selected objects, which have been found in more than one radio catalogue or for which at least two data points in different frequencies are known in the available astronomical databases. These parameters allowed to conclude if the radio spectra are flat (a_r > -0.5) or steep (a_r < -0.5). If a_r is flat, then the object can be the FSRQ type blazar (Impey et al. 1990).

The most significant amount of the blazar candidates were found in the SUMSS catalogue.

All objects are optically faint with the V band mag level between 18 and 22; the FSRQ blazar candidates are distant with redshifts up to 3.3



Distribution of selected blazar candidates behind Large (left panel) and Small (right panel) MCs. The FSRQs are shown with red open diamond symbols and BLs are shown with red open triangular symbols. The gray scales of both MC optical images are taken from Bothun & Thompson (1988).

To further verify the blazar nature, we calculated their fractional linear polarization and linear polarization angle. We checked up on the AT20G catalogue and analyzed polarized flux density on 4.8 and 8.6 GHz radio maps of the LMC and SMC. As a result, we extract 9 objects from the selected sample, 6 FSRQ and 3 BL candidates and notice that all of them are strongly polarized sources with p > 3. Assuming, the average fractional polarization for all 9 objects is $p_{4.8\mathrm{GHz}} \sim 6.8\%$, we expect that this value should be similar for rest of the sampled objects.

Object	Fractional linear Polarization					Linear Polarization Angle	
	4.8 GHz [%]	5 GHz [%]	8 GHz [%]	8.6 GHz [%]	20 GHz [%]	4.8 GHz [°]	8.6 GHz [°]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
FSRQs							
J0114-7320	9.5			7.0		70.7	-12.9
J0120-7334	5.0					-52.2	
J0442-6818		11.7	10.0		8.1		
J0512-6732	3.3	12.7	10.7		13.6	13.6	
J0551-6916	7.3					8.3	
J0551-6843	9.1					-3.9	
BLs							
J0111-7302	4.1	8.3	8.3		9.7	4.4	
J0501-6653	10.7			22.1		-2.8	-11.1
J0518-6755	12.6					-14.2	

FURTHER DIRECTIONS

The work is still in progress. We are going to characterize the optical variability of all catalogued objects and to study broadband emission energy spectra, from radio frequencies to gamma rays, for objects where the archival multi-wavelength observations are available.

REFERENCES

[1] Condon, J. J. et al. 1993, ApJ, 106, 3
[2] Impey, C. D. et al. 1990, ApJ, 354, 124
[3] Kellermann, K. et al. 1989, AJ, 98, 4
[4] Kozłowski, S. et al. 2013, ApJ, 775, 92
[5] McConnell, D. et al. 2012, 422, 1527
[6] Murphy, T. et al. 2007, MNRAS, 382, 382
[7] Murphy, T. et al. 2010, MNRAS, 402, 2403
[8] Stocke, J. T. et al. 1992, AJ, 396, 487