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Mapping optically variable QSOs towards the Galactic plane

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Abstract

We present a method designed to detect QSOs near the Galactic Plane, based on their optical photometric variability, and we analyze its performance using data from the CIDA Low Latitude Variability Survey (CLLVS). This survey contains photometric data from extended and adjacent regions of the Milky Way disk. In this work we have analyzed 2.5 square degrees of the survey . We have selected a sample of 288 QSOs candidates using the variability, the periodicity, and the Structure Function. We obtain a low efficiency in recovering previously reported QSOs in the SDSS (≈5%), however we expect a high degree of contamination. Additionally, we present preliminary results of follow-up spectroscopic observations carried on at CASLEO (Argentina). The results shown in this work are a first attempt to develop a robust method to detect QSOs in the Galactic Plane in the era of massive surveys such as VISTA and Gaia.

INTRODUCTION. In the present work we use observations at low Galactic latitudes (lbl < 30), i.e., we employ data from the CIDA Low Latitude Variability Survey (CLLVS, see details in Mateu et al. 2012, MNRAS, 427, 3374). The observations in the CLLVS (photometric data for ≈ 7×10^6 sources in V, R and I bands) were obtained between late 1998 and mid-2008 with the QUEST camera and the 1.0/1.5m Jürgen Stock Schmidt telescope at the National Observatory of Venezuela, in Llano del Hato (Venezuela). The survey spans a total area of 476 deg^2 (see Fig.1), and comprises different observational projects in different regions of the sky, with various scientific goals. We selected a specific section of the catalog (near to the Galactic plane) with high number of observations per source, covering an area of 2.5 deg^2 and with an overlap of approximately 1.96 deg^2 with the SDSS (DR9), given us the opportunity to test QSO selection algorithm using time variability that could be used in the future to map QSO sources towards the Galactic plane. Since, currently exists ongoing surveys as VISTA or forthcoming surveys as GAIA, to develop a method to search QSOs based on their variability is of significant worth and deserves attention. The QSOs are interesting, because serve as probes of galaxy evolution, and probe the intergalactic medium (e.g. Schmidt et al. 2010, ApJ,714,1194).

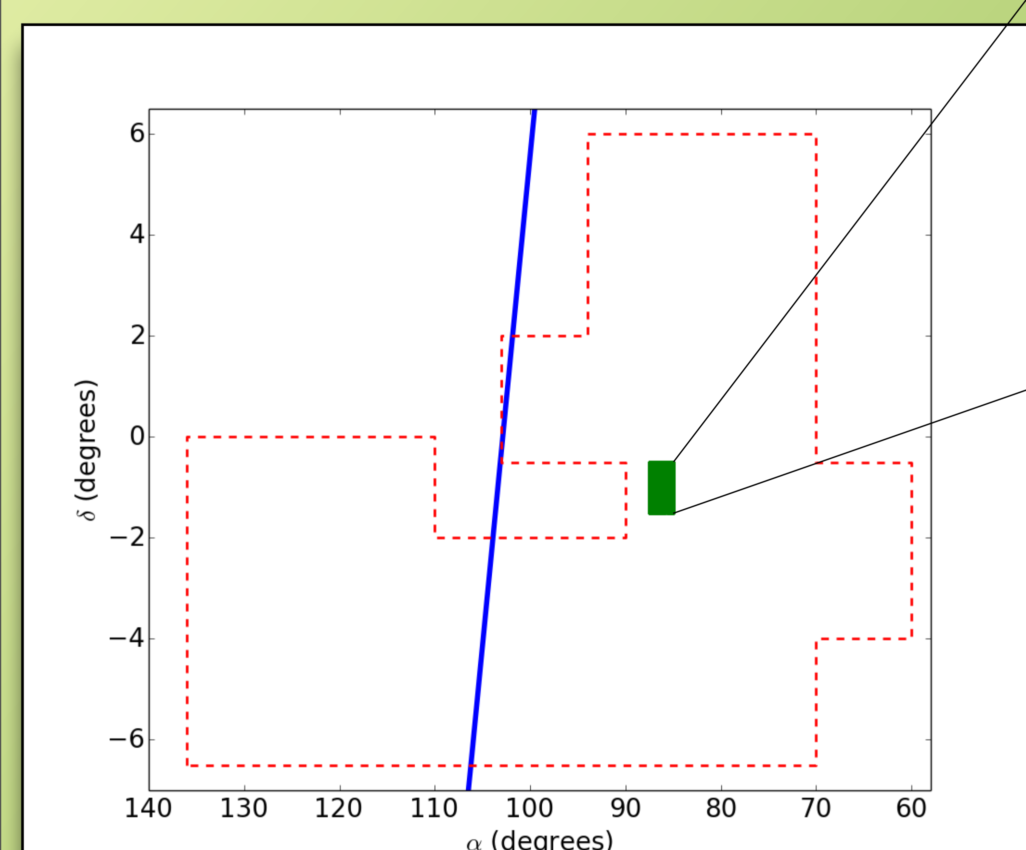

Fig. 1. Plot showing the region covered by the CIDA Low Latitude Variability Survey (red dashed line). In green the 2.5 deg^2 analyzed in the present work. The blue line maps de Galactic plane.

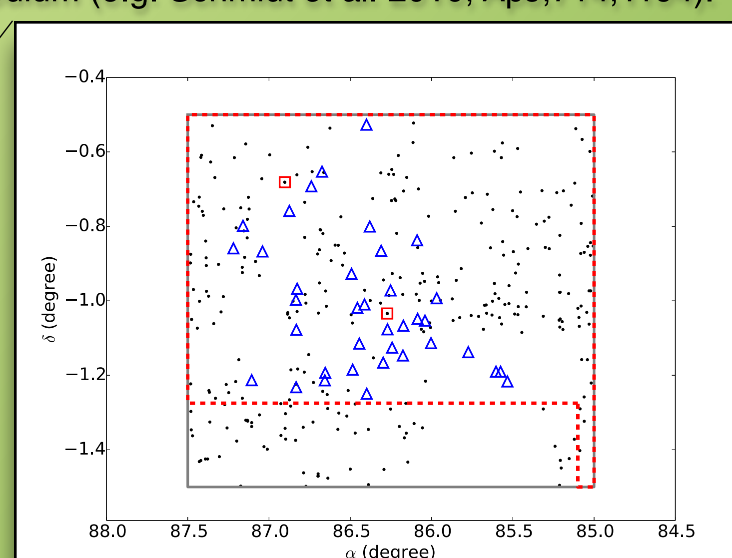

Fig. 2. Spatial distribution of the 288 QSOs candidates (black dots). The region in common with the SDSS (DR9) is represented by the red dashed polygon. QSOs spectrally confirmed are shown in blue and red open symbols (open squares are the QSOs recovered in the final step).

2. SELECTING CANDIDATES. The method to select our candidates consists of three steps: Variability, aperiodicity and the Structure Function. In the first step, we follows Rengstorf et al. (2006,ApJ,131,1923) and we define a variability index, Vi, suitable to our CLLVS data, and select 1,931 as variable sources with Vi > 66.5. On this subsample we apply again the method proposed by Rengstorf et al. (2006,ApJ,131,1923) in order to separate periodic and aperiodic variable sources. We obtain 1,481 sources flagged as variable and aperiodic. The final step consists on separating QSOs from variable stars. Following Schmidt et al. (2010, ApJ,714,1194) we analyzed the Structure Function and separate the objects according to the distribution in the (A_T-γ_T) plane (see Fig. 3).

"The structure function characterizes the variability of quasars (and the other sources) by quantifying the variability amplitude (AT) as a function of the time lag (γT) between compared observations" (e.g. Schmidt 2010, ApJ,714,1194, and references therein).

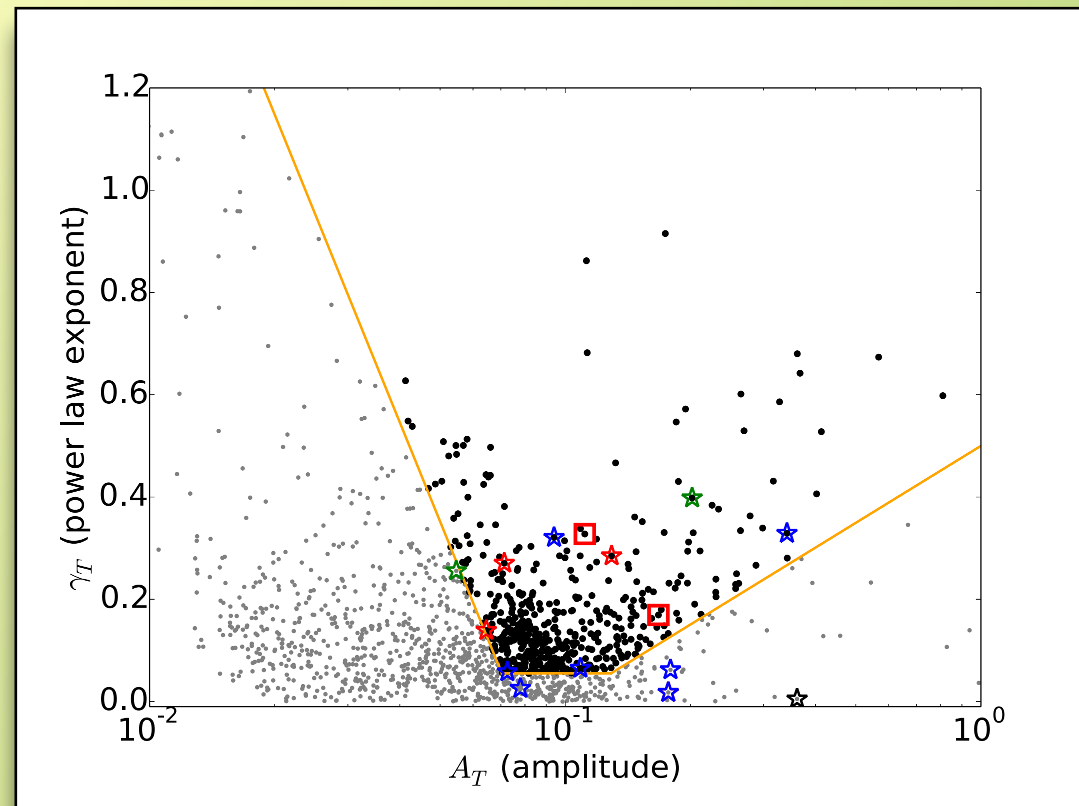

Fig. 3. Distribution of the variability structure function in the plane A_T-γ_T. QSO candidates are depicted as black dots. QSOs spectrally confirmed are shown in red open squares. The gray and black dots correspond to the sample of 1,481 sources analyzed in final step. Note the contaminants in the QSO candidates: Binary stars (blue open stars), RR Lyrae (black open stars), Brown dwarf (green open stars), Variable stars in the CATALINA survey (open red stars).

3. OUR FINAL SAMPLE. After the final step we obtained 288 QSOs candidates, of which only two have been reported as QSO by the SDSS (see Fig. 2). It is important to note that our sample could be contaminated by variable stars, since the scarce sampling between epochs can contribute to decrease the efficiency in the *A*–γ technique to select QSOs (Schmidt et al. 2010, ApJ,714,1194). This could also explain the low performance (approximately 5%) to recover the QSOs spectrally confirmed.

4. THE SPECTROSCOPIC FOLLOW-UP . At the present time we have obtained spectra for four objects as a part of a spectroscopic follow-up project that is being carried on with the REOSC Spectrograph installed on the 2.0-m telescope at CASLEO (Argentina). The four targets were discarded as QSOs since they show clearly stellar features in their spectra. Fig. 4 shows the light curves as well as the spectrum of one of this objects (probably a star of spectral Class M). It is clear that we "cannot give strong conclusions" with only four analyzed targets, but this result is consistent with the efficiency discussed before. And it is related with a high degree of contamination.

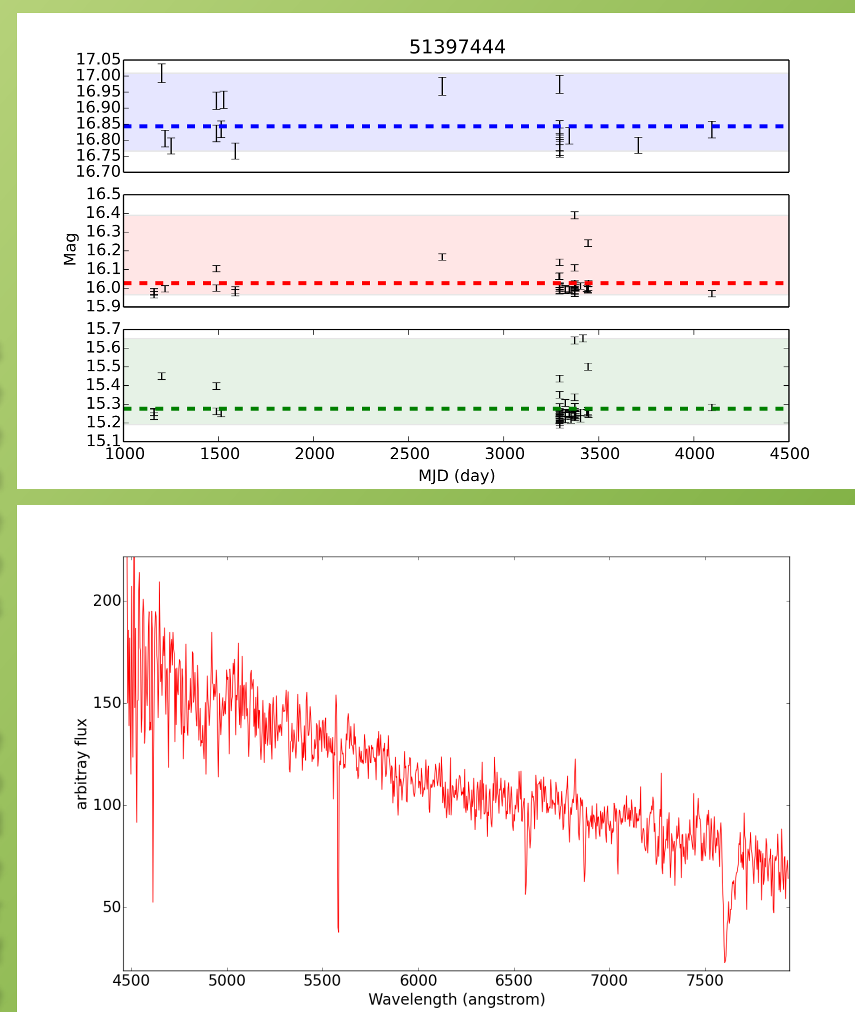

Fig. 4. In the top panel, the light curve (V, R and I, from top to bottom) for the object 51397444. Bottom panel, the spectrum.

5. CONTAMINATION. Since we are near the Galactic plane, we expect a high degree of contamination (foreground stars), which is not present in previous surveys of QSOs using variability. This makes complicated to use past surveys to estimate such contamination, and this is an important point to quantify in our methodology especially for future surveys as GAIA or VISTA. At this moment we are in the process to measure this contamination, since the CLLVS is a not homogeneous survey with lack of information through epochs. However we can do a simple and rough projection of the more likely field stars "K/M stars contaminants" present in our sample using the Besançon models (Robin et al. 2003), and comparing the synthetic colors with those observed in our sample candidates (see Fig. 5).

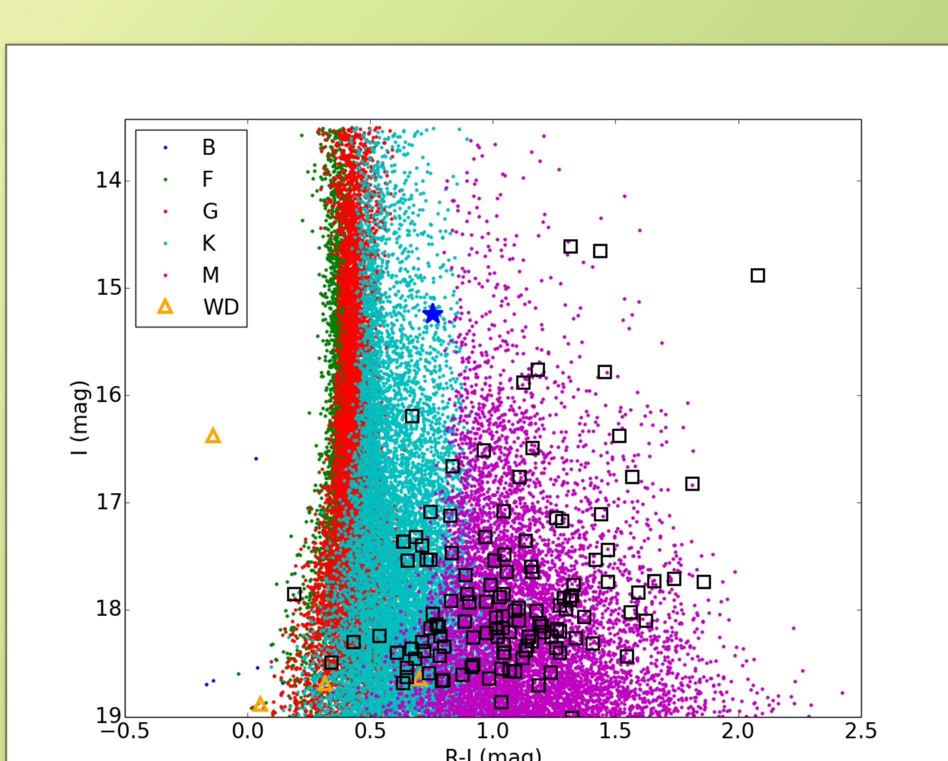

Fig. 5. CMD diagram for 126 QSOs candidates (black symbols) with I and R information. The blue star is the object 51397444 showed in Fig. 4. The simulation of the Besançon model is presented by dots with different colors for each stellar populations.

6. RESULTS:

1. We have obtained a list of 288 QSOs candidates in 2.5 deg^2 of the CLLVS. Of which only two have spectroscopic confirmation from the SDSS.
2. Spectroscopic follow-up is being carried on at CASLEO. The four objects observed are variable stars. However more objects will be observed in a near future.
3. We obtain a low efficiency (≈5%) in recovering previously reported QSOs, however a high degree of contamination is expected in surveys with lack of sampling). We are in the process to quantify and measure properly this contamination.

Acknowledgments

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