MORPHOLOGICAL CLASSIFICATION OF QSOs IN THE SDSS DR7 POPULATION

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ABSTRACT. The luminosity of the central part of QSOs may surpass that of the entire host galaxy by two or three orders of magnitude. This is certainly true among the most extreme objects, and for that reason their host galaxy study has been limited to a small number of cases at relatively low redshifts. But even in the case of less luminous objects, and given the point-like scale of the central region, it is possible to pinpoint the host galaxy through the analysis of compound PSF. In the past, we proceeded to the analysis of SDSS QSOs, that clearly showed the signature of the host galaxy of QSOs on a statistical basis. That study validated the method of using redder to bluer multi-color determinations of the QSO PSF relatively to the average PSF of nearby stars. The present study aims to analyse the complete 105783 SDSS DR7 population of QSOs, from their images in the five u, g, r, i, z bands and derived relative PSFs. This is a work in progress, and here we present the results concerning a representative sample of 8874 SDSS QSOs. The main results are that in the five bands there is a steady population of non-point-like objects, and that the targets morphology become less point-like towards the redder bands.

1. INTRODUCTION

Gaia is a mission of the European Space Agency with launch predicted for 2013. The main goal of the Gaia mission is to investigate the origin and evolution of our Galaxy. It will perform spectral and photometric observations and measure the position of ∼1 billion objects with an accuracy down to 20 μas, allowing the construction of the most accurate three-dimensional map to date of the Milky Way. Gaia observations will also have impact in research areas such as: solar system, stellar astrophysics, extra-solar planets and AGNs. Along the five years – the predicted duration of the mission – Gaia will detect ∼ 500000 QSOs, and the extreme accuracy in their positions will produce a reference frame that will change the future paradigm of the International Celestial Reference Frame–ICRF (Ma et al., 2009). QSOs are among the best objects for the materialization of such a frame, given that they are so distant that do not show proper motions, and look point-like sources (even if they live in galaxies). From the on-board broadband filter detection, and later through variability and peculiar motion confirmation, Gaia is planned to possess the capability of single out QSOs from the contaminant stellar population. At the same time, an Gaia Initial Quasar Catalog (GIQC) is being developed to support the initial matching, enlarging the color comparison template, and to provide a safety minimum of proven, point-like, invariable QSOs for the construction of Gaia's non-rotating, fundamental frame. As referred above, QSOs live in galaxies, as demonstrated by the detailed analysis of nearby objects. Their common point-likeness appearance results on one hand from the fact that the brightness of the central region (ie the AGN) may surpass by orders of magnitude that of the whole galaxy, on the other hand, the far the object is the more difficult it is to detect the fainter extended emission from the stars. Andrei et al. (2009 and 2010) demonstrated

that it is possible to pinpoint the host galaxy through the analysis of compound Point Spread Function, that work based on a large sample of 1343 QSOs from DSS and SDSS multiband images. The fact that an extended component may be detected in the QSOs is of extreme relevance for Gaia, as it has an impact on the accuracy of the coordinates of the objects. This is demonstrated in Figure 1, where we compare the light profile of a point-like object that is well described by a PSF, and the light profile of an extended object. It is clear that the existence of an extended component affects the determination of the photocenter position (xc). A significant fraction of the QSOs detected by Gaia will be nearby objects translating in a non negligible fraction of extended objects. In order to model this effect we have embarked in the study of the morphology of the QSOs of the SDSS Quasar Catalogue, that comprises 105 783 objects. This is work in progress, and here we present the results concerning a subsample of 8874 QSOs.

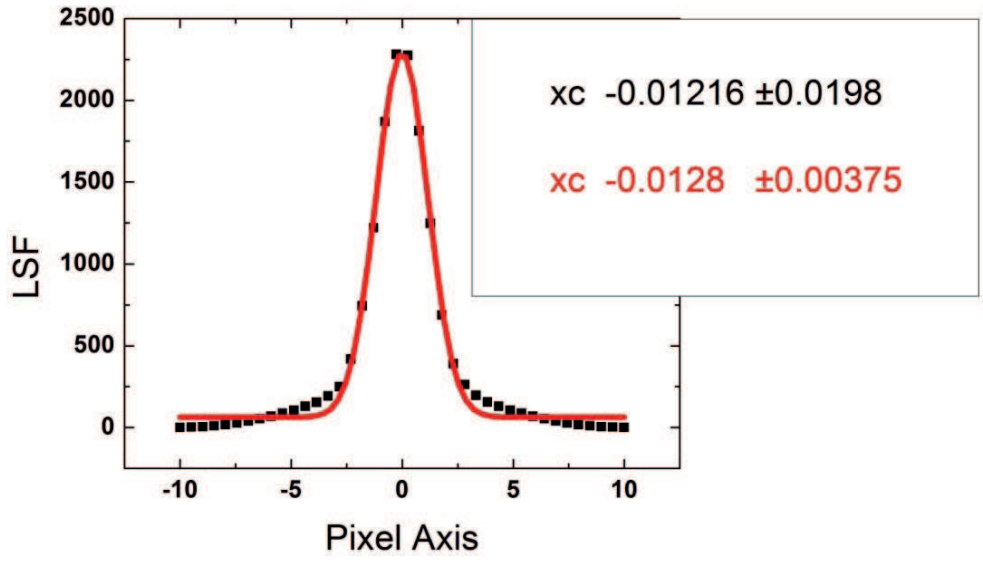

Figure 1: Comparison between the centroid of a profile of an extended object an a point-like source (red).

2. SAMPLE & DATA

This work aims at studying the extended or point-like nature of the QSOs population in Sloan Digital Sky Survey – Data release 7 (SDSS–DR7, Schneider D. et al., 2010). There are 105783 spectroscopically confirmed quasars in SDSS–DR7, covering an sky area $\sim$ 9380 deg^2 and having redshift (z) between 0.065 to 5.46, with a median value of 1.49. We obtained SDSS frames in the in u, g, r, i and z bands for all objects, making in total 528915 frames with 2048x1489 pixels (0.396 arcsec/px). Each frame has approximately 4 MB, so the total amount of data downloaded is $\sim$1.5–2 TB.

3. STRATEGY

We run a IRAF pipeline on the SDSS DR7 frames to issue three PSF parameters: SHARP (skewness), SROUND (circularity) and GROUND (normalness). For each of the frames we obtain a mean PSF. The later are computed firstly based on all the available and suitable field stars, and finally from the combination of the ten objects closest to the QSO, in position and magnitude, which best match the frame's PSF. Stars close to the frames' edges, pack grouped, or saturated are preliminarily excluded. For each QSO in the frame (might happen to exist more than one) we build three morphological indexes as the difference to the frame's local PSF parameters, as normalized by their standard deviation. If any of the morphological indexes differences is larger than two standard deviations of the parameter distribution, then that target is regarded as exhibiting a host galaxy signature. The IRAF pipeline automatically

detects and determines the photometric characteristics of the QSOs and field stars.

4. RESULTS

This work is in progress, and by the time of the Journeés 2011 we had u, i, half of the g, r and z frames processed for a subsample of 8784 objects, randomly distributed in the sky (see Figure 2).

Considering the 8784 objects and the frames processed we notice that there are several cases of QSOs present in more than one frame. The actual numbers varied, because of a same detection threshold adopted for all the ugriz bands, and because of unenveness of completion of the analysis for all the frames - nevertheless the samples are always significant, the smallest being the z band with 3725 frames analysed. Table 1 shows that the averages are always close to 1, whereas for an ideal point source the indexes are 0. This indicates the presence of a significant fraction of quasars which strand from point-like. On the other hand the averages of the differences of the indexes of a same quasar imaged in different frames are effectively very close to 0, meaning that the indexes for a same quasar repeat independently of variations of the PSF.

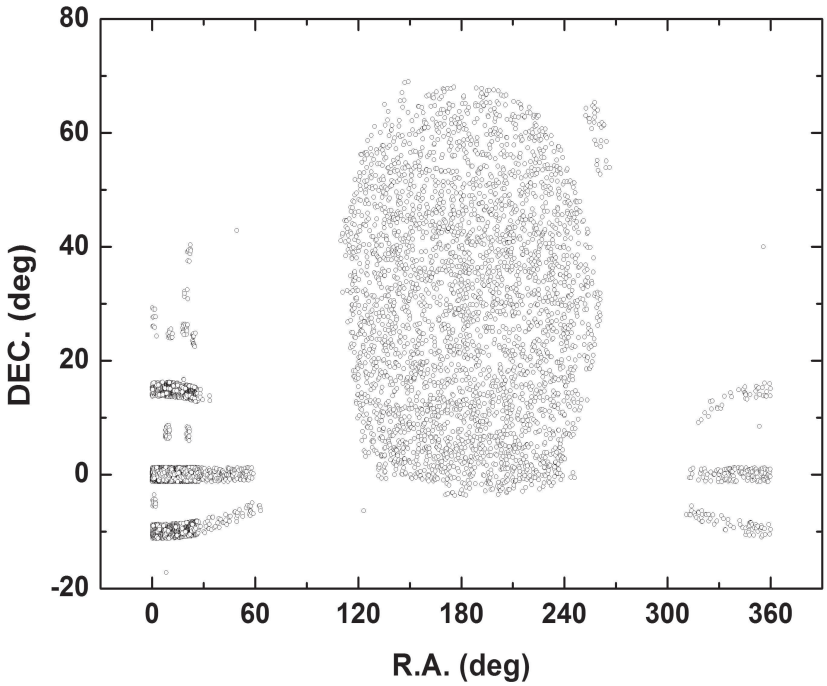

Figure 2: Sky distribution of the 8 784 QSOs.

Band	u		g		r		i		z	
Averages for	Rep.	All	Rep.	All	Rep.	All	Rep.	All	Rep.	All
sharp	0.05	1.13	0.05	0.65	0.01	0.78	0.01	0.88	0.10	1.15
sround	0.03	0.78	0.01	0.71	0.01	0.79	0.02	0.88	0.01	1.02
ground	0.02	0.63	0.04	0.60	0.00	0.73	0.03	0.82	0.03	1.05

Table 1: Average values of the morphological indexes. Under repeated (Rep) are shown the averages for a same quasar found in more than one frame. Under (All) are shown the averages for all the quasars.

Figure 3 presents the distributions of the three PSF parameters, for each ugriz band, of 3114 QSOS (those that were detected in all the bands). That distributions reveal that most of the QSOs have stellar-like morphological indexes (values below 2). However, we also found that in statistically significant number of QSOs, an extended component is present, as demonstrated by their relatively large morphological indexes (i.e. > 2). The extended component is more predominant the redder the band is. We interpret that

as the signature of the host galaxy which are mainly redder in comparison with the central (point-like) region. The consistent behaviour revealed by the three distributions illustrate the robustness of the three morphological indexes.

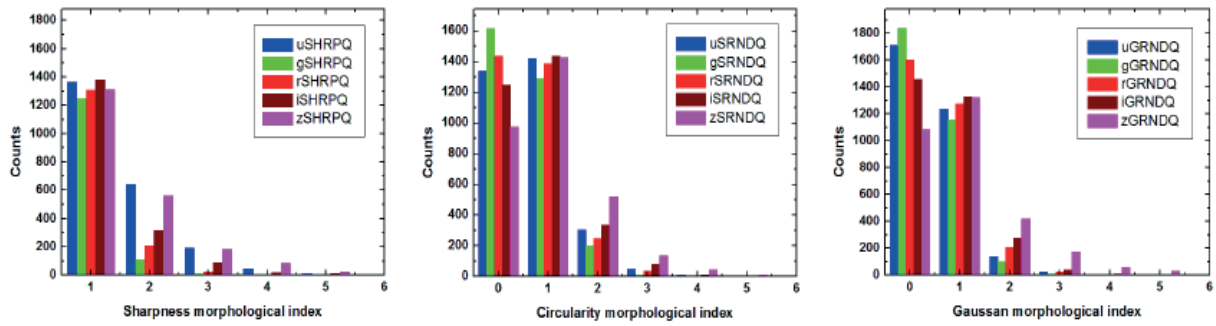

Figure 3: Distributions for 3 114 QSOs with all bands processed. Left–SHARP, center–SROUND, right–GROUND.

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