Study of the AGN population at intermediate redshifts in the SHARDS survey

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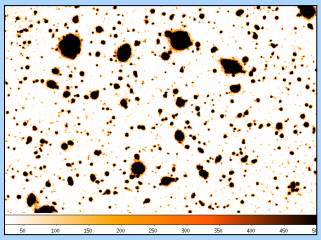
We present the first results of a program aimed to study the stellar populations of moderate luminosity X-ray selected Active Galactic Nuclei (AGN) at intermediate redshifts. We use observations taken as part of the Survey for High-z Absorption Red and Dead Sources (SHARDS) with the optical instrument OSIRIS on the 10.4m Gran Telescopio Canarias (GTC). SHARDS is an on-going ESO/GTC Large Programme that is observing the GOODS-North cosmological field with 24 medium-band filters (22 of 17nm and 3 of 25nm) in the spectral range 500-950nm. Although SHARDS was originally designed to select and study the properties of high-z massive and passively evolving galaxies, it can also provide very valuable information about AGN at intermediate redshifts. We show that the SHARDS observations provide sufficiently high spectral resolution (R~50) to detect broad absorption stellar features (e.g. , the 4000Å break) as well as emission lines and to estimate accurate photometric redshifts. Together with the SHARDS observations we use the wealth of multi-wavelength data from the UV to radio available for this cosmological field to study the stellar populations and star formation histories of AGN at z~0.5-1.2.

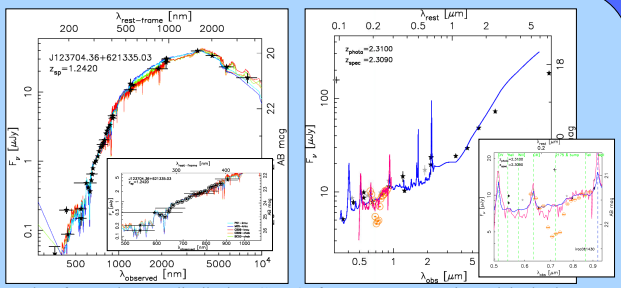
http://guaix.fis.ucm.es/~pgperez/SHARDS/index.html

1. SHARDS: the Survey for High-z Absorption Dead and Red Sources in GOODS-North

SHARDS is an ESO/GTC Large Programme (Pérez-González et al. 2012) approved in 2009A, which was awarded twenty nights on the 10.4m GTC telescope. The entire GOODS-N region is surveyed in 24 medium band (17nm and 25nm) filters with OSIRIS covering the wavelength range 500-950nm with contiguous pass-bands to provide a spectral resolution of R~50. The depth of the survey is at least 26.5 mag at the 3σ level in all filters. As of June of 2012 the survey is 75% complete.



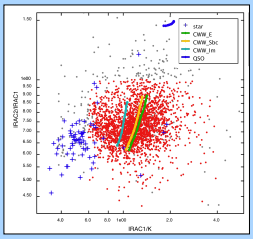
Stacked SHARDS image using all filters of the portion of the GOODS-North Field observed to date.



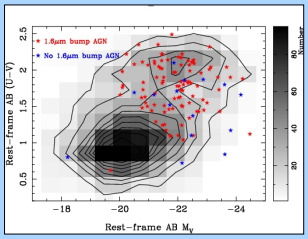
Examples of spectral energy distributions (SEDs) of two sources, a massive and dead galaxy (left) and an IR power law galaxy (right). The insets show in detail the SHARDS photometry.

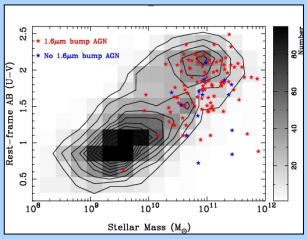
2. The samples of X-ray selected AGN and non-AGN galaxies at intermediate redshifts z=0.5-1.2

We used the X-ray selected sample of AGN in GOODS-N of Alexander et al. (2003) at z=0.5-1.2. For the comparison sample of non-AGN galaxies we selected galaxies (including AGN) with a clear 1.6μm bump using a color selection: $f_{4.5}/f_{3.6}$ and $f_{3.5}/f_{2.2}$ We imposed the following S/N criteria: 5 for K and 3.6μm, and S/N=3 at 4.5μm. In what follows we focus on those AGN with a 1.6μm bump. That is, the AGN does not dominate the rest-frame near-IR emission and we can study their host galaxies. These are thus moderate luminosity AGN (see also Alonso-Herrero et al. 2008).



Color-color diagram used to select 1.6μm bump galaxies and AGN in GOODS-N.

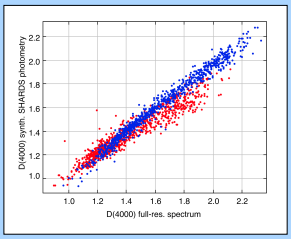




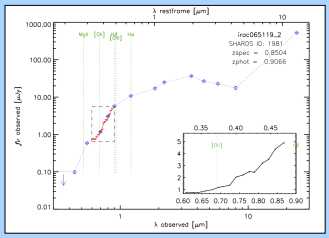
Color-magnitude (left) and color vs. stellar mass (right) diagrams. The grey scale image and contours are the 1.6μm bump galaxies. The AGN with and without a 1.6μm bump are the red and blue stars, respectively. The stellar masses of AGN without the bump are not reliable.

3. Measuring the 4000Å break index for SHARDS galaxies

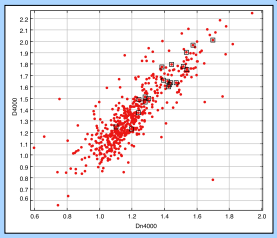
We use the strength of the 4000Å break to get an indication of the age of the stellar populations. We use two definitions for the index: D(4000) for [4050, 4250] and [3750,3950] and the narrower definition Dn(4000) with bands [4000, 4100] and [3850,3950]. To assess the accuracy of our measurements, taking into account the spectral resolution of the SHARDS data (R~50) and the errors of the photometric redshifts σ(Δz/(1+z)) 0.009, we simulated SHARDS photometry using 1377 zCOSMOS spectra of galaxies in the same redshift range.



Simulated and real D(4000) (blue) and Dn(4000) (red) indices for zCOSMOS galaxies at 0.5 < z < 1.2



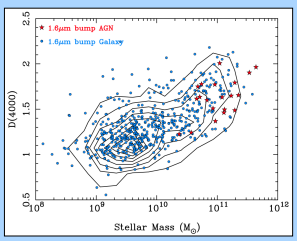
SED of a 1.6μm bump AGN in GOODS-N. The inset shows the SHARDS photometry in the spectral region of the 4000Å break.



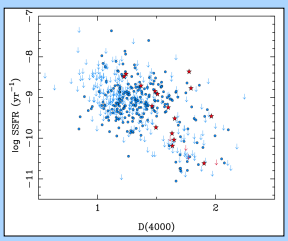
Comparison of the two indices measured for galaxies in GOODS-N. The 1.6μm bump AGN are the squares.

4. Stellar populations of X-ray selected AGN and comparison with non-AGN galaxies

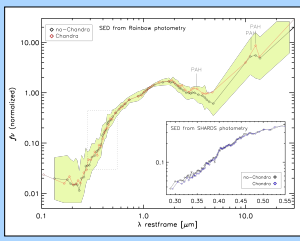
We find that most galaxies selected to have a 1.6μm bump at z=0.5-1.2 show young stellar populations D(4000)<1.5. X-ray selected galaxies tend to reside in the most massive galaxies at the same redshift. However, unlike in the Local Universe (Kauffman et al. 2003), AGN (at least those with a 1.6μm bump) show D(4000) values comparable to those of galaxies of similar stellar masses. That is, they do not appear to have on average younger stellar populations. On the other hand, AGN show an excess of IR emission at λ>3μm with respect to galaxies of the same mass, which might be interpreted as an excess of current SFR.



Stellar masses vs. the D(4000) index. Stellar masses are from SED fitting as described in Pérez-González et al. (2008).



Specific SFR (=SFR/stellar mass) vs. the D(4000) index. The SFRs are the sum of a UV and an IR SFR (see Pérez-González et al. 2008).



Average SEDs of massive galaxies with and without an AGN. Note the similarity of the rest-frame UV-optical SED, whereas AGN tend to show an excess of IR emission at λ>3μm.

REFERENCES: Alexander, D. M. et al. 2003, AJ, 126, 539 ; Alonso-Herrero, A. et al. 2008, ApJ, 677, 127; Kauffmann, G. et al. 2003, MNRAS, 346, 1055; Pérez-González, P. G. et al. 2008, ApJ, 675, 234; Pérez-González, P. G. et al. 2012, in preparation.