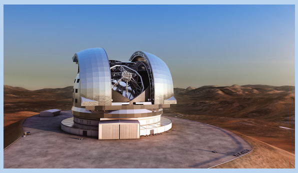
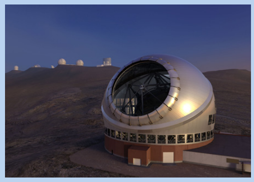
QSO host galaxy and environments in the ELT era

S. Paiano[1], R. Falomo[1], M. Uslenghi[2], C. Arcidiacono[3], D. Fantinel[1], R. Ragazzoni[1]

(1) INAF – Osservatorio Astronomico di Padova, Italy
(2) INAF – Istituto di Astrofisica Spaziale e Fisica Cosmica di Milano, Italy
(3) INAF – Osservatorio Astronomico di Bologna, Italy





INTRODUCTION:

Quasars represent our main lighthouses to explore the high z Universe and to investigate the processes of formation of galaxies and their central supermassive black holes. The discovery of a relationship between the central black hole and the properties of their host galaxies is a fundamental ingredient for a comprehensive interpretation of the structure and evolution of the galaxies. Of particular relevance is the understanding how this relationship evolves over the cosmic time and it can offer important clues for the study of the formation processes of galaxies and their central massive BHs. Another key issue is to explore the immediate environment of the galaxies that host powerful active nuclei to search for signature of interaction and/or merging that is considered a fundamental ingredient for triggering and fueling the nuclear activity (e.g. Heckman et al., 2014).

The characterization of the key parameters as the galaxy mass, size, morphology and their close environments are hindered by the limited resolution and sensitivity of the present instrumentation. The measurement of the properties of the QSO host galaxies is increasingly more challenging at high redshift. This is because the contrast between the bright central nucleus and the starlight from the host galaxy critically depends on the size and shape of the latter compared with that of the point spread function (PSF). Observations from space with HST can indeed provide an excellent narrow PSF but because of the faintness of high z host galaxies these results are usually limited by the small collecting area of the telescope and the limited performances in the near-IR. The future James Webb Space Telescope (JWST) expected to be operative by end of this decade would yield a further significant improvement to these studies because of its large aperture and optimization for NIR frequencies. In spite of that, the resolution of JWST (NIRCam) images is still smaller (pixel size~30 mas) with respect to that of ground based Extreme Large Telescopes (pixel size: 2-4 mas) assisted by adaptive optics module. It is therefore envisaged that only in the ELT era it will be possible to detect and characterize very small and faint features in the host galaxies of distant quasars.

We investigate here the foreseen capabilities of future observations obtained with near-IR Adaptive Optics imaging cameras for ELTs. In particular the case of MCAO observations of distant quasars obtainable by (MICADO+Maory)@EELT is considered and compared with expected images from JWST and current observations AO images at 8-m telescopes.

QSO and host galaxy (z = 1)

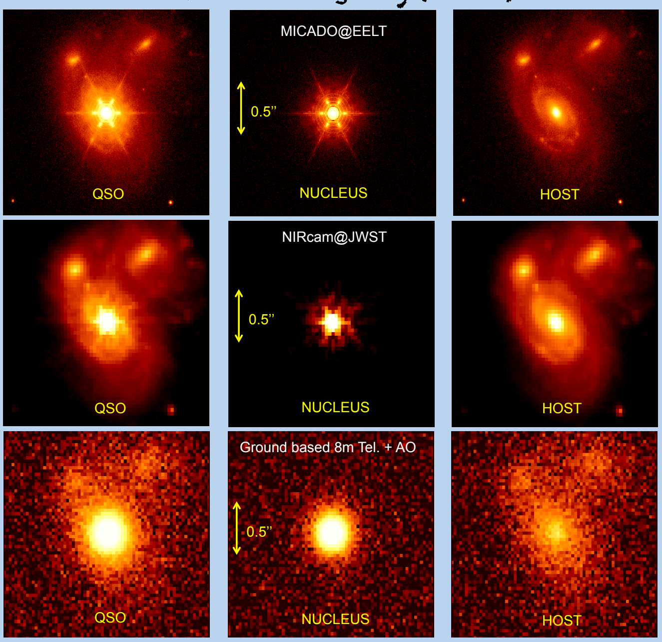


Figure 1: Simulated images (Ks band; 2h exp) of a QSO at z=1 as imaged by MICADO@EELT *(top)* and compared with those expected using NIRcam@JWST *(middle)* and by a ground-based 8m telescope equipped with AO (alike MAD@VLT; *bottom*). The QSO *(left panels)* is composed by a nucleus *(middle panels)* of Ks=18 and a host galaxy *(right panels)* of Ks=19 and size Re=0.3". For the host galaxy the image template of NGC 6050 (the brightest galaxy and its companions) is used.

QSO and host galaxy (z = 3)

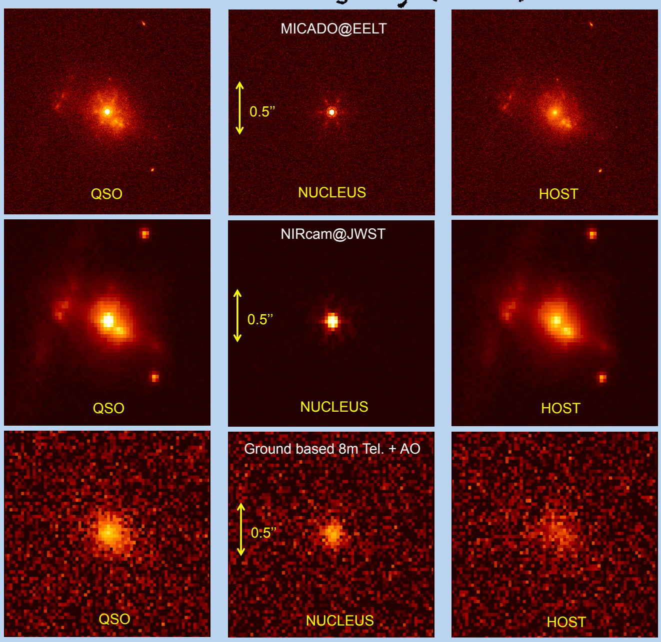


Figure 2: Similar to Fig. 1 but for a QSO at z=3 with 3 hours of exposure time. In this case the nucleus of the QSO is Ks = 21, the host galaxy is Ks = 21 and Re=0.1". For the host galaxy the image template of NGC 1309 was used with in addition two faint companions (Ks=21.5) at a distance of 0.15" and 0.35" from the nucleus.

SIMULATION OF QSO IMAGES

We use a preliminary evaluation of the PSF for the MCAO module of Maory (Arcidiacono et al. 2014) to probe the capabilities of EELT images to detect morphology of host galaxy of QSOs and signature of interactions. Since the final Maory MCAO PSF is not yet available, we use the 2012 release of the PSF in the phase-A study and added the pupil segmentation effects (M1 primary shape). These effects looks important in terms of contrast both in the inner and outer region of the PSF. From the original PSF we retro-engineered the MCAO PSF, subtracting the diffraction pattern and computed a new one for a set of wavelengths in order to fill the Ks filter. The simulations are performed using the Advanced Exposure Time Calculator (AETC) tool (http://aetc.oapd.inaf.it/) with the following parameters: Throughput and sky and environment background as defined by EELT + MICADO + Maory configuration (see AETC). These include sky and environment background, statistical and read out noise, and appropriate convolution of the galaxy models with the PSF. Both statistical and fixed pattern noise are also included.

To simulate the host galaxies of the QSO we consider images of low redshift galaxies secured by HST ACS as template and add a point source for the nucleus. The galaxy template is convolved with the PSF and then scaled to the flux and angular size that is expected for a QSO at a given redshift. We are carrying out several simulations of high redshift QSO in order to evaluate the capabilities of MICADO@EELT to characterize the structural and photometric properties of their host galaxies and of the immediate environments. In Figure 1 and Figure 2 we show two representative examples of a QSO at z = 1 and z = 3.

For comparison we also performed similar simulations as would be obtained by NIRCam on board of JWST using the specifications given in http://jwstetc.stsci.edu/etc/) and by a MCAO system (alike MAD@VLT, Liuzzo et al., 2016) on an 8-m ground telescope for the same targets and same exposure times.

[1] Heckman T. M. and Best P. M., 2014, ARAA, 52, 589H.
[2] Arcidiacono C. , et al, (http://adsabs.harvard.edu/abs/2014SPIE.9148E..6FA)
[3] Liuzzo E., Falomo R., Paiano S., et al., 2016, AJ, 152, 38L.

AO4ELT5: Adaptive Optics for Extremely Large Telescopes, Tenerife, 2017