Quasar host galaxies of GEMS first results: $0.5<z<2.75$

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GEMS and quasars:

Quasars and their host galaxies are likely an important link between the evolution of galaxies and central black holes. As part of the GEMS project we study quasar host galaxies and their morphologies, luminosities, ages and environment up to redshift $z\sim 3$.

GEMS – Galaxy Evolution from Morphologies and SEDs – is a large, two-color (F606W and F850LP) imaging survey with the *HST* ACS. Centered on the Chandra Deep Field South, it covers an area of $\sim 26'\times 26'$, about 120 Hubble Deep Field areas, to a depth of $m_{AB}(\mathrm{F606W}) = 28.3(5\sigma)$ and $m_{AB}(\mathrm{F850LP}) = 27.1(5\sigma)$ (for compact sources). In its central ~1/4, GEMS incorporates ACS imaging from the GOODS project, in total comprising 78 ACS fields. For this area photometric redshifts are available from the COMBO-17 project (Wolf et al., 2001) for $\gtrsim 25\,000$ galaxies and ~130 AGN (full GEMS overview in talk by Hans-Walter Rix).

Using the COMBO-17 classification we defined two quasar samples (Fig. 1) with redshifts $0.5<z<1.1$ and $1.8<z<2.75$ (16 and 22 quasars); both being complete and flux limited samples. In addition, one of the strongpoints of the GEMS project is the availability of comparison samples of inactive galaxies, lacking previous quasar host galaxy studies (see talk by Eric Bell).

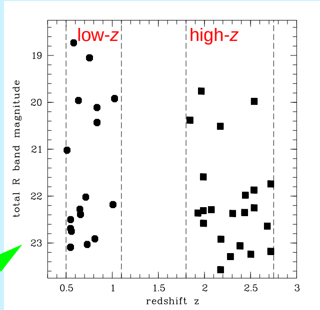
Host galaxy extraction:

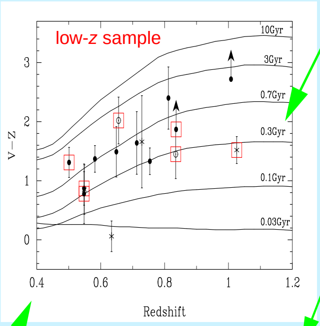
For these two samples we estimate flux, colours, and morphologies of the underlying host galaxies using two independent methods: (i) subtraction of a PSF scaled to the central flux of the quasar, and (ii) two-dimensional modelling using GALFIT (Peng et al., 2002). Peak scaled PSF subtraction is strictly conservative with respect to the host galaxy flux, thus always underestimating it. GALFIT on the other hand yields fluxes somewhat dependent on the host galaxy model used (exponential disk, deVaucouleurs spheroidal, Sérsic profile with shape parameter n free). We corrected for this, and determined the size of error bars, with extensive simulations of ~ 4000 artificial host galaxies and subsequent application of the nucleus removal pipeline.

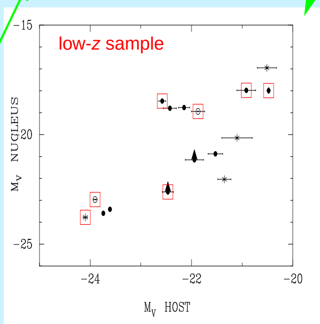
These simulations showed that in the current state of extraction precision we can recover host galaxies with fluxes of 5% (10%) of the total quasar flux with 12% (3%) chance of a spurious detection, judging from the application of the peak scaling to 200 field stars. While we hope to improve this in the near future, we adopted a flux limit of $>5\%$ of the total (before application of corrections from simulations) as our detection criterion.

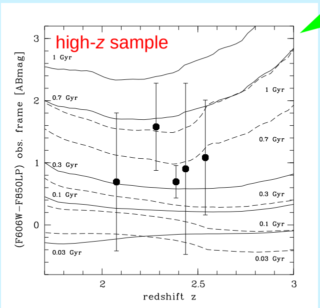
'Low'-z results:

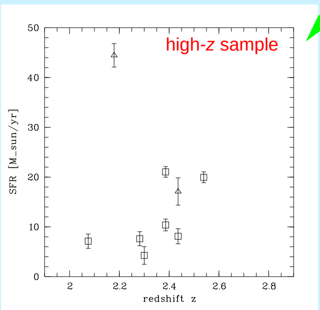
In the low redshift sample 88% (100%) of the hosts are detected in the V (z) band, comprising 60% (30%) of the total flux. In Figure 2 the resulting colours are shown. The symbols mark the morphology of the host galaxies: 2/3 are spheroid-dominated (filled circles), 1/4 disk dominated (stars) and the remaining objects show different morphologies in the two bands. With red squares merging or tidally interacting objects are marked (45%), as judged from visual inspection. The average half-light radius of the host galaxies is $r_{1/2} = 1.9$ kpc, with a spread of 0.8 kpc.











Overplotted in Figure 2 are analytical single star formation burst models by (Bruzual & Charlot, 1996, solar metallicity) with the age given relative to the redshifts. Using this as a rough age indicator the hosts are moderately young, ~0.7 Gyr. While they are not in the state of extreme starburst, they do show significant star formation and not a pure old, evolved population despite 2/3 spheroid dominated hosts.

Using a 0.7 Gyr old SED model for the host galaxy and a power law for the nucleus, we convert the observed z band to absolute rest frame V band magnitudes. The resulting Figure 3 recovers the (cor)relation between nuclear and host galaxy luminosity as described e.g. by McLeod & Rieke (1995), holding also at intermediate redshifts, as was previously found by ground-based observations (Sánchez & González-Serrano, 2003).

High-z results:

The second sample is the by far largest high-z studied up to now. Despite the $(1+z)^{-4}$ surface brightness dimming, 8 of 22 host galaxies are at the moment resolvable in both bands. To allow at least a statistical statement on the 'unresolved' quasar hosts, we coadded the quasar images and are successful in detecting the host galaxy in the much higher S/N coadded V band image. The hosts make up ~40% (~25%) of the total flux in the V (z) band, however with a large spread, and ~6% in the 'average' quasar, respectively (all values after correction). A morphological classification of the hosts is at this moment possible for only one case, showing a spheroidal morphology.

Resulting colours are shown in Figure 4 with again colours of single burst models overplotted, in this case for two model families with different IMF. We find a similar age range as for the lower redshift sample, with no cases of an extremely strong global starburst. This is confirmed by converting the rest-frame UV fluxes observed with the two bands to star formation rates (SFRs) following Kennicutt (1998), lying in the range of $\sim 10\ M_\odot\ \mathrm{year}^{-1}$ (Figure 5: Squares are from the deeper V band. If not available the z band (triangles) is used).

This means what?

These results are consistent with new data from multicolour imaging that suggests star formation and corresponding blue colours for the general population of intermediately luminous quasar hosts, as investigated in this study, independent of apparent morphological type (Jahnke & Wisotzki, 2003; Jahnke et al., 2003). This is in strong support that, for at least one mechanism of AGN fuelling, star formation in the host and nuclear fuelling have a commong cause, i.e. tidal interaction. This does, however, not rule out other fuelling mechanisms at e.g. much lower host galaxy masses.

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