The Quasar Pairs Environment at $z \sim 0.5$

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BH activation into a QSOs phase: mergers between gas-rich galaxies. (e.g. Toomre 1972, Green 2010, Kauffmann 2000, Hopkins 2008)

but also other alternative (e.g. Ciotti & Ostriker 2007).
Galaxy environment around isolated QSOs

*Environment of QSO pairs similar to that of inactive galaxies*

Large samples of QSOs and inactive galaxies at z<0.5 in SDSS Stripe82

Karhunen+2014
Why QSO pairs?

**QSO pairs:** physically associated QSOs

Expected in richer environments

special rare cases

to investigate how and to what extent
the environment deals with the nuclear activity

rich galaxy environments?

(e.g. Djorgoski 2003, Zhdanov & Surdej 2001)
QSO pairs: rare, but not too much

excess of QSO Pairs in sub-Mpc scale

- from mutual galaxy interaction (tens kpc)
  (e.g. Djorgovski 1991, Myers 2008)

- statistical predictable result of overdense group-scale environments (>100 kpc)
  (e.g. Hopkins 2008)
Galaxy environment around QSOPs

The role of the environment on QSO pairs activity

previous works:

<table>
<thead>
<tr>
<th>Study</th>
<th>QSOPs, z~</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boris+2007</td>
<td>4</td>
<td>QSOs, z~1, inconclusive</td>
</tr>
<tr>
<td>Green+2010</td>
<td>1 close (~20 kpc)</td>
<td>QSO in act of merging, role of the environment not clear</td>
</tr>
<tr>
<td>Green+2011</td>
<td>7 close QSOP (&lt;30 kpc), z~1, no evidence of rich environments</td>
<td></td>
</tr>
<tr>
<td>Farina+2011</td>
<td>6 QSOPs (z&lt;0.6)</td>
<td>one case of pair in a moderately rich group</td>
</tr>
<tr>
<td>Sandrinelli+2014</td>
<td>14</td>
<td>QSOPs, z&lt;0.85, on average galaxy over density similar to that of isolated QSOs, But hint of galaxy over density for close QSOPs</td>
</tr>
</tbody>
</table>
Search for QSO physical pairs

- Position-redshift correlation from QSO catalogues
- Estimation of **systemic radial velocity** $V_R$ from $[\text{OIII}]5007$

**low redshift QSO pairs**

![Image of QSO pair with redshift and velocity information](image)
Search for physical QSO pairs

SDSS images/catalogue

Chance superposition or bound systems?

redshift permutation method
(Zhdanov & Surdej 2001)

Low z to detect faint galaxies

20 QSOs at 0.4<z<0.65

\[
\Delta PD < 500 \text{ kpc} \\
\Delta V_R < 800 \text{ km/s}
\]
Spectroscopic probe of QSO pairs

- Optical spectroscopy to properly evaluate difference of systemic velocity ($< 50$ km/s).

GTC – La Palma
Galaxy environment of QSO pairs

SDSS images: *i* filter
objects classified as galaxies in SDSS DR12 catalogue

\[ i < 22 \text{ mag} = 50\% \text{ completeness} \]
\[ M^* < M < M^* + 2 \text{ galaxies} \]

Galaxy overdensity of QSO pairs

Cumulative Galaxy Overdensity vs. Projected Distance [kpc]
Galaxy overdensity of QSOPs

Comparison sample of isolated QSOs from SDSS DR12 QSO cat (Paris+2015) matching in redshift and luminosity with the QSO in pairs
Galaxy overdensity of QSOPs

On average QSO pairs environment is richer than that around isolated QSO of similar redshift and luminosity.
Preliminary Conclusions  *(on going project)*

- Enhanced galaxy environment around QSO pairs with respect to that isolated QSOs

*Evidence for galaxy merging effect? Maybe.*

Further planned study:

- Larger sample of QSO pairs
- Extension to higher redshift
- Spectroscopy of the galaxies
  - ✓ prove physical association
  - ✓ dynamical mass of the system
  - ✓ signature of star formation

Running program at GTC for near-IR MOS spectroscopy