The quest for Dual AGN: The first spectroscopic sample

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Introduction

Supermassive black hole (SMBH) pairs at sub-kpc scales (<0.7″) are expected to form at the centre of galaxies during the hierarchical merging. SMBH pairs can undergo orbital decay via dynamical friction, form a gravitationally bound binary [1] and eventually coalesce with the associated emission of gravitational waves (GWs) [2].

SMBHs at kpc separation have long dynamical timescales, up to a few Gyr, and they may accrete material and be revealed as pairs of luminous AGN separated by a few kpc dubbed **dual AGN**.

Our aim is **classifying** many dual AGN and **studying their properties** to:

1. Test galaxy/SMBH co-evolution models
2. Study the effect of merging on AGN activity
3. Make predictions of the GW event rate and background

Dual AGN Channel

The Novel GMP technique

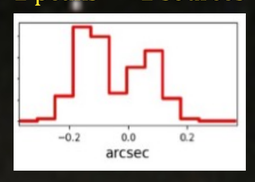
The novel selection technique Gaia Multi-Peak (GMP, [3]) reveals the presence of multiple sources at sub-arcsec separation indicating the fraction of differently oriented transits/scans in which the object appears to have multiple light peaks in the 1D light profiles observed by Gaia.

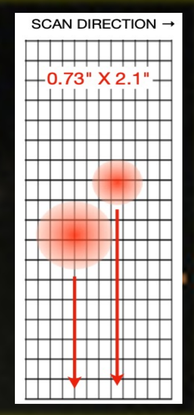
Multiple systems could be:

- Dual AGN
- Gravitationally-lensed systems
- AGN plus a foreground star (30%)

They need high resolution observations to be classified

2 peaks → 2 sources





Unresolved spectroscopy

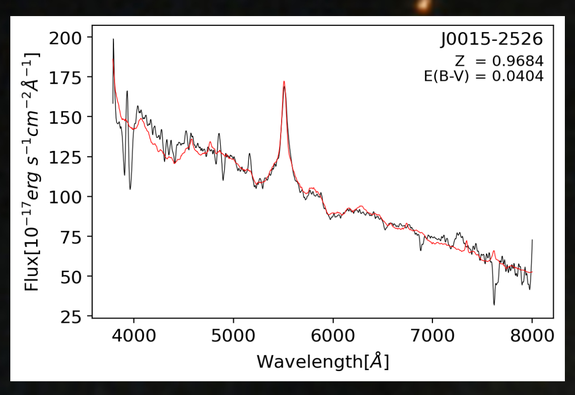
To increase the sample size of multiple AGN candidates with a spectroscopic redshift, we observed 250 GMP photometric targets with EFOSC2 and DOLORES spectographs mounted on NTT and TNG, respectively.
With these spectra we want to:

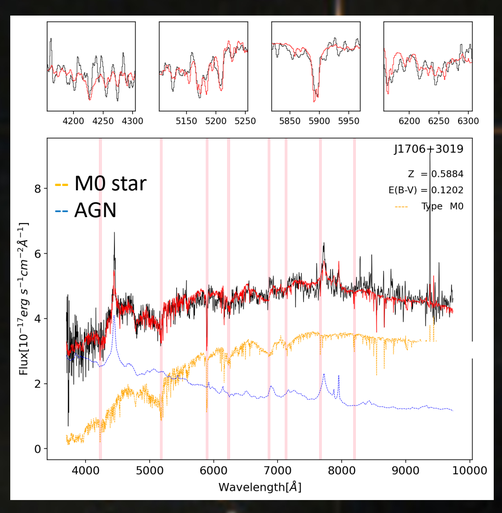
1. Confirm the presence of almost an AGN
2. Determine the redshift
3. Identify AGN plus a foreground (30%)

We developed a procedure which decomposes the total ground-based spectrum into a combination of a quasar and a star [6].
The routine fits the data *(in black)* with a combination of:

- a dust obscured AGN component: parametric SED model [4]
- a stellar component: a combination from the *MaNGA Stellar Library* survey [5] considering only G,K,M spectral types.

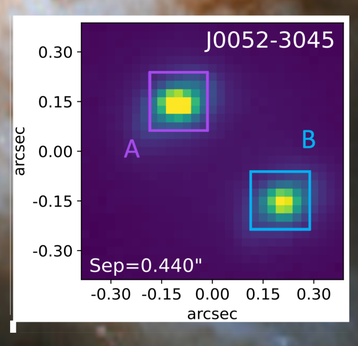
Red line: Best fit based on χ^2



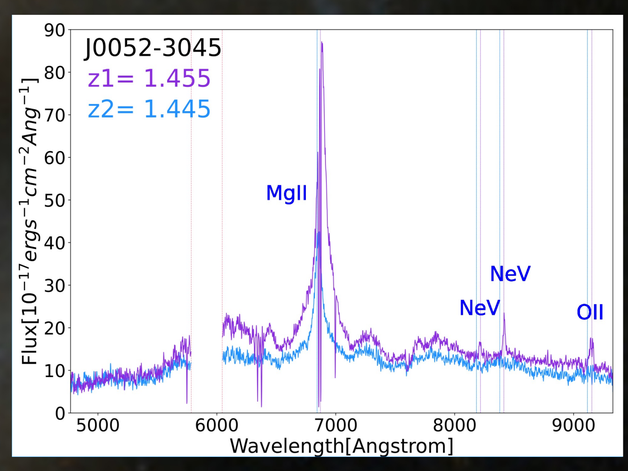


Resolved spectroscopy

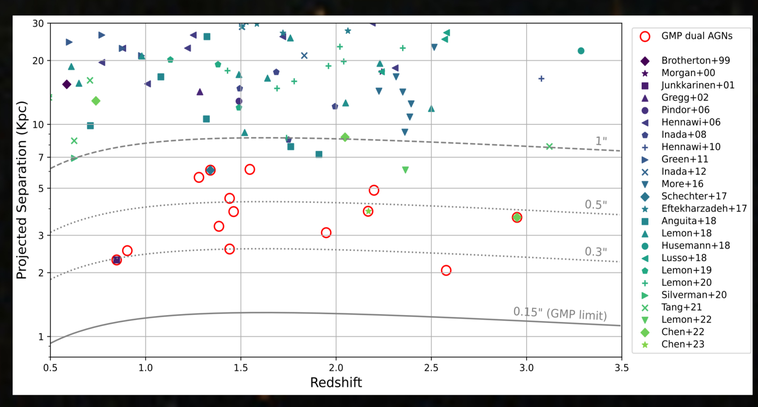
AO-assisted observations of dual candidates with MUSE-NFM on Very Large Telescope (VLT, Chile). The spatially resolved spectra have been extracted from the shown squared apertures of the datacubes



Scialpi+23



Used high spatial resolution spectrographs in the optical and near infrared λ: MUSE/VLT, OSIRIS/KECK, ERIS/VLT, STIS/HST [7].



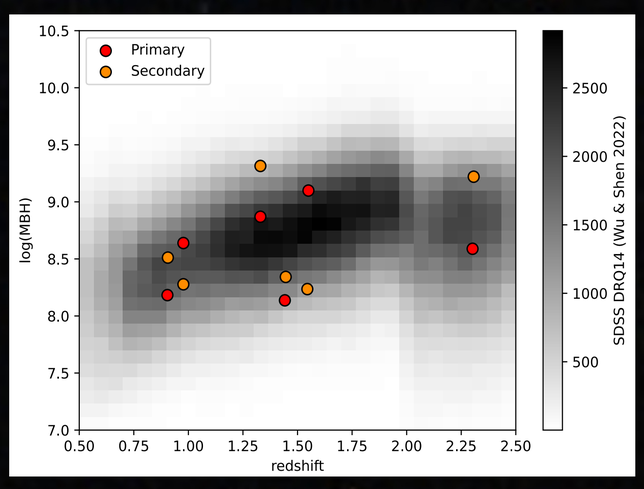
Projected separation vs. redshift of all the spectroscopically confirmed dual AGN with separation below 30 kpc (within the same host galaxy, [7]).

Conclusions and further studies

After dual systems classification , we are now testing many of the predictions of the models of SMBH merging:

- The AGN1 and AGN2 mass function
- The separation distribution
- The Eddington luminosities
- The dual AGN fraction over single AGN

First Result:
Mass distribution *of the two AGN components in function of redshift*



Strong lensed AGN

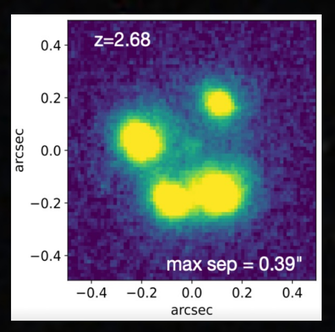
These systems allow us to sample the very inner kpc of the lensing galaxy, where the mass is dominated by the baryonic, stellar component.

Studying the properties of such lenses will provide a robust measurement [8] of the:

- Measure mass within the Einstein radius and the mass-to-light ratio (M/L)
- Estimate the IMF

Most compact quadruply-images QSO ever discovered?

D'Amato+, in prep.



References: [1] Volonteri+22, MNRAS, 514, 640; [2] Colpi, M. 2014, Space Sci. Rev., 183, 189;[3] Mannucci+22, Nature Astronomy, 6, 1185, [4] Temple+21, MNRAS, 508, 737; [5] Yan+19, ApJ, 883, 175; [6] Scialpi+23, arXiv: 2305.11850; [7] Mannucci+23, A&A, 680, A53; [8] Shen+23, ApJ, 943, 38