

Quasar radio polarizations align with large quasar group major axes

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Using quasar polarizations and a sample of large quasar groups drawn from the SDSS DR7, we showed that at HIGH REDSHIFTS ($z \sim 1.5$) the spin axis orientations of black holes are correlated to the major axes of the groups to which they belong. Inside very rich groups the BH spins are aligned with the major axes. When the richness decreases, the spin axes become preferentially perpendicular.

– Motivations –

Recently, Hutsemékers et al. (2014) studied the optical polarization of the quasars belonging to the Huge-LQG and the CCLQG at redshift $z \sim 1.3$ (Clowes et al. 2013). They used the fact that the optical polarization position angle (PPA) and the morphological axis of quasars are correlated to show that the spins of the central black holes of the quasars are preferentially aligned with the most elongated axis of the large quasar group (LQG) to which they appertain.

– This study –

We search for similar correlations between PPA and the position angle of the LQG morphological axes (MPA).

- Einasto et al. (2014) built LQG samples from the SDSS DR7 quasar catalogue in redshift range $1 - 1.8$ using friend-of-friend algorithms. We use the catalogue built with the linking-length of $70 \text{ h}^{-1} \text{ Mpc}$.
- We use the inertia tensors of the LQGs to describe their morphologies and orientations.
- We collect radio polarization for 185 quasars from the JVAS/CLASS 8.4-GHz surveys (Jackson et al. 2007).
- We have 41 pairs of PPA – MPA with confident MPA estimates, i.e. for LQGs with at least 10 members.
- We study the distributions of acute angles between PPA and MPA ($\Delta_{\psi\chi}$).

– Results –

Despite our small data sample we unveil correlations between the PPAs of quasars and the MPAs of the major axes of their host LQGs.

- Inside very rich LQGs having membership $m \geq 20$ the PPAs are preferentially perpendicular ($\Delta_{\psi\chi} > 45^\circ$) to the MPAs with a binomial probability $P_{bin} \leq 1\%$.
- Inside less rich LQGs ($10 \leq m \leq 19$) the PPAs are preferentially parallel to the MPAs with a binomial probability $P_{bin} \leq 1\%$.
- There is a richness dependence of the preferred orientations of the quasar polarizations with respect to the major axis of the LQG to which they appertain. The probability of obtaining this result by chance is $< 0.1\%$.

– Discussion –

As the radio polarization of a quasar is perpendicular to the spin axis of its central super massive black hole (SMBH), our high redshift ($z \sim 1.5$) observations show that the spin axis of a SMBH is either parallel or perpendicular to the major axis of its host LQG, depending on the richness of the latter.

These results confirm the observations obtained for the Huge- and CC-LQG with optical polarization measurements.

No alignment of the SMBH spins with their LSSs – and so of the polarization of quasars – are expected at lower redshifts due to consecutive mergers (Dubois et al. 2014).

The study of quasar polarization reveals to be a promising tool to probe these expected correlation at high redshifts.

– References –

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- Einasto, Tago, Lietzen, et al., 2014, A&A, 568, A46
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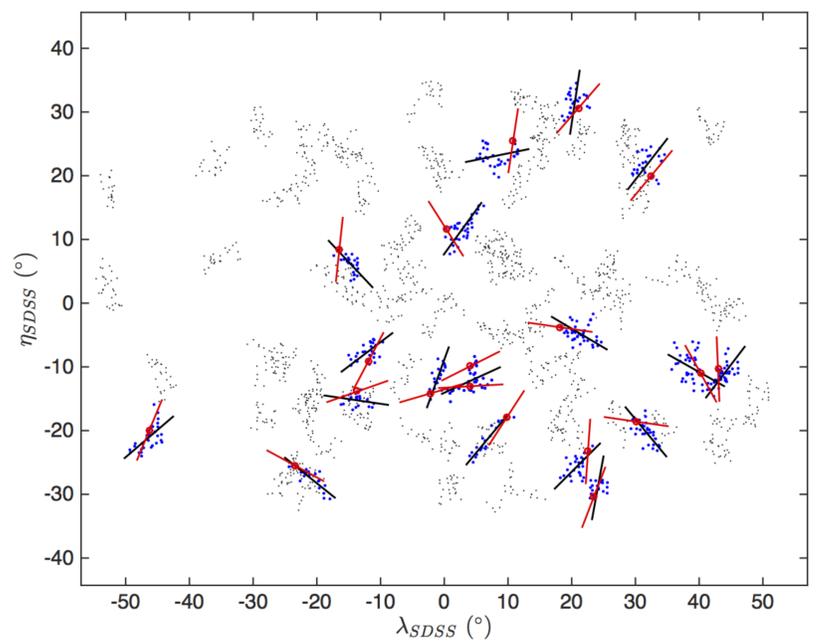


Figure 1. Sky projection of the LQGs (grey dots) having at least 20 members in SDSS coordinates. LQGs are taken from the sample of Einasto et al. (2014) defined with a linking-length of $70 \text{ h}^{-1} \text{ Mpc}$. All quasars have redshift in the range $1.0 - 1.8$. LQGs for which we found radio polarization for at least one member are highlighted in blue. The black lines are the projection of the major axes of the system. The red lines are the spin axes of the quasars (little red circles) inferred from the polarization vectors from JVAS/CLASS 8.4-GHz data. One sees that these lines are preferentially parallel, suggesting that the spin axes of the SMBHs at the centre of the quasars align with the major axes of the LQG to which they belong, leading to preferentially perpendicular radio polarizations as seen from the histogram in Fig. 2 (bottom).

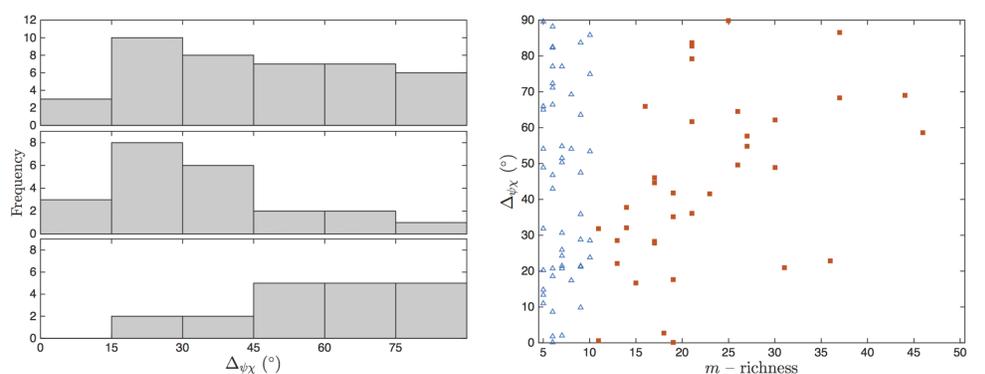


Figure 2. (Left) Histograms of the acute angles $\Delta_{\psi\chi}$ between the polarization position angle (PPA) of a quasar and the major axis position angle (MPA) of the LQG to which it belongs. For the 41 pairs with LQGs having richness $m \geq 10$ (top), for LQGs with $10 \leq m \leq 19$ (middle) and for very rich LQG with $m \geq 20$ (bottom). A two-sample K-S test reveals that the probability that the low and high richness parts of the sample are drawn from the same parent distribution is $5.1 \cdot 10^{-5}$. (Right) Scatter plot of the $\Delta_{\psi\chi}$ versus m . A correlation is observed for $m \geq 11$. The Spearman correlation test gives the probability of 0.08% of obtaining this result by chance. Below $m=10$ the MPAs are not well determined.

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