Red Quasars: the missing link in galaxy evolution?

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Introduction

Active galactic nuclei (AGN) consist of a super massive black hole at the centre of a galaxy, surrounded by an extremely bright disc of matter, outshining the entire galaxy. Further out there is a dusty torus-like structure, and sometimes powerful jets which blow out lots of material, affecting the host galaxy. There are many types of AGN, the brightest of which are quasi-stellar objects, known as quasars. The majority of quasars have blue colours, but there is a small subset that are much redder (called "red quasars"); the most popular idea behind the red colour is dust, which scatters the blue light. The relationship between red and blue quasars has been widely debated: red quasars could represent an inclined blue quasar or could represent an early stage in an important transitional stage for galaxies (Fig. 1). In our group we have found fundamental differences in the radio properties of red quasars, which rules out simple orientation model alone [1,2,3,4,5].

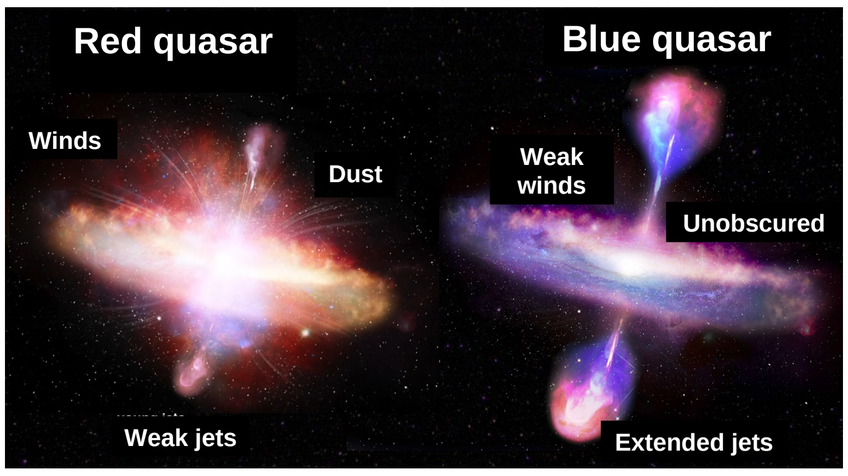

Figure 1: A schematic of potential evolutionary differences between red and blue quasars; a red quasar has more dust, stronger winds and weaker jets [1].

High Resolution Radio Data

To further explore the radio differences in red quasars, I have used high resolution, deeper radio data. Fig. 2 displays the radio images used in the previous study [1] (left), with the same source in higher resolution data [2] (right), resolving much finer details.

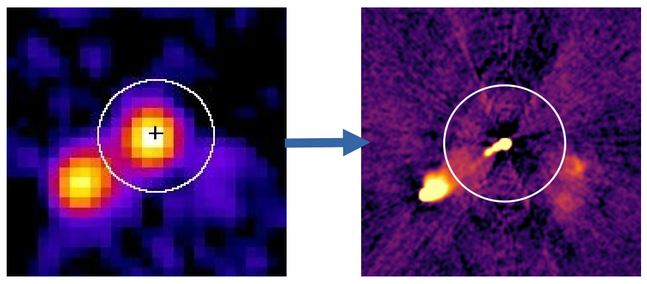

Figure 2: Comparison of radio images used in previous study [1] (left) and high resolution data used in this study [2] (right).

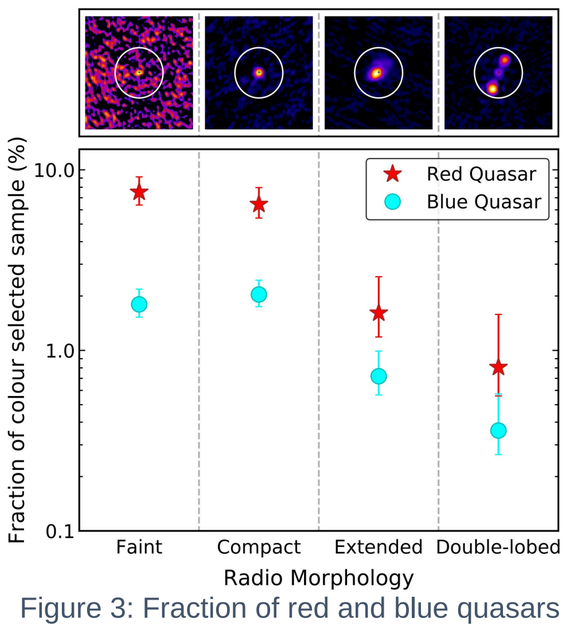

Figure 3: Fraction of red and blue quasars in different morphology groups: red quasars show a preference for faint and compact morphologies [2].

We found that red quasars are ~3 times more likely to be detected in the radio, compared to blue quasars. To explore radio morphologies (structures), we categorise the sources as faint, compact (point-like), extended (shows extended features) and double-lobed: we find that overall red quasars are compact or faint in the radio band (see Fig. 3). We also see tentative evidence for differences in the extended category, which we confirm with even higher resolution data [4].

Spectroscopy

Taking the spectra (light at different wavelengths) of blue quasars, I have investigated whether adding the effects of small amounts of intervening dust can re-create the shape of the spectra of red quasars. From this successful analysis, we demonstrate that dust is the main cause of the red colours in our red quasars (see Fig. 4). From fitting the continuum of the spectra, I find no difference in the black-hole properties between red and blue quasars. This suggests that the differences in the radio properties are not driven by differences in the central engine; wind-driven shocks interacting with a dusty environment is the most probable cause.

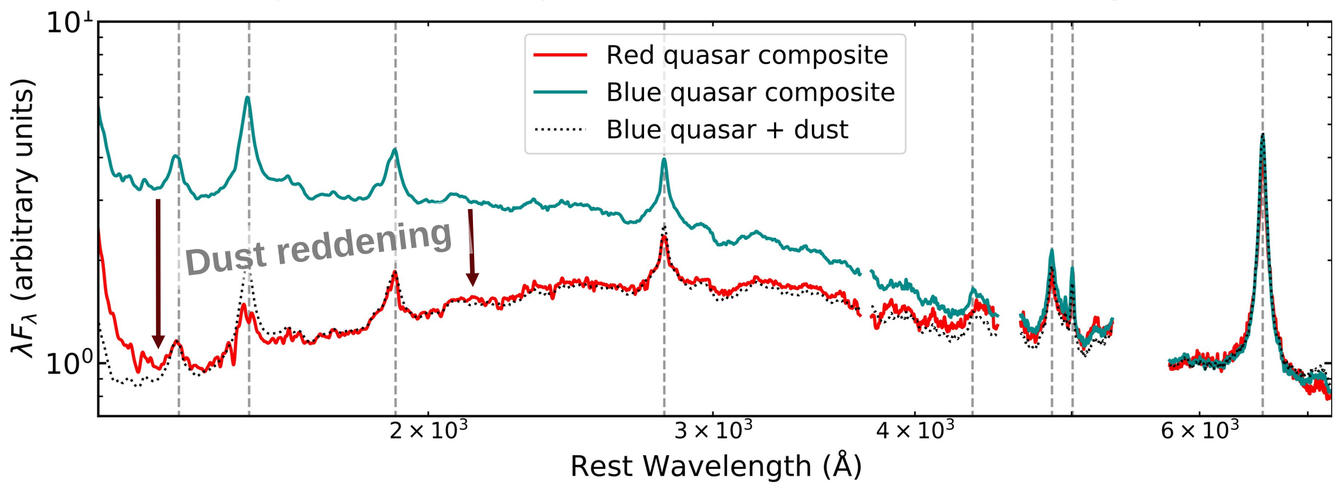

Figure 4: Spectrum of a blue quasar compared to a red quasar; the red spectrum is consistent with dust reddening [6].

Conclusions

We have found that pushing to smaller scales, red quasars show a preference for compact radio structures and the enhanced radio emission in red quasars rules out the orientation model alone. We also prove the red colours are due to dust and find no difference in the black-hole properties. Therefore, the enhanced radio emission in red quasars could be driven by winds interacting with a dusty environment, and so they may represent important phase in galaxy evolution.

References

[1] Klindt et al. 2019, [2] Fawcett et al. 2020,
[3] Rosario et al. 2020, [4] Rosario et al. 2021,
[5] Fawcett et al. 2021, [6] Fawcett et al. (submitted)

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