Prevalence of Radio Emission in LoBALs Showing Disturbed Morphologies in the Optical

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ABSTRACT

We present results from an archival investigation using radio data from the Very Large Array Sky Survey (VLASS) of a volume-limited sample of nearby Low-ionization Broad Absorption Line (LoBAL) quasars. They are interesting because of their blue-shifted broad absorption lines in the UV spectra indicating winds. Either radiation fields or radio jets drive these winds and potentially influence the growth of the galaxy, but the driving cause is still debated. Radio jets might drive these extreme outflows in the case of young radio sources with emerging jets. This sample has been previously analyzed in IR and in the optical using the Hubble Space Telescope (HST) to determine the levels of star formation and morphologies. These objects were thought to be radio quiet or intermediate. The radio-to-optical ratio classifies them as radio quiet or radio loud. We investigate the correlation between the optical and the radio morphologies. We create contour maps from the radio data using SAOImage DS9. We overlay the radio contour maps onto the optical images from the HST and investigate any correlations. Preliminary results show a higher fraction of LoBALS having radio emission than is seen in typical quasars, which merits further investigation.These objects were thought to be radio quiet or intermediate. The radio-to-optical ratio classifies them as radio quiet or radio loud. We investigate the correlation between the optical and the radio morphologies. We create contour maps from the radio data using SAOImage DS9. We overlay the radio contour maps onto the optical images from the HST and investigate any correlations. Preliminary results show a higher fraction of LoBALS having radio emission than is seen in typical quasars, which merits further investigation.

INTRODUCTION AND BACKGROUND

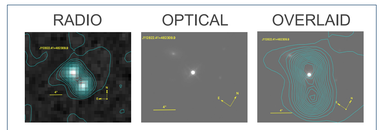
- Low ionization broad absorption line (LoBAL) quasars are a special type of quasar that make up about 15% of the 10% of broad absorption line (BAL) quasars and generate outflows.
- Quasars are quasi-stellar objects that are a type of active galactic nuclei (AGN). These AGN are central regions of galaxies that are more luminous than all the other stars in the host galaxy combined. Massive amounts of excess energy are generated from these regions, and the cause is still debated.
- One theory is that the supermassive black holes in the centers of these galaxies accrete dust and matter; the energy generated from this accretion is then blown out in the form of radiation, jets, and winds.
- These outflows can result in either shooting gas out from the host galaxy so there is no material available to form stars or this gas outflow could actually be the cause of star formation. These LoBALs are windy quasars with winds that can be upwards of 1,000 km/s.
- It is still unknown what drives these winds, but radio jets could drive these outflows in the case of young radio sources.

SAMPLE AND DATA

- This is a sample of 22 Low Ionization Broad Absorption Line (LoBALs) quasars. These quasars all have a redshift of 0.5 < z < 0.6. Redshift is calculated by measuring the location of atomic emission and absorption lines of the object being studied. This cosmological redshift is the result of the expansion of the universe and indicates that these galaxies are moving away from us. As the universe expands, wavelengths are stretched or “red-shifted.” This distance can be measured and can tell us the age of the objects. These quasars are between 5-7 billion light-years away from us.
- The radio data for these 22 quasars comes from the Very Large Array Sky Survey (VLASS) database which uses the Karl G. Jansky Very Large Array, located near Socorro, New Mexico, to collect radio data that covers the entire sky visible from a declination above -40 deg. As of November 2020, the first half of the Epoch 2 survey is completed and Quick Look images for all data are available at https://archive-new.nrao.edu/vlass/quicklook. These Quick Look Images are so named because the survey covers 40 square degrees in just a few seconds when following up on an event detected from the scheduled survey and are useful in detecting transient objects. These Quick Look tiles are 1 x 1 degree images that have limited accuracy due to a relatively simple algorithm used to resolve the images quickly.
- The optical data comes from the Hubble Space Telescope (HST).

The LoBALs listed below all have emission detected in radio as well as optical. Each object is shown with the radio emission detected from VLASS and is contoured to show the gradient of the radio emission from the source. The optical image from HST is also shown, and then the radio contours overlaid onto the image. Each image has a reference bar measured in arcseconds as well as a compass which gives the orientation of the radio respective to the optical.

STRONG



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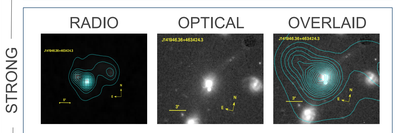

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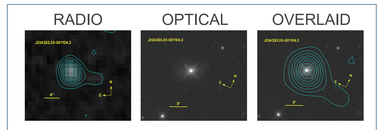

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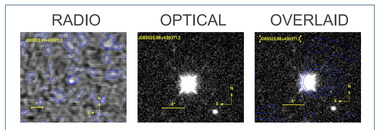
WEAK



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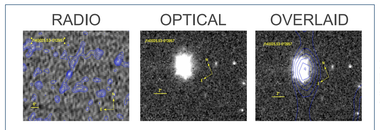

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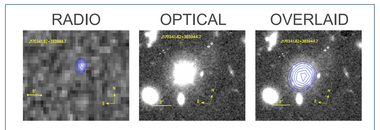

Object J170341.82+383944.7

METHODOLOGY

- VLASS data was downloaded from https://cirada.ca.
- The software used was SAOImageDS9 which is an astronomical imaging and data visualization software.
- The files were downloaded as Flexible Image Transport System (FITS) files.
- The region and analysis features were used to create the contours for the radio data.
- The scale feature was used to adjust the brightness of the optical images.

CONCLUSION

- We find that there are 6/22 of these LoBALs that have either strong or weak radio emission. We expect to see about 10% of these objects as radio loud.; 3/22 or 13.6% have strong radio emission and another 13.6% have a weaker radio emission. Total radio emission found from these 22 LoBALs is 27.2%.
- Further work is needed to assess the morphologies. One of the areas to be addressed in this assessment is that the resolutions on the radio and optical images are vastly different. The resolution on the radio data is ~2.5 arcseconds and the resolution on the optical images is 0.16 arcseconds.
- Another takeaway for future studies is that these objects should be compared to other samples of quasars that have a similar range of radio emission.

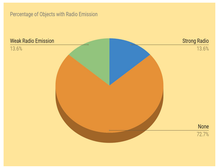

Figure 1. 3/22 (13.6%) of these LoBALs show strong radio emission and 3/22 (13.6%) show weak radio emission. 16/22 (72.7%) show no emission on the source.

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