SPATIALLY RESOLVED SPECTROSCOPY OF EMISSION-LINE GAS IN QSO HOST GALAXIES

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Abstract  We present off-nuclear spectra of 3 radio loud QSO’s, 3C249.1, 3C273 and 3C323.1, taken with the echellette spectrograph and imager (ESI) at Keck observatory. From these spectra we have extracted the spatial profile along the slit of the [OIII], $\lambda = 5007$ line. Fitted Gaussian distributions to each of these profiles show emission-line gas out to several tens of kiloparsecs from the galaxy nucleus. Most observations show several gas components at distinct velocities and velocity dispersions, much of which is above the escape velocity for any resonable mass galaxy. In addition, we show slitless spectroscopy images for one other object, 3C48. From the slitless spectroscopy images we can extract 2-dimensional spatial as well as velocity information on the emission line gas.

1. Spatially resolved Off-Nuclear spectroscopy

We have taken off-nuclear spectra of 3 radio loud QSO’s, 3C249.1, 3C273 and 3C323.1 (Boroson and Oke 1984), using the Echellette spectrograph and imager (ESI) (Sheinis et. al 2000) at Keck observatory. Each object was observed at several different position angles and offsets from the nucleus. From these spectra we have extracted the spatial profile along the slit of the [OIII], $\lambda = 5007$ line.

Each image is the median of four 15 minute exposures. The data were processed using the Information Data Language (IDL). They were first rectified to remove the instrument distortion, bias subtracted then a two dimensional sky model was subtracted. After this extraction we fit a linear combination of two Gaussian distributions to each of these profiles, using (IDL).
Figure 1 shows the two-dimensional extraction image for each object. For 3C249.1, three slit position are shown, 3 seconds east, 3.5 seconds north and 3 seconds west are shown. One position is shown for each of the remaining objects, 3C273 and 3C323.1. Those positions are 4 seconds east and 3 seconds east. The lower panels of figure 1 show the results of the Gaussian fit for each object, namely the mean, dispersion and magnitude of the Gaussian fit for each gas component.

The plots show bright extended emission at tens of kiloparsecs from the galaxy nucleus. This emission is observed to have peak velocity FWHM = 2.35 x σ of 540, 940 and 535 km/sec for the three slit positions of 3C249.1, 500 km/sec for 3C273 and 470 km/sec for 3C323.1. These velocities are most likely well beyond escape velocity for these galaxies.

![Figure 1. 3C249.1, 3C273 and 3C323.1 seen in [OIII], spatially resolved.](image)

2. Slitless Spectroscopy

We have obtained slitless spectroscopy images of several objects. The four panels of figure 2 show ten minute exposures of one well-studied object, 3C48 (Canalizo 2000) taken at four different position angles, through a six arcsecond wide slit. They have been processed identi-
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cally to the above images. Additionally, a modelled QSO continuum was carefully subtracted to reveal details within a half arcsecond of the nucleus.

In order to deconvolve the velocity and spatial information in the y axis of each image, we have produced pairs of images that have the dispersion axis rotated relative each other, by 180 degrees. In objects (like 3C48) that contain well defined clumps of gas moving at a definite velocity, position and velocity can be inferred directly by comparing the two images. In objects with a more complex spatial and velocity structure this method becomes less effective.

![Figure 2. Slitless spectroscopy of 3C48, seen in [OIII].](image)

Figure 2 shows the emission-line gas of 3C48 as viewed through a 6 arcsecond wide by 20 arcsecond long slit. The two images show two different position angles separated by 180 degrees. In first pair of images of 3C48 (upper and lower left) we see one bright gas knot (X) redshifted by ≈ 200 km/sec relative to four smaller knots (A-D) that appear to be at similar velocities. All 5 knots are located to the north of the nucleus. Closer to the nucleus we see one higher dispersion (≈ 600 km/sec), higher velocity knot (≈ 500 km/sec) (E) to the north and another (F) to the south. A similar evaluation can be done to the rightmost pair of images.
This method has shown promise to produce spatial and velocity information in emission-line gas.

References

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