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Cospatial Line Emission and Accelerated Outflow in the Spatially Resolved Narrow-Line Region of NGC 4151: Confirming Model Predictions

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Abstract. We present results of high S/N, high spatial and spectral resolution (0″.65 and 0.8 Å FWHM, respectively) spectrophotometry of the NLR of NGC 4151 using the Keck 10-m Telescope. The observations are the first in a series that test unambiguously several specific predictions that are based on earlier modeling of spatially unresolved emission-line spectra. Importantly, we partially resolve the source of most of the emission-line flux. Thus, the observations suitably complement analyses of spatially unresolved NLR spectra.

1. Background

We have recently completed an observational study and analysis of the emission-line spectra of Seyfert 1 galaxies (Moore, Cohen, & Marcy 1996). We obtained high S/N in order to extract high-quality [Fe VIII] λ6087 and [Fe X] λ6374 profiles. We have also completed comprehensive modeling of the spectra (Moore & Cohen 1996). The models include collimated emission, radially dependent rotation and turbulence, explicit photoionization calculations, and realistic treatments of both internal and external obscuration. They allow for gradients in the electron density (n_e), column density (N_{col}), ionization parameter (Γ), and a radial-velocity distribution of line-emitting clouds throughout the NLR. More importantly, the models have yielded several testable predictions for experiments that can spatially resolve the source of most of the NLR emission-line flux (Moore & Cohen 1994, 1996).

2. Results

For NGC 4151, the following predictions are confirmed:

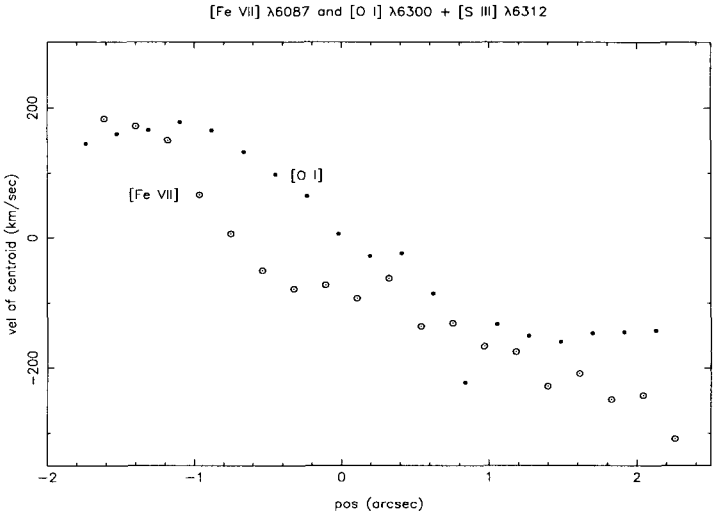

Figure 1. The centroid of the [O I] and [Fe VII] emission-line profiles versus angular displacement from the continuum emission.

1. The [Fe VII] λ6087 and [O I] λ6300 emission-line fluxes have comparable angular extents on the sub-arcsecond angular scale that partially resolves the source of most of the line emission.

2. Emission in the high-velocity wings of the [S II] λλ6716, 6731 profiles coincides spatially with that in the high-velocity wings of the [Fe VII] and [O I] profiles.

3. On the sub-arcsecond scale, the profiles of all three lines show a velocity shift relative to the systemic velocity that increases systematically with angular displacement from the nucleus.

Again, the velocity of the [Fe VII] and [O I]-emitting gas both increase outward (see Fig. 1). The velocity dependence on distance from the nucleus is very similar for both species as well. Our explaination for cospatial line emission is a near-uniform high ionization parameter and clouds that are individually stratified in ionization (see Moore & Cohen 1994). Other objects, in which line width correlates with ionization potential, are explained by a column density that is lower by a factor of only order unity.

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References

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