Refining emission line fitting in NGC 4552 for black hole mass determination

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Abstract

The elliptical galaxy NGC 4552 is about 15.6 Mpc away and show signs of nuclear activity. A supermassive black hole (BH) is surely present, but a secure BH mass is not yet published for this galaxy. A dataset from Space Telescope Imaging Spectrograph (STIS) shows promise for providing a BH mass using the gas kinematics method. Here we report on the emission line fitting which is a prerequisite for the gas kinematical modelling. We fit gaussians to the lines using chi-squared minimization. For some of the spectral extractions the fitting is problematic because of either noise, non-gaussian line profiles, or a strong blending of narrow lines with broad lines from the active nucleus. We present our final rotation curves which look consistent with a disk of excited gas rotating about a central dark mass.

Properties of NGC 4552

- Distance: 15.6 Mpc  
- Scale: 75.5 pc/arcsec  
- \( r_0 = 250 \pm 5 \) km/s  
- AGN Sp. Type: Sy 2  
- BH Mass: 4.3 \( \times \) 10^7 M_\odot  
- Galaxy Type: E0?  
- \( R_0 = 27^" \)  
- M_\text{BH} (from M_\text{BH} \pm r_0) = 3.4 \times 10^7 \text{M}_\odot  
- Using Gultekin et al. (2009)

Results

Figure 2-a: 2-D Spectrum for 0.1" slit  
Figure 3-a: 2-D Spectrum for 0.2" slit  
Figure 4-a: Spectral Extractions for 0.1" slit  
Figure 4-b: Spectral Extractions for 0.2" slit  
Figure 5-a: Line Fitting for 0.1" slit  
Figure 5-b: Line Fitting for 0.2" slit  
Figure 6-a: Kinematics Profiles for 0.1" slit  
Figure 6-b: Kinematics Profiles for 0.2" slit

\* We have run over 30 automated fits to each extracted spectrum by varying wavelength ranges, number of lines fit (sometimes [SII] included), fitting h0 (symmetric deviations from a Gaussian), first guesses for parameters, the fractional tolerance and parameter "deltas" for the amoeba algorithm. We also tried "manual" fitting of parameters.

- The central bins of the 0.1" slit show a strong, broad-line component (BLR). Our 4-line fits of the H\alpha+[NII] emission lines shows that the broad-line is fairly well fit by a Gaussian as well as the 3 narrow lines.

- Our chi-squared minimization algorithm (amoeba from Numerical Recipes) requires careful guidance to provide good fits, especially to the 0.1" slit. This means finding sensible parameters manually (i.e., trial and error) and using these as the starting point in the parameter search.

- Many fits to H\alpha+[NII] lines for the 0.2" slit give widths (\sigma) which appear too large (see Fig. 5-b). These were robust to different fitting approaches. We produced a fit of "manual" fits by eye as an alternative.

- Despite the irregular morphology of the disk in NGC 4552, the velocity profiles are consistent with a rotating gas disk (see preliminary model in Fig. 8). This has been seen in other galaxies like M87 (NGC 4486), M84 (NGC 4374), and M109 (NGC 3379).

- Future Work: So far our best fit \( M_\text{BH} = 3.2 \times 10^7 \text{M}_\odot \) however more work needs to be done searching parameter space. Our preliminary models demonstrate that the data are consistent with a rotating gas disk which is rotated about 15° relative to slit.

References


Press et al. 1999, “Numerical Recipes in Fortran 77 2nd Ed.”

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Figure 7: Geometry of a model gas disk (orange) and 0.1" STIS slit (inner rectangle). This is a general case in which the disk is rotated and translated relative to the slit. (Optimum sa, y, and z have not yet been determined for NGC 4552.)

Figure 8: Model kinematics (x's) compared to the data (circles) for 0.1" and 0.2" slits. This model used \( M_\text{BH} = 3.2 \times 10^7 \text{M}_\odot \), slit angle = −15° and inclination=45°.