PHY340 Data Analysis Feedback:

Group A03 doing Problem A1

# Data Analysis

The data analysis is broadly valid, but there are some basic problems. The “fit” shown in figure 1 is clearly not a good fit at all: this line profile is not a simple Gaussian. Either you have a blend of several lines at similar wavelengths, or you have contributions from different parts of the AGN with different widths and different central values, e.g. because of outflows. The former seems more likely, but in any case it’s clear that fitting a single Gaussian will not properly re­pro­duce the FWHM of any of the individual components. There is no discussion of this in the text—it seems that this clearly unsatisfactory fit was simply accepted without question. I believe that DIPSO can fit blended lines: there appear to be three present in the line profile shown.

There also appears to be some confusion about line identification. The statement that “the time delays used here, and therefore also the calculated radii, do not correspond to the spectral lines found previously in the literature search” makes no sense: in NGC 5548 (*z* = 0.01627), the lines in table 1 correspond to Ly α, possibly Si IV, C IV, C III], Hβ, the [O III] doublet, and Hα. Of these, Hα and Hβ occur in your table of lag times, and lag times for Ly α, Si IV and C IV are given in De Rosa et al., *ApJ* **806** (2015) 128. One should not use forbidden lines, since they do not come from the BLR, so in fact every line in table 1 has a measured lag time. I see no reason to doubt that the same is true for the other AGN; certainly in the spectra I looked at (the ascii ones, since I don’t have a FITS reader on my laptop) Ly α, C IV, Hα and Hβ seemed generally identifiable. Using identified lines is clearly preferable to averaging the lag times, since the lags of different lines are not always consistent (in NGC 5548, Hα and Hβ appear to have consistent lag times, but they are significantly different from He I and He II, and very different from Ly α, Si IV and
C IV, which De Rosa et al. give as , and days respectively (measured in the source rest frame). Therefore, applying a mean lag time to all the observed lines will seri­ously distort the results. The argument for using the Si IV + O IV λ1400 blend as your “stan­dard” line is weak (as, in most cases, is the line…): since you are averaging different sets of lines in each case, there is *no* reason to believe that it will always be the best estimate.

Even given the poor fitting technique, some of the errors quoted are extraordinarily large, and some of the values obtained do not seem to match the data. The FWHM of Fairall 9 is quoted in table 3 as 5.9±3.7 Å (rounded to a reasonable number of sig­ni­ficant figures, which you did not), but the data from the first datafile do not seem consistent with either the central value or an uncertainty of >60%—or, for that matter, a line centre of 1263.9±1.6 Å. There is something seriously wrong here. Similarly, though I personally would not touch the Mg II λ2796 line in Akn 564 with a ten-foot pole—it’s got a dip in the middle, so I don’t know if it’s one line or two blended—it clearly does not have a peak at 2860.7±1.1 Å or a FWHM of 3.3±2.7 Å, see figure 2. Did nobody actually *look* at the line profiles?

*Figure 1: the Ly α line of Fairall 9, from file swp50671. By eye, the central value is approximately 1274 Å (corresponding to rest-frame 1217 Å, in good agreement with Ly α at 1216) and the FWHM is approximately 12 Å. It is difficult to see how the width could be reported as 5.9±3.7, and impossible to reconcile the centre with 1264 Å.*

 *Figure 2: Mg II line profile for Akn 564, from file a516745r.*

Because of these questionable line widths, some of the derived black hole masses are clearly not correct. A black hole with a mass of 4500 *M*⊙, which you quote for Akn 564, could not *possibly* power even a comparatively low-luminosity AGN: it is wrong by several orders of magnitude (Bian and Zhao (2003) quote 2.9×106 *M*⊙). I note that your error on this value is greater than the value itself, which is unphysical—a negative black hole mass makes no sense. This is pro­bably caused by using the standard formulae for propagating errors, which are not valid when the error is not small compared to the central value. But the main point is that *you should recognise when your results cannot be right.*

As regards the actual *M*BH–*M*bulge relation, once again—as in the literature search—you appear to be unable to copy an equation correctly. Kormendy and Ho (2013) quote two equations:
(their equations 10 and 11, converted to logarithmic form). They most certainly do *not* quote an expression for , because they are sensible people and this makes no sense (the bulge mass is greater than the BH mass already, so multiplying it by 109 would be a stupid thing to do; instead, as in their equation 11, we multiply the *black hole* mass by an appropriate factor—which is not, however, 109).

The second equation, which is the equation you use apart from a minor factor of 1011, has a gradient which is not very different from zero: a zero gradient would be equivalent to stating that the black hole mass is a fixed fraction of the bulge mass. This is the equation you should be comparing with yours. Although your result appears to be inconsistent with Kormendy and Ho, it is being badly pulled by the silly black hole mass you adopt for Akn 564. Removing this, and the almost equally silly mass adopted for NGC 4151, gives a gradient of in an unweighted fit, which is not insanely distant from (the difference is , which has an 11% probability of occurring by chance if the true value is zero). The intercept as defined by Kormendy and Ho is , which is consistent with their (to compare with your intercept, subtract 11 from these numbers).

Average grade for this section: 25.75/50.

# Data Presentation

The figures and tables are properly numbered, and have captions—though in many cases the captions could usefully present more information (if you look at captions in published papers, you will see that yours are much too short). The axis labels in figure 1 are too small to read, and figure 3 should have error bars (without these, the comparison between your values and those of Mathur et al. (2001) is completely meaningless) but the other figures are OK. Most of the problems arise in the tables. First, uncertainties should be quoted *with the corresponding central value*, not as a separate column, and should be rounded to the appropriate number of significant figures: thus, for example, the first line of table 1 should read 1237.66±0.10 for the line centre and 4.30±0.32 for the FWHM (a value I don’t actually believe, but the line structure between 1210 and 1250 Å in NGC 5548 is a horrible mess with at least 3 peaks). There is no justification for more than two significant figures in the uncertainty, and the central value must match the precision of the uncertainty.

In tabulating results from the literature, it is good practice to cite the references directly in the table (usually as a separate column) rather than simply saying that the sources are in the reference list. Also, I cannot reconcile some of the values in table 2 with the sources: for NGC 5041 Peterson et al (2000) quote days for Hβ and for He II, which do not agree at all with your values, while for NGC 7469 Collier et al. (1998) quotes values for Hβ and Hα, *with* uncertainties (5.4±0.8 and 5.6±1.3 for the centroid of the cross-correlation function), so the UV line lag times reported in table 2 come from somewhere else. Although the bulge masses were given in your literature search, this table and its sources should have been repeated here, since they are necessary to understand the results and you should not assume that the reader automatically has access to your earlier report.

The statement that “peaks that were obviously merged and indistinguishable were not used in the analysis” before table 3 does not seem to be consistent with your figure 1, which shows a clearly blended line (Hα plus two [N II] lines, one on either side, I think): if this line was not used, why is it shown as an example of line fitting? Certainly, some of the lines given in table 3 are not simple Gaussians, as seen for example in figure 1 and figure 2 above. Many values in table 3 are quoted to absurd numbers of significant figures (8!!): you should certainly know better than this.

*Figure 3: Line profiles for NGC 3783: top left, Hα; top right, Hβ; bottom left, C IV.*

I do not understand the statement that “there was only one measurable feature in the spectra for NGC 3783”: in the first optical data file n38593d there are perfectly clean Hα and Hβ lines, and in the first UV file swp43438ca a clean C IV line, as shown in figure 3 above. By eye, these have FWHM values of about 58, 50 and 15 Å respectively, giving Doppler speeds of 2623, 3050 and 2879 km/s respectively. Onken and Peterson (*ApJ* **572** (2002) 746) give lag times of days for Hβ and days for C IV, giving a black hole mass of 1.9×107 *M*⊙ for Hβ and 6.1×106 *M*⊙ for C IV (I haven’t calculated the errors, given that the FWHM values are estimates). The Georgia State University AGN black hole mass database[[1]](#footnote-1) gives , so the Hβ value at least is in the right range.

It is good practice to compare your results with the literature, but how you did this and *still* did not notice that you are not plotting the correct quantity is beyond my comprehension. You do not appear to have realised that a discrepancy of 12 in the intercept of a logarithmic plot repre­sents *a factor of 1012*—obviously this is not just a neglected systematic error, it’s simply *wrong*. Also, the statement that “using the value without an error was unavoidable for … the time delays for Mrk 509, NGC 3783 and NGC 7469” is completely unjustifiable: Carone et al. (1996) state that “the Gaskell-Peterson formula yields estimates of the uncertainties in the lags of ~7 days,” Reichert et al. (1994) say “we expect that the uncertainties in Δ*t*(peak) are probably of order ±2 days, while those in Δ*t*(center) are likely to be of order 2-3 days for the stronger features (Ly α, C IV) and 3-4 days for the weaker ones (He II + O III], Mg II, Si III] + C III])” and as stated above Collier et al. (1998) are not the source of your quoted UV lags, but do give lags for Hα and Hβ with uncertainties. Wandel (2002) says that he assumes a factor of 2 uncertainty in bulge luminosities, from which it is easy to calculate the corresponding uncertainty in the bulge mass, so there is no problem there either. In short, *all* of the quantities that you claim have no errors in the literature do in fact have such errors: they’re just discussed in the text instead of being listed in the tables. It appears that you did not read your sources very carefully.

Average grade for this section: 16.25/30.

# Style

The style of the report is generally OK, although the use of the American “fit” for “fitted” is jar­ring, and the tone is a bit self-pitying, especially when the complaints are nearly always unjusti­fied, as discussed above. There are some minor typographical issues: function names such as “log” should not be italicised (the Word equation editor de-italicises them automatically, so I don’t know how you managed to get this wrong), and symbols defined in the test should be typeset as they are in the equations (so if *G* is italic in the equation, it should be italic in the definition: this is because a different font *means a different quantity*—for example, momentum **p** is a vector, whereas *p* is its magnitude). There were one or two odd phrases (“mean average”—as opposed to a generous average? If you mean “arithmetic mean”, *say* “arithmetic mean”—and explain why you aren’t using a weighted mean, which would be the obvious choice given the significantly different uncertainties of the values in question), and a couple of references were missing—for example, the statement that “emission lines do not vary much with time” needs a reference (especially as it’s *wrong*—the *widths* of the lines don’t vary much, but their intensities most defi­nitely do). However, overall the style was not really a problem: the issues were with the content.

Average grade for this section: 12.8/20.

Overall average grade: 54.8%.

1. [www.astro.gsu.edu/AGNmass](http://www.astro.gsu.edu/AGNmass) [↑](#footnote-ref-1)