Computational Astrophysics
2019
Exercises 08. Root Finding

Curve Fitting: The $M_{\rm BH} - \sigma_*$ Relation

The code `solution8ab.py` implements the routine to read the data files using the `astropy` command `ascii`. The data is stored in numpy arrays. We also implemented a function to perform the linear fit in the form

$$\log\left(\frac{M_{BH}}{M_\odot}\right) = \alpha + \beta \log\left(\frac{\sigma_*}{\sigma_0}\right) \tag{1}$$

with the equations presented in class, including data uncertainties. The reference value in the dispersion velocity is $\sigma_0 = 200$ km s^{-1}. The linear fit function returns the coefficients α and β together with the corresponding uncertainties σ_α and σ_β.

For the given data, without errors, the $M_{\rm BH} - \sigma_*$ relation is given by the linear fit with parameters

$$\alpha = 7.663 \pm 0.183 \tag{2}$$
$$\beta = 2.925 \pm 0.547, \tag{3}$$

which can be seen in Figure 1.

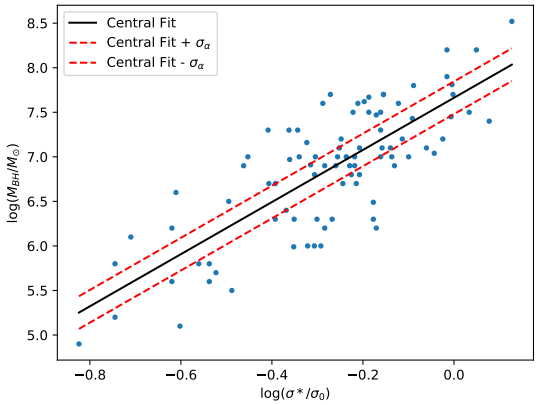

Figure 1: Linear fit without data errors.

In `solution8c1.py` we include the error data for the black hole mass. Te resulting linear fit has the parameter

$$\alpha = 7.779 \pm 0.015 \tag{4}$$
$$\beta = 3.232 \pm 0.061, \tag{5}$$

and the corresponding plot is given in Figure 2.

Finally, including data errors in both variables, the linear fit has the parameters

$$\alpha = 7.680 \pm 1.462 \tag{6}$$
$$\beta = 2.912 \pm 4.917, \tag{7}$$

and the corresponding plot is given in Figure 3.

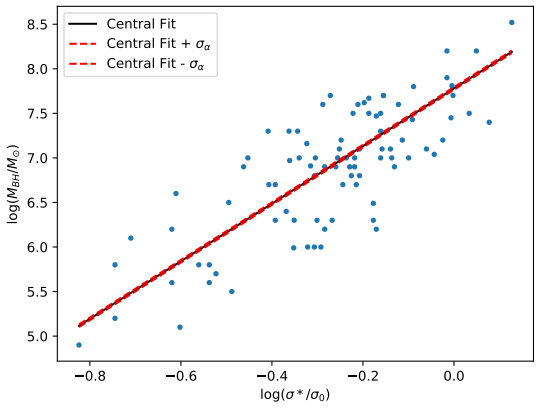

Figure 2: Linear fit with data error in $\log(M_{BH}/M_\odot)$.

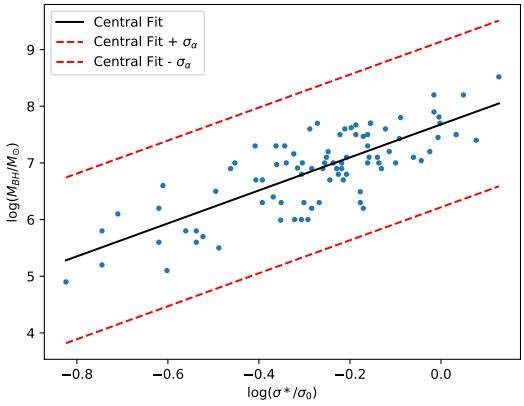

Figure 3: Linear fit with data errors in $\log(M_{BH}/M_\odot)$ and σ_*.