Notes for Brandon C. Kelly et al. "QUASAR BLACK HOLE MASS ESTIMATES IN THE ERA OF TIME DOMAIN ASTRONOMY"

Malte Brinch
University of Copenhagen
October 2019

1. Introduction

AGN x-ray PSD slopes are tpically well modelled by a bending power law form $P(f) \propto 1/f^{\alpha}$ with α 1 down to a high frequency break where α 2 instead.

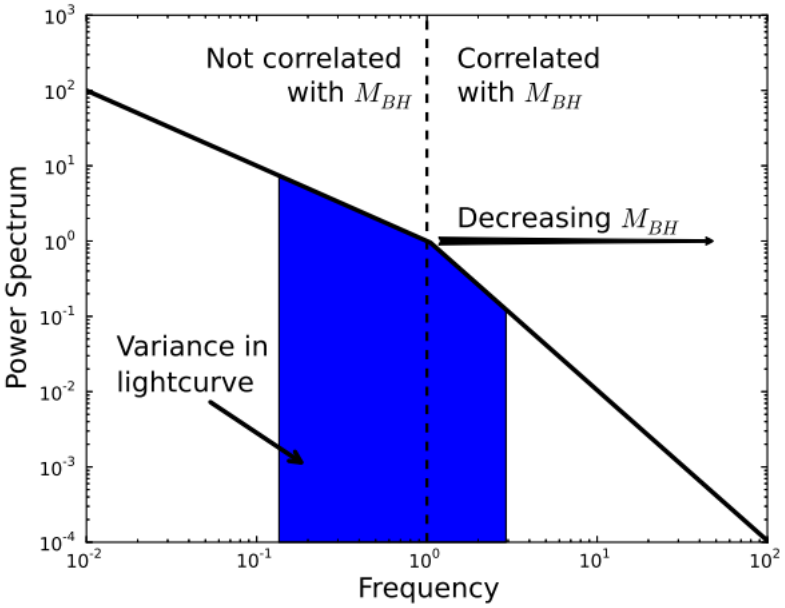

Fig. 1.— Illustration of how the variance in a lightcurve relates to the PSD features, neglecting the window function caused by sampling a continuous time process; note that the units are arbitrary. Both the break frequency and the PSD amplitude above the break depend on M_{BH}. The variance of a lightcurve is given by the integral of the PSD over the frequencies corresponding to the time scales probed by the lightcurve. When the lightcurve is probing time scales corresponding to frequencies above the break, then the variance is correlated with M_{BH}. However, when the lightcurve is probing time scales below the break, the correlation with M_{BH} weakens. Because the break frequency is in general unknown, this can cause problems when using the lightcurve variance as a M_{BH} estimator. In this work we describe a statistical technique to always measure the PSD amplitude above the break frequency, which can then be used to estimate M_{BH}.

The article applies the OU process to time series with counts data with three paramters: the characteristic frequency, $\omega_0 = 1/\tau_0$ where τ_0 is the relaxation time where break in the PSD is (variations become uncorrelated), the stationary mean μ, and the amplitude of driving noise, ζ. ζ controls the shorts timescale variability. It is assumed that the OU process is Gaussian (Gaussian white noise) and stationary (probability distribution does not vary in time). It is possible to have a superposition of OU processes to model multiple breaks in the PSD. This process can also have negative values, so it is a good idea to work with the logarithm.

Turns out this is mostly about BH mass scaling relationships, so not very useful for us.