Notes for Shintaro Koshida et al. "REVERBERATION MEASUREMENTS OF THE INNER RADIUS OF THE DUST TORUS IN 17 SEYFERT GALAXIES"

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1. Introduction

The near-infrared continuum emission of type-1 AGNs is considered to be dominated by the thermal re-radiation of hot dust driven by the reprocessing of the ultraviolet (UV)–optical continuum emission from the accretion disk. The apparent size of the dust torus is so compact, it has been almost impossible to resolve and examine the detailed structure of the dust torus directly by imaging observation.

Lag times of weeks to months corresponding to 0.01–0.1 pc for the inner dust torus were obtained for several Seyfert galaxies from optical and near-infrared monitoring observations, in which a strong correlation between lag time and optical luminosity was found to be consistent with $\Delta t_{dust} \propto L^{0.5}$.

The equation for the dust sublimation temperature is

$$R_{sub} = 1.3(\frac{L_{UV}}{10^{46} erg/s})^{0.5}(\frac{T_{sub}}{1500K})^{-2.8}(\frac{a}{0.05\mu m})pc$$

where L_{UV}, T_{sub}, and a are the UV luminosity of the accretion disk, sublimation temperature of dust, and dust grain size, respectively. The temperature might be 1700K and the grain size might be $1\mu m$ instead of 1500K and $0.5\mu m$

2. 3. Dust reverberation analysis

This is done by CCF analysis and also maximum likelihood lag by looking at the K and V band.

In the K band there is a component from the torus and the accretion disk. For the accretion disk this is a power law continuum emission, which varies and has to be subtracted to obtain the torus contribution or else the time-lag found will be shorter than the real lag when doing CCF analysis. any emission lines also have to be subtracted.

The lag time was determined as the centroid around the peak of the CCF, τ_{cent}, which was calculated by utilizing a part of the CCF near the peak with a value larger than 0.8 times the peak value of the CCF.
The uncertainty of the lag time was estimated by Monte Carlo simulation. A pair of artificial light curves was generated for the V and K bands, and the CCF was calculated to determine the centroid lag, τ_{cent}. The cross-correlation centroid distribution (CCCD) was then derived from a large number of realizations of the simulation, and the uncertainty of the lag time was determined from the CCCD. Artificial light curves were calculated by the flux randomization (FR) method combined with a method based on the structure function (SF), which simulates the flux variability between the observed data points.

JAVELIN was also used to find the time-lag which uses a damped random walk for the variability of the UV-optical continuum emission and assumes a top hat transfer function. JAVELIN fits the continuum and response light curves using the Markov chain Monte Carlo (MCMC) method to obtain the likelihood distribution for the lag time as well as those for the two DRW model parameters for the continuum variability, the width of the transfer function, and the scaling coefficient that determines the response for a given change in the continuum. The parameter values of the DRW model and their uncertainties are supplied to the lag-time fitting process as prior distributions, thus they are usually obtained from the continuum light curve before the lag-time fitting.