Notes for Lynge R. B. Lauritsen Master Thesis "Dust reverberation mapping of AGN in the local universe"

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1. 1: Introduction

The paper discusses the reduction of data from the REM telescope in La Palma to obtain usable AGN (Active Galactic Nuclei) light curves which is needed for reverberation mapping. AGN observation in different bands (J,H,K,g,r,i,z) can be used to determine optical and thermal lags times in the AGN. This is done by the use of a Markov Chain Monte Carlo algorithm to determine the best fit for the UV-continuum light curve and transfer function for the AGN, which are used to determine lag times. The wavelength range for the bands are listed below for my own reference:

- J- 1.1 to 1.4 μm
- H- 1.5 to 1.8 μm
- K- 2.0 to 2.4 μm
- g- 0.50 to 0.57 μm
- r- 0.65 to 0.74 μm
- i- 0.74 to 1.0 μm
- z- 28 to 48 μm

A description of the Hubble relationship/flow is given and the difference between peculiar velocity of galaxies, which comes from the gravitational interaction between the galaxies (especially those locally) and recessional velocity, which comes as a result of the expansion of the universe. The Hubble law lets us determine distances to galaxies where the recessional velocity dominates

$$d \simeq \frac{c}{H_0} \frac{(z+1)^2 - 1}{(z+1)^2 + 1}$$

here H_0 is the Hubble constant and the source of trouble. The trouble came historically from accurate distance measurement and Malmquist bias (as the distance increases only objects of increasing absolute flux will be included.) though today the trouble is related to the discrepancy (5σ today) between the H_0 value obtain in the local universe with Cepheids and Type Ia Supernovae (SNe Ia) measurements and the CMB value from the Planck Collaboration, where they are using a flat LCDM cosmology.

A list of the condition for a perfect standard candle/ruler is given, which can be used to determine H_0:

- Has physical properties allowing the identification as a standard candle or ruler
- Can be independently calibrated e.g. does not build upon previous distance or luminosity determinations (a one-step process), as errors stack
- At sufficient distance that error associated with peculiar velocity is small
- Astrophysically simple i.e. distance determination is independent on internal properties of the object
- Determines the Hubble constant independently of other cosmological

an example of a one step method for obtaining H_0 is the megamaser method where interferometry of nearby galaxies with Super Massive Black Holes(SMBH) have gas clumps that are assumed to move with Keplerian motion around the SMBH. Observations of these clumps can be used to determine their velocity and acceleration, which with the assumption of Keplerian motion can give us the gas radius from the SMBH and the SMBH mass. The gas radius can then be used to determine the distance to the galaxy using trigonometry. There are uncertainties for this method related to the disk geometry and inclination.
A distribution of the classical distance ladder is given, i will list the steps in order:

- 1. Parallax approach for close stars
- 2. Open clusters for nearby galaxies
- 3. Cepheids for 20-30 Mpc
- 4. Type Ia Supernovae (SNe Ia) for d>50 Mpc here peculier velocity error drops below 10 %
- 5. other methods (Tully-Fisher/Faber-Jackson relation) also for d>50 Mpc

the main issue here is error propagation through each step in the ladder

AGN/Quasars are not good standard candles since they have a varying luminosity but unchanging SED (Spectral Energy Distribution), though they can be observed at high redshifts and therefore if their inner dimensions are known then they can be used as standard rulers. The internal dimension can be determined using reverberation mapping. These internal measurements could then be used for galaxy distance measurements which can be used to determine H_0.