AGN Reverberation Mapping with the Australian Dark Energy Survey

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Reverberation Mapping

- RM uses time delays to measure sizes of AGN features
  - Radius of the Broad Line Region (BLR) clouds
- Assuming black hole and clouds are in virial equilibrium

\[ M = \frac{f c \tau \Delta V^2}{G} \]

- Allows you to obtain geometrical information about regions too small to image directly
The Big RM Questions

- A relationship between the BLR radius and AGN luminosity has been observed at low redshifts
  - Does this hold out to high redshifts?

- Can AGN be used as a high redshift standard candle?

- If we have black hole mass measurements out to high redshifts what can this tell us about black hole and galaxy evolution?

Fig 11: Bentz et. al. 2013 ApJ 767:149
Reverberation Mapping with OzDES

- Targeting 771 AGN
  - $0 < z < 4.5$

- Weekly observations with Dark Energy Survey (DES)
  - 525 nights over 6 years on the Blanco Telescope with DECam
  - Model the continuum emission from the disk

- Monthly observations with OzDES
  - 100 nights over 6 years on the AAT with 2dF AAOmega
  - Model the response of the BLR
  - H$\beta$, MgII, CIV emission lines

- Expect lags for 30-40% of our AGN
  - Around 140 time lags measured from all previous surveys (most at $z < 1$)
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Lag Calculations

- Perform spectrophotometric calibration of OzDES data
  - Mean scatter in sensitivity ~5%

- Perform local continuum subtraction and iron subtraction (MgII, Hβ)

- Line flux found by integrating over the emission lines

- Lag found by performing interpolated cross correlation of the light curves
DES J003352.72-425452.60

Observed Lag = $332^{+44}_{-80}$ days

$z = 2.593$

Rest Frame Lag = $92^{+12}_{-22}$ days

$~350$ days

332 days
DES J023828.19-040044.30

Observed Lag = 363$^{+126}_{-113}$ days

$z = 1.905$

Rest Frame Lag = 125$^{+43}_{-39}$ days

~350 days

363 days
Summary

- OzDES is targeting 771 AGN out to z=4
- Recovered first 2 lags using the CIV line
- Expect to recover 100’s more with full data set
- Will allow us to directly measure the Radius-Luminosity Relationship out to high redshifts