Chapter 7

Conclusions and Future Work

Variability is a key feature of AGN activity, being one of the most convincing pieces of evidence in favour of the black hole accretion model of AGN fuelling. Taking advantage of this property of AGN emission, flux variations in many wavelengths have been used to study different parts of the AGN system. However, the timescale these variations take place on is known to increase with wavelength, leaving variability in longer wavelengths less well studied due to the time cost required for observations to occur. However, the UKIDSS UDS solves this issue as it provides 8 years of deep NIR imaging of the night sky. The work presented in this thesis shows that active galaxies selected through long-term NIR monitoring are a different population with different properties compared to active galaxies selected based on X-ray emission, which is more commonly used in the literature. We also find that AGN with different properties are systematically selected depending on the NIR band used to select variable AGN, and finally we explored the environment and host galaxies of the AGN.

7.1 Conclusions

In Chapter 4, we compared the properties of AGN selected by long-term NIR variability to X-ray bright AGN. Inspecting the luminosity functions of the active galaxies finds both variable and X-ray groups to have an increase in the fraction of active galaxies with increasing luminosity for all redshifts probed. However, the two techniques do appear to select different populations of active galaxies, with only a 37 per cent overlap in active galaxies selected for the same imaging area of sky. Mass functions show that NIR variability is able to detect AGN in galaxies with a wider range of stellar masses compared to X-ray emission; NIR variable AGN comprises $\sim$1% of galaxies at any stellar mass probed, whereas the fraction of X-ray bright AGN increases with galaxy stellar mass. One plausible explanation for these differences could be extinction of X-ray emission if lower mass host galaxies are more likely to be obscured, causing NIR variability to be a more effective detection method in such cases. Clearly, these results illustrate the need for multiple detection methods to be used for complete samples of AGN to be detected for systematic study.

Chapter 5 focuses on how the properties of NIR variable active galaxies depend on the waveband used to detect them. We first find that AGN variable in the J-band show an opposite correlation of variability amplitude and wavelength compared to AGN variable in the K-band. Investigating the origin of variability in the variable AGN finds a majority of K-band variable AGN exist at rest-frame IR wavelengths, whereas J-band variables show no obvious preference for the rest-frame of emission. Model comparisons as well as inspecting X-ray bright AGN, which provide a sample of AGN found independent of their variability, suggest these differences are not due to biases in the selection method employed. Spectral energy distribution analysis finds K-band variable AGN to be systematically more UV absorbed than J-band variable AGN, with a similar feature found when comparing X-ray hard to X-ray soft systems as a measure of more and less obscured AGN respectively. UVJ measurements also confirm the observed colour differences cannot be attributed to different passive fractions in galaxy populations. Finally, variability timescales were calculated, with K-band detected AGN generally found to vary on longer timescales compared to J-band AGN. The results found in this chapter suggest that the IR spectrum of K-band variable AGN is dominated by thermal emission from heated dust, whereas the J-band variability originates from fluctuations in the accretion disk. Physically, this explanations implies K-band variable AGN could be hosted in dustier systems than J-band variable AGN, as higher levels of obscuration would absorb UV emission, dilute variability and reprocess light further into the IR increasing variability timescales, as observed.

The work in Chapter 6 investigates the environment and host galaxies of AGN as well as observational differences between AGN when split by detection method. We find X-ray and variability detected active galaxies to be found in different environments, both with respect to each other and when compared to corresponding sets of control galaxies matched in stellar mass, redshift and effective radius. X-ray bright active galaxies are found in denser environments compared to controls, whereas variability detected active galaxies show no obvious dependence on environment. Inspecting the optical V - I and infrared J - H colours as a function of redshift and morphology finds X-ray bright active galaxies to have largely similar evolutions as matched control galaxies, whereas the variability detected samples show no strong similarities as matched controls. However, comparing X-ray and variability detected samples to each other finds the X-ray sample to be redder than the variable sample at the 4000Å break. One possible explanation for the colour difference could be the higher passive fraction that is common to high mass galaxy samples, which X-ray emission probes. From these results we conclude that the triggering of variability detected active galaxies appears to be stochastic in nature, whereas X-ray bright active galaxies are found in overdense environments but otherwise have properties typical of galaxies at a similar stellar mass, radius and redshift.

Inspecting X-ray and infrared AGN luminosities in X-ray bright active galaxies show that a two component Sérsic and point source fit is able to effectively separate out AGN and host galaxy emission. Using the data from the two component modelling of active galaxies, we find the hosts of X-ray bright AGN to be redder than matched control galaxies in the optical (V - I) colour, but have similar infrared (J - H) colours compared to control galaxies over cosmic time. We also find the colour evolution of the AGN hosts to be dependent on morphology, with disk-type hosts remaining redder than controls in both optical and infrared colours, while spheroidal hosts having no consistent trend in the optical colour but appearing very blue compared to control galaxies in the infrared colour. Overall we conclude that different detection methods preferentially find active galaxies in different environments and with broader observational characteristics. Currently, we cannot confirm if environment influences the triggering of AGN activity in a given galaxy or if specific types of galaxies are more likely to host AGN. The impact of AGN feedback on the galaxy it exists in is also a large area of interest in the study of active galactic nuclei, and the preliminary work completed into the host galaxy properties of X-ray bright AGN shows that AGN - host decomposition is an effective approach in determining intrinsic active galaxy parameters.