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INFRARED AND HARD X-RAY DIAGNOSTICS OF AGN IDENTIFICATION FROM THE AKARI AND SWIFT/BAT ALL-SKY SURVEYS

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ABSTRACT

We combine data from two all-sky surveys, the *Swift*/Burst Alert Telescope 22 Month Source Catalog and the AKARI Point Source Catalogue, in order to study the connection between the hard X-ray (> 10 keV) and infrared (IR) properties of local active galactic nuclei (AGN). We find two photometric diagnostics are useful for source classification: one is the X-ray luminosity vs. IR color diagram, in which type 1 radio-loud AGN are well isolated from other AGN. The second one uses the X-ray vs. IR color-color diagram as a redshift-independent indicator for identifying Compton-thick (CT) AGN. Importantly, CT AGN and starburst galaxies in composite systems can also be separated in this plane based upon their hard X-ray fluxes and dust temperatures. This diagram may be useful as a new indicator to classify objects in new surveys such as with *WISE* and *NuSTAR*.

Key words: galaxies: active; infrared: galaxies; X-ray: galaxies

1. INTRODUCTION

In this paper, we explore the X-ray vs. infrared (IR) correlation using unbiased samples, and then define new and simple photometric diagnostics for active galactic nuclei (AGN) classification. We use two all-sky survey catalogs: one is the *Swift*/Burst Alert Telescope (BAT) 22 Month Source Catalog (Tueller et al., 2010) as the base AGN selection catalog covering the hard X-ray (> 10 keV) band, which reflects the intrinsic luminosity of a source and provides samples unbiased by obscuration. The second is the AKARI Point Source Catalogue (AKARI/PSC; Ishihara et al., 2010; Yamamura et al., 2010) over a range of wavelengths from 9 to 160 μm.

The completeness of the base samples allows us to examine and design various color plots, which can be useful for source classification in blind surveys and particularly powerful if they are redshift independent. We propose one color–color diagnostic providing the capability of distinguishing starbursts from Compton-thick (CT) AGN. This has been an important problem for many years because star formation and obscured accretion activity often occur together in composite systems (cf. ‘starburst-AGN connection’). These two phenomena are difficult to distinguish with soft X-ray and IR observations. But the hard X-ray selection adopted here enables this. Details of our study are presented in Matsuta et al. (2012), building upon the study of Gandhi et al. (2009).

2. RESULTS AND DISCUSSION

We find a good correlation between the observed mid-IR and hard X-ray luminosities over four orders of magnitude. Under the AGN orientation-based unification scheme, this result may support the clumpy torus model, although the broad-band correlation alone cannot prove the underlying emission mechanism for the two bands. We also find that the radio-loud (RL) AGN follow a similar correlation, suggesting that their dominant hard X-ray and IR emission processes are similar to those of radio-quiet (RQ) AGN. Blazars show a linear correlation of slope 1 between the two bands, which is due to the fact that the synchrotron and inverse Compton powers match each other well along the blazar sequence. We evaluate quantitative correlation statistics and show that the correlation is not a redshift artifact for either RQ or RL AGN. Most CT AGN show a large deficit in their observed X-ray powers compared to unobscured AGN. This is expected because their observed fluxes are diminished by high gas column densities, even in the hard X-ray band.

We study hard X-ray and IR photometric diagnostics for source classification. We can isolate type 1 RL AGN and blazars by using the X-ray luminosity vs. IR color diagram such as $\log L_{\rm X}$ vs. $\log \lambda L_{9\mu m}/\lambda L_{90\mu m}$. Type 2 AGN show a smaller color ratio than type 1 AGN. The trend probably arises because type 2 AGN have on average lower intrinsic accretion (X-ray) luminosities as compared to type 1 (Winter et al., 2009), as well as a relatively stronger 90 μm contribution from dust in the host galaxy (Malkan et al., 1998).

We also find that the color–color plot of $\log L_{\rm X}/\lambda L_{9\mu m}$ vs. $\log \lambda L_{9\mu m}/\lambda L_{90\mu m}$ can distinguish starburst galaxies and composite CT AGN from non-CT AGN. In Fig 1, CT AGN are successfully isolated by the approximate boundary of $\log L_{\rm X}/\lambda L_{9\mu m} < -0.9$ with very high (100%) reliability, but with a completeness of 56%. Starburst galaxies are isolated in a region with approximate boundary of $\log L_{\rm X}/\lambda L_{9\mu m} < -2.5$ and $\log \lambda L_{9\mu m}/\lambda L_{90\mu m} < -0.4$ and very high (100%) reliability. These simple photometric diagnostics can be useful tools for new and upcoming surveys.

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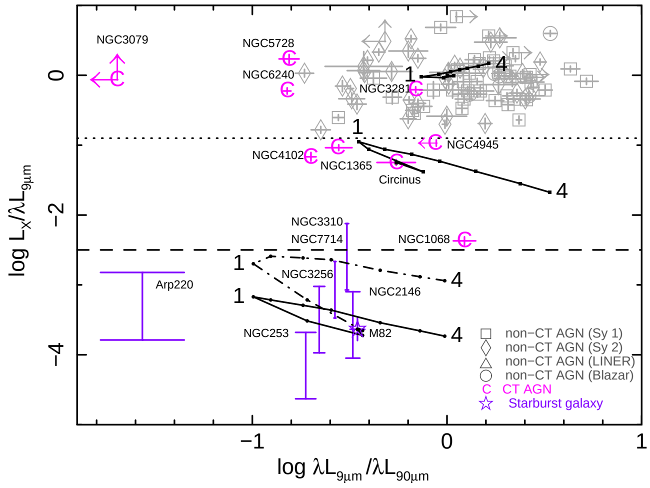

Fig. 1. Color-color plot of $\log L_{\rm X}/\lambda L_{9\mu m}$ vs. $\log \lambda L_{9\mu m}/\lambda L_{90\mu m}$ for 89 AGN including 9 CT AGN and 7 starburst galaxies detected by AKARI. The dotted line at $\log L_{\rm X}/\lambda L_{9\mu m} \sim -0.9$ denotes an approximate boundary between non-CT and CT AGN. The dashed line at $\log L_{\rm X}/\lambda L_{9\mu m} \sim -2.5$ shows the boundary below which only starburst galaxies are present. The solid and dot-dashed lines show how the sources move on the plot when the redshift is changed from 0.0 to 4.0. The lines are calculated for three source classes: a non-CT AGN located at (0, 0), Circinus galaxy as a CT AGN, and M82 as a starburst galaxy.

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