The PAH 3.3 micron Feature as a SFR Indicator: Probing the Interplay between Star Formation and Nuclear Activities in AGN

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Along with Myungshin Im, Dohyeong Kim, Jong-Hak Woo, Hyung Mok Lee, Myung Gyoong Lee, Hyunsung D. Jun, Dawoo Park (SNU), Masatoshi Imanishi (NAOJ), Takao Nakagawa, Hideo Matsuhara, Takehiko Wada, Toshinobu Takagi (ISAS/JAXA), Shinki Oyabu, Rika Yamada (Nagoya University), George Helou, Yong shi (IPAC/Caltech), Lee Armus, Hanae Inami (SSC/Caltech), and Youichi Ohyama (ASIAA)
Super Massive Black Holes

- SMBHs are believed to exist in every bulge (Kormendy & Richstone1995; Ferrarese & Ford 2005).

- a tight correlation between black hole masses with host galaxy properties (Gebhardt et al. 2000; Marconi & Hunt 2003; Häring & Rix 2004; Gültekin et al. 2009)

- the coevolution of black holes and their host galaxies?

- Cosmological theorists say it is all about AGN feedback within hierarchical galaxy merging scenarios (Volonteri et al. 2003; Springel et al. 2005; Croton et al. 2006; Hopkins et al. 2007, 2009).
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Probing the direct connection between star formation and AGN is crucial to understand the coevolution of BHs and their hosts.

In general, most studies support a positive correlation between nuclear starburst and nuclear activities (Netzer et al. 2007; Lutz et al. 2008; Shi et al. 2009; Oi et al. 2010).

Any dependence on morphological types of host galaxies and physical scales for the correlation between SF and nuclear activities?

There are alternative predictions on the correlation, e.g. Kawakatu & Wada (2008) and Ballantyne (2008).
The 3.3 PAH Emission as a SFR proxy?

- AMUSES (AKARI mJy Unbiased Survey of Extragalactic Sources)
- a subsample of 5MUSES (5mJy at 24μm in the Spitzer First Look Survey)
- 20 out of 44 targets were observed before AKARI’s death.
- It correlates well with L_{IR} at L_{IR} < 10^{12} L_⊙ (Also, R. Yamada’s poster).

1. destruction of PAH?

2. bigger contributions from AGN for ULIRGs?

- It correlates well with the 6.2μm PAH emission.

Kim et al. (submitted)
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Application to z~0.36 Seyfert 1

- 27 Seyfert 1 at z~0.36
- A very unique sample at a cosmologically significant distance
- This sample deviates from the local $\text{Mbh-}\sigma$ relation, meaning black holes proceed host galaxies.
- 7 targets are detected with the PAH 3.3 μm emission feature.
- Within the sample, the correlation b/w SF and nuclear activities appears to be not significant, or even negative.
- Compared to local type 1 AGN, they appear to follow the overall trend.

Woo et al. (2008)
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Woo et al. (2012)
Application to LQSONG

- The Low-redshift Quasar Spectroscopic Observation in Near-infrared Grism: a mission program of AKARI (D. Kim’s posters)

- Two subsamples
  1. bright type-1 AGN and QSOs with BH masses measured by reverberation mapping method - 31 objects
  2. Palomar-Green QSO sample - 49 objects

- Even higher detection rates than AMUSES
  1. ~50% (16 out of 31) for the reverberation-mapped sample
  2. ~20% (10 out of 49) for the PG-QSO sample

- Any dependency of the correlations between SF and nuclear activities (Lx, L5100, Eddington ratio) on host galaxy morphology, the presence of radio jets, etc.?
Summary

- Various AKARI programs provide good samples to investigate star formation activity and physics of star-forming ISM.

- A mission project, AMUSES, shows that L$_{3.3}$ correlates well with L$_{IR}$ and L$_{6.2}$.

- The PAH 3.3 μm can be a good SFR indicator.

- Seyfert 1s at z~ 0.36 show that SF probed by PAH 3.3 μm correlates well with nuclear activity.

- However, it still remains unclear if the correlation between SF and nuclear activities depend on other properties.

- LQSONG including the reverberation-mapped sample and PG QSOs will enable us to probe the link between star formation and nuclear activities much better.