# Search for Dust-free Quasars at $z > 6$ Using *SPICA* MCS Photometry

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## ABSTRACT

I propose to search for *dust-free quasars* without hot-dust emission at $z > 6$. I plan to perform the deep mid-infrared photometry with Mid-infrared Camera and Spectrometer (MCS). Its high sensitive and continuous-band (5–38 $\mu$m) imaging enables us to investigate the contribution not only of the hot dust component (rest frame: 1–3 $\mu$m) but also of the warm dust component (rest frame: $> 3$ $\mu$m) of quasars at $z > 6$. When the *SPICA* begins the observation, several hundreds of quasars at $z > 6$ are expected to be discovered by Hyper Suprime-Cam (HSC) which is a gigantic digital still camera for 8.2 m Subaru telescope. For these $z > 6$ quasars, we examine the hot-dust abundance by utilizing the spectral energy distributions of rest-frame near-infrared regime. This study is expected to provide us the clue about the origin of the dust torus.

## 1. INTRODUCTION

Active galactic nuclei (AGNs) are among the most energetic objects in the universe. The nuclear activity is powered by a supermassive black hole (SMBH) and its accretion disk, and this central engine is surrounded by a dusty toroidal structure, so-called "dust torus". The radiation from hot dust (~1,500 K) is one of the characteristics of AGNs (e,g, Kobayashi et al. 1993; Suganuma et al. 2006). It is also widely accepted that the hot dust contributions can be observed as an infrared (IR) bump which starts ~1 $\mu$m and extends to longer wavelength in the near-IR (NIR) region of their spectral energy distributions (SEDs). The hot dust is considered to the inner region of dust torus, based on the unified model of AGNs (Antonucci 1993; Urry & Padovani 1995). Recently, however, two quasars without hot-dust emission were discovered at $z \sim 6$ (Jiang et al. 2010). While these hot-dust-free quasars are suggested to be the first generation ones that do not have enough time to form a dusty torus, the origin of these dust free quasars is still unclear because the sample was limited to only the two sources.

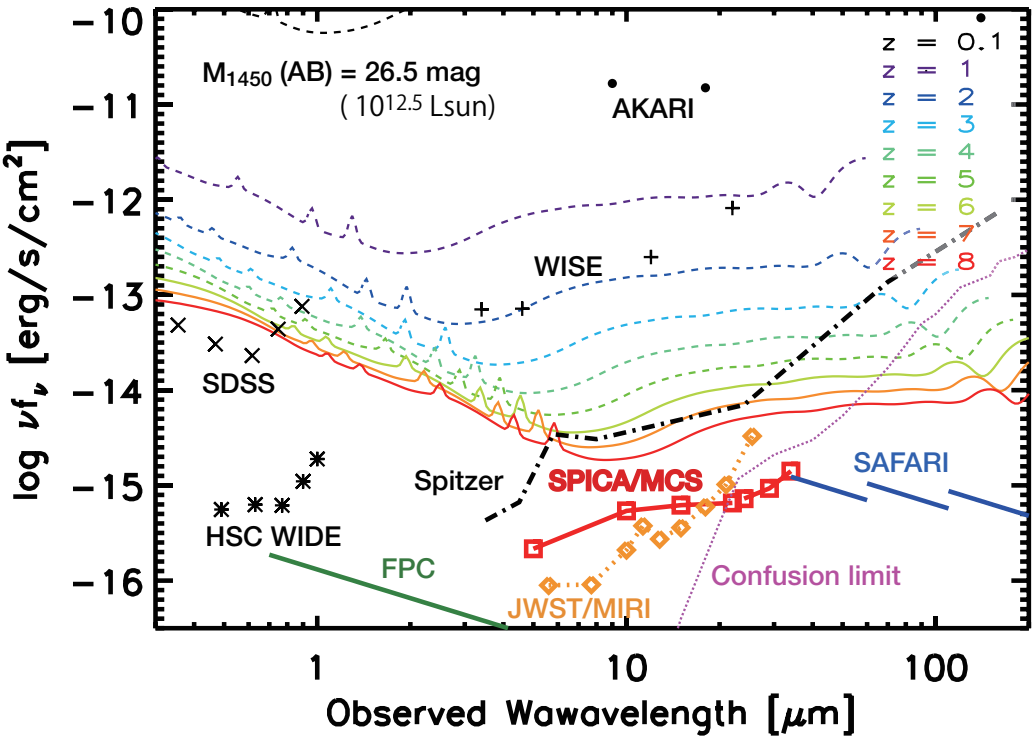


**Figure 1.** MCS 5$\sigma$ sensitivity in one hour exposure. The SEDs of quasars at various redshift ($z$ =0.1–8) are also plotted. The SED template was used by Assef et al. (2010). See Takeuchi et al. (this volume) for the confusion limit.

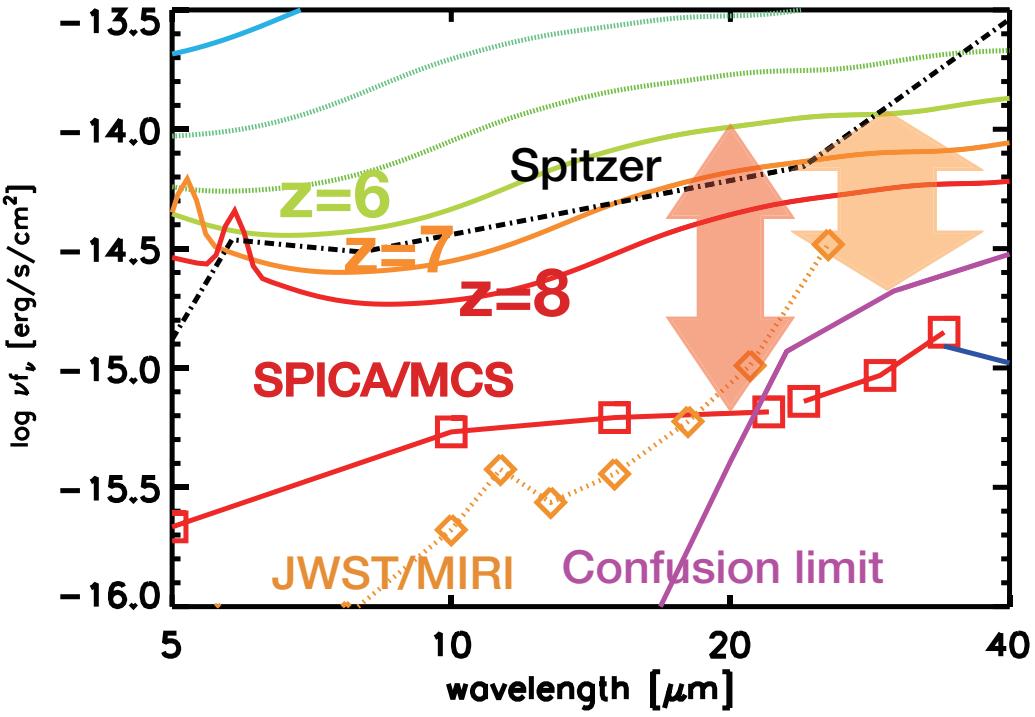


**Figure 2.** Same as in Figure 1, but localized in the MIR region. MCS provides us the opportunity to discuss not only the hot dust component but also the warm dust component of quasars at $z > 6$, 7, and 8.

## 2. SURVEY STRATEGY

In order to examine the properties of the hot dust around the AGNs at high redshift statistically, we plan to perform the deep mid-IR (MIR) photometry with Mid-infrared Camera and Spectrometer (MCS: Kataza et al. 2012) on board *SPICA* (Nakagawa et al. 2012). Its high sensitive and continuous-band (5–38 $\mu$m) imaging enables us to investigate the contribution not only of the hot dust component (rest frame: 1–3 $\mu$m) but also of the warm dust component (rest frame: $> 3$ $\mu$m) of quasars at $z > 6$. When the *SPICA* begins the observation, several hundreds of quasars at $z > 6$ are expected to be discovered by Hyper Suprime-Cam (HSC: Miyazaki et al. 2012) which is a gigantic digital still camera for 8.2 m Subaru telescope. For these $z > 6$ quasars, we examine the hot-dust abundance by utilizing the SEDs of rest-frame NIR regime. In addition, we will compare its physical properties (black hole masses and Eddington ratios etc.) to other "normal" quasars.

## 3. ADVANTAGE OF *SPICA*

To check the capability of *SPICA* to discover a lot of dust free quasars, I demonstrate the expected SEDs of high-z quasars. Figures 1 and 2 show the SEDs of quasar which has $M_{1450}\,(AB) = 26.5$ ($\sim 10^{12.5}\,L_{\odot}$) at various redshift ($z = 0.1, 1, 2, 3, 4, 5, 6, 7, 8$), based from the quasar SED template (Assef et al. 2010). It should be noted that any extinction was not considered, but when we focus on the MIR regime, the influence of extinction on the SED is expected to be neglected. The $5\sigma$ sensitivity of MCS in one hour exposure is also plotted. For comparison, we also show the capability of other instrument of *SPICA* (SAFARI, FPC) and notable current (SDSS, *Spitzer*, *AKARI*, and *WISE*) and future missions (HSC-WIDE and JWST/MIRI) in Figures 1 and 2. As shown in these figures, *SPICA*/MCS has a strong potential to search for not only dust free quasars but also various types of quasars with a high level of confidence. This study is expected to provide us the clue about the origin of the dust torus.

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