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TYPE 1 AND TYPE 2 QUASARS IN THE MID-INFRARED

S. E. Ridgway,[1] C. Harrison,[1] M. Lacy,[2] A. Sajina,[2] A. Petric,[2] N. Seymour,[2] L. Storrie-Lombardi,[2] L. Armus,[2] and G. Canalizo[3]

RESUMEN

Los AGN Tipo 2 u “oscurecidos” han sido identificados en AGNs de baja luminosidad (ej. Seyfert 2s) o por su emisión en radio (ej. radio galaxias). Pero, los cuásares radio-callados, RQQ, son mucho más comunes que los radio-fuertes, por tanto no es sorprendente que en búsquedas recientes los cuásares radio-callados 2s conformen una población significativa. Encontrar el número, propiedades y la distribución en corrimiento al rojo de cuásares 2s resulta importante para responder preguntas relacionadas con la formación y co-evolución de agujeros negros y galaxias. Hemos conformado una muestra de cuásares Tipo 1 y Tipo 2 empatados en su luminosidad en el mediano infrarrojo del Spitzer First Look Survey, seleccionándolos por las propiedades de emisión del polvo en el mediano infrarrojo (medidas fotométricas del Spitzer IRAC). Esta emisión provee una huella distintiva de la actividad AGN y no debería estar afectada por la orientación o el ángulo de apertura del toroide. Hemos realizado espectroscopía en el mediano infrarrojo IRS de estas muestras para estudiar la actividad de formación estelar en las galaxias anfitrionas y el polvo en el medio ambiente de los AGN, utilizando las mediciones obtenidas con las líneas de PAH, la forma de la SED en el mediano infrarrojo y el ancho equivalente de emisiones de silicatos a 10 micrones. Encontramos que los cuásares 2s tienen propiedades en el mediano infrarrojo más diversas y que el oscurecimiento de los AGN está ligado a la actividad de formación estelar en la galaxia anfitriona.

ABSTRACT

Type 2 or “obscured” AGN have long been identified at low AGN luminosities (e.g. Seyfert 2s) or through their radio luminosities (e.g. radio galaxies). But radio-quiet quasars (RQQs) are many times more common than radio-loud quasars, and it’s therefore unsurprising that recent searches have revealed that radio-quiet quasar 2s also form a significant population. Finding the numbers, properties, and redshift distribution of quasar 2s will be very important to resolving questions about the formation and co-evolution of black holes and galaxies. We have selected a sample of Type 2 and Type 1 quasars matched in their mid-infrared luminosity from the Spitzer First Look Survey by selecting on their mid-infrared dust emission properties (as measured by Spitzer IRAC photometry). This emission provides a distinctive signature of AGN activity but should not be affected by orientation or torus opening angle. We have obtained mid-infrared IRS spectroscopy of these samples to study star formation activity in the host galaxies and the dust environments of the AGN, using measurements of the PAH features, the shape of the mid-infrared SED, and the equivalent width of the silicate features at 10 microns. We find that the quasar 2s have more diverse mid-IR spectral properties, and that obscuration of the AGN is linked to star formation activity in the host.

Key Words: quasars

1. INTRODUCTION

Recent results have revealed that there is probably a very close link between the formation and evolution of the supermassive black hole population and that of the galaxy population. Therefore, determining the actual number densities and properties of the black hole population over a wide range of epochs is vital to understanding even the basics of galaxy formation. Optical surveys such as the SDSS and 2DF have found unprecedented numbers of type 1 luminous quasars up to very high redshifts. However, identifying their optically-obscured counterparts, the quasar 2s, which may have similar or greater number density than the type 1s, has proven more difficult. Radio-quiet quasar 2s have been identified in deep X ray surveys and from Sloan spectral properties. However, until recently it has been very difficult to identify luminosity-matched samples of quasar 1s and 2s, and having such a matched sample

[1]Cerro Tololo Inter-American Observatory, NOAO, Casilla 603, La Serena, Chile (seridgway@ctio.noao.edu).

[2]Spitzer Science Center, Caltech, 1200 E. California Blvd., Pasadena, CA 91125, USA.

[3]Institute of Geophysics and Planetary Physics, University of California, Riverside, CA 92521, USA.

(selected on similar, mostly isotropic properties) is essential to resolving basic questions about the relationship between the two types. The two quasar types may be related purely by orientation, or it has also been posited that the optically-obscured quasar 2s may evolve to quasar 1s after the initial triggering merging event. If evolution plays a strong role in determining whether a quasar is type 1 or 2, we might expect enhanced star-formation activity in the host galaxies of the type 2 quasars.

2. SELECTING QUASAR 2S IN THE MID-INFRARED

The rest-frame SED of an AGN at > 3 μm is dominated by emission from hot dust in the torus (Sajina et al. 2005). This roughly isotropic emission results in Spitzer IRAC colors that can be used to select both obscured and unobscured quasars (Lacy et al. 2004; Stern et al. 2005). Lacy et al. (2004) selected targets from the Spitzer Extragalactic First Look Survey (XFLS), and followed up with optical spectroscopy to verify candidate quasar 2s and obtain redshifts. From this sample, we selected a subsample of Type 1 and Type 2 quasars at $0.3 < z < 0.8$, matched in mid-IR luminosity, for study with Spitzer IRS mid-infrared spectroscopy and MIPS photometry.

3. IRS SPECTROSCOPY, SEDS AND HOST GALAXIES

We detected PAH features and broad silicate features in most of the quasar 2 spectra, which were not seen in the quasar 1s. We also detected molecular hydrogen lines and some forbidden lines in spectra of both types. In Figure 1, we show IRS spectroscopy (from 5 to 20 μm rest wavelength) of the Type 2 quasars. We also obtained MIPS photometry of both Q1 and Q2 samples to determine the far-IR spectral energy distribution (SED), as well as HST imaging of the hosts of the Q2 sample.

4. RESULTS AND DISCUSSION

In this small sample, we found much more diversity in the spectral properties of the Q2s than in the Q1s. Among the Q2s, objects with high silicate absorption tended to show stronger PAH features and

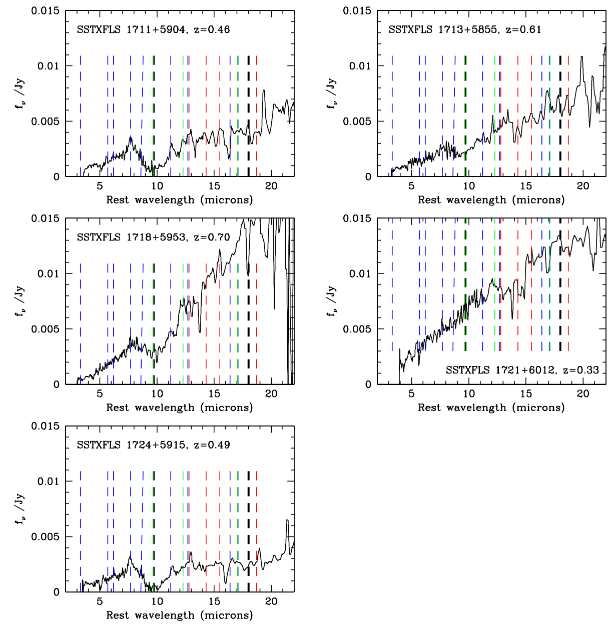

Fig. 1. IRS spectroscopy of the Quasar 2 sample, rest-frame λ (μm) vs. f_ν in Jy. The spectra show prominent 7.7 μm PAH features and silicate absorption features at 9.7μm.

more FIR excess, along with more edge-on hosts. These Q2 hosts appear to be obscured and star-forming, and dusty star forming disks may be contributing to the obscuration in many of these Q2s (c.f Martinez-Sansigre et al. 2006; Lacy et al. 2007). Orientation alone may not be enough to explain the differences between Type 1 and Type 2 quasars. If the quasar 2s have more host galaxy star formation, it is likely that some Type 2s may evolve into Type 1s after an initial merger event that triggers the AGN.

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