Revista Mexicana de Astronomía y Astrofísica
Universidad Nacional Autónoma de México
rmaa@astroscu.unam.mx
ISSN (Versión impresa): 0185-1101
MÉXICO

2005
Itziar Aretxaga / David H. Hughes
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Revista Mexicana de Astronomía y Astrofísica, diciembre, año/vol. 024
Universidad Nacional Autónoma de México
Distrito Federal, México
pp. 170-172

RevMexAA (Serie de Conferencias), **24**, 170–172 (2005)

HIGH-z QSO ENVIRONMENTS

Itziar Aretxaga[1] and David H. Hughes[1]

RESUMEN

Se describe el estado actual de los estudios sobre galaxias huéspedes de QSO y se comentan algunos proyectos que podrán llevarse a cabo con el GTC y el LMT para resolver la naturaleza de estas galaxias a altos z, las cuales, potencialmente, son lugares de formación estelar masiva.

ABSTRACT

We describe the present status of QSO host galaxy studies and point to some of the projects that the GTC and the LMT will be able to accomplish in order to solve the nature of the hosts of high-z AGN, which potentially are the sites of massive galaxy formation.

Key Words: **GALAXIES: ACTIVE — QUASARS: GENERAL**

1. INTRODUCTION

Quasar hosts provide important clues on how nature has chosen to relate nuclear accretion activity to the onset of the bulk of star formation in the Universe. This simultaneous activity is supported by the coincidence in redshift ($z \approx 2.5$) of the maximum density of blue light emitted by both processes (Boyle & Terlevich 1998). Quasar hosts have actually been subjected to detailed multiwavelength studies since their discovery, in the 60's. Optical/infrared studies have unarguably identified the hosts of quasars at low-redshift ($z < 0.3$) with normal massive elliptical galaxies (Dunlop, Taylor, Hughes & Robson 1993), and the presence of very blue hosts at high-redshift ($z \approx 2-3$) which, if explained by stellar activity, could be identified with the formation of first-rank elliptical progenitors (Lehnert, Heckman, Chambers & Miley 1992; Aretxaga, Boyle & Terlevich 1995; Aretxaga, Terlevich & Boyle 1998). Thus, direct imaging of quasar hosts offers a further link between nuclear activity and spheroid formation. Indeed, the tight relationship between the mass of the spheroid and the mass of the central black hole, followed by active and inactive galaxies alike (Gebhardt, Kormedy, Ho et al. 2000), strongly supports this connection between the formation of black holes and the formation of spheroids in galaxies, and thus, the idea that all galaxies might have experiences a quasar phase in their life-time (e.g. Ferrarese 2002) might be crucial to their build-up as galaxies.

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2. SCIENCE WITH THE GRAN TELESCOPIO DE CANARIAS

While the morphological information gathered from the various imaging efforts is very rich, by contrast, little is known about the spectroscopic properties of the galaxies that host activity. The most recent attempt to study the nature of the off-nuclear light from a representative sample of nearby radio-loud and radio-quiet quasars and radio-galaxies (Hughes, Kukula, Dunlop & Boroson 2000), using 4m-class telescopes, has produced relatively low S/N spectra. These had, however, sufficient resolution to see strong stellar atmospheric absorption features in the $z < 0.15$ objects, which undoubtedly demonstrate that stars are the source of the light detected in direct imaging. A crude 4000Å break measurement (Nolan, Dunlop, Kukula et al. 2001), shows that these are predominantly old stellar populations (8-12 Gyr), but a modest $\sim 2\%$ contamination by a younger ~ 100 Myr population is also suggested from the modeling of the continuum shapes. Some contamination of the blue spectra by scattered light, even in the 5" off-nuclear configuration, is however still present. An accurate measurement of the ages that dominate the hosts is thus required. Ages determined on the base of spectral absorption features, in the presence of the possibly contaminating quasar blue source, would be able to offer a more definitive probe of youth in the case of the hosts. Confirmation of a contamination due to recent star formation is, in particular, needed to directly link AGN activity to (what might be) the last stages of spheroid formation. This is especially true in the higher redshift sample ($0.15 < z < 0.3$), for which the spectra are too poor to derive any definitive information. It should be noted that a small contamination by a young burst can be readily detected through the combination of spectroscopic indexs that trace age and metallicity in an almost independent way (e.g. D_{4000} or Hβ and [MgFe] indexs, Worthey 1994). Following this method, the youth of a ($< 5\%$) contaminating population in shell-like and pair elliptical galaxies has already been probed (Longhetti, Bresan, Chiosi & Rampazzo 2000).

The data from a 10m telescope will significantly improve on previous studies: a factor of $\sim$3 in S/N because of the aperture size and improved spectrograph performance; and an additional factor of ~ 5 if the slit is placed through the quasar nucleus and one is able to recover the contribution of the inner isophotes of the host galaxy through deconvolution (e.g. Courbin, Letawe, Magain et al. 2002), provided a bright stellar point spread function (PSF) is acquired simultaneously. The multi-object capabilities of OSIRIS (`http://www.iac.es/proyect/OSIRIS/`, and Cepa in these proceedings) will be ideal to develop a science case like this, where simultaneous spectroscopic acquisition of science and calibration targets (PSFs) are a fundamental requirement to control the systematics that could impact on a positive detection.

3. SCIENCE WITH THE LARGE MILLIMETRE TELESCOPE

The mm view of quasar hosts aligns with the interpretation of massive galaxies, but offers one more surprise into the picture: quasar hosts are not only massive and young, but have been chemically enriched, in such a way, that from primordial abundances, these galaxies must have found a way to produce a body of $> 10^9$ M$_\odot$ in dust in the space of only $\sim 1-2$ Gyr (Hughes, Robson & Dunlop 1993; Hughes, Dunlop & Rawlings 1997; Dunlop, Hughes, Rawlings et al. 1994; Isaak, McMahon, Hills, Withington 1994; McMahon, Omont, Bergeron et al. 1994). Very intense and continuous episodes of star formation ($\gtrsim$ 1000 M$_\odot$ yr^{-1}) are again implied by the large fluxes of thermal emission detected in the mm. Studies made with the present generation of sub-mm/mm telescopes (15m JCMT, 30m IRAM), have established the presence of dust in some of these systems up to $z = 5$, but the inability of these telescopes to go below a 10 mJy threshold in a statistically significant sample (Isaak, Preiddey, McMahon et al. 2002), has left significant inconsistencies in our understanding of the properties of dust/gas in quasars. In particular, the dust mass-function of quasars has not been explored, since just the brightest of them have been detected. Also, different samples appear to prove or disprove the presence of larger and larger quantities of gas and dust at higher redshifts (Archibald, Dunlop, Hughes et al. 2001; Priddey, Isaak, McMahon & Omont 2003), leaving the evolutionary picture of the conversion of gas into dust into stars at odds. A possible, but not yet probed, possibility, is that the sample definition is at the root of these discrepancies, since the selection has been based on a variety of non-uniform and biased techniques that tried to enhance detection, but do not prove the basic properties of the population as a whole. The confirmation of fundamentally different evolutionary histories of dust content for radio-loud, radio-quiet quasars and radio-galaxies could, on the other hand, cast further doubt on the universal validity of the unification picture for AGN (e.g. Goodrich 2001).

The Large Millimeter Telescope, with its fast ultra-sensitive set of bolometer cameras (BOLOCAM, SPEED, see `http://lmtsun.phast.umass.edu/overview/ins/` and Carrasco in these proceedings) can reach the present levels of detection (10 mJy) in a second, go a factor of 15 deeper in only 5 min of integration per object, and even assign a reasonable amount of time, 1 hr/object (including overheads), before confronting the confusion limit of the telescope, $\sim$ 0.1mJy with S/N = 5, offering measurements at two orders of magnitude below the present detection thresholds. This will allow us to build samples in a bias-free way, attending to those intrinsic properties of the quasars that allegedly are powered by accretion, and that are free of extinction considerations, such as the radio flux or the strength and width of the UV/optical emission lines.

Samples mapped in this way will allow us to measure the mass function of dust in quasars (via multi-colour mapping) and the clustering of other mm-bright galaxies around them. All these issues will set stronger constrains on the unification of the different flavours of active galactic nuclei (quasars among them) and the role of dust formation and enrichment in galaxy formation, science goals which, at the required depths, will be attainable just by telescopes in the range of apertures of the LMT.

We are grateful to the organizers for the support offered to attend the conference. IA and DHH's research is partly funded by CONACyT grants 39953-F and 39548-F.

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