A SUBMILLIMETER SELECTED QUASAR IN THE FIELD OF
ABELL 478

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We report the discovery of a $z = 2.83$ quasar in the field of the cooling flow galaxy
cluster Abell 478. This quasar was first detected in a submm survey of star forming
galaxies at high redshifts, as the brightest source. We discuss the optical spectrum
and far–IR spectral energy distribution (SED) of this object.

1 Introduction

We are performing a survey of gravitationally lensed submm sources — a
project aimed at studying the cosmic star formation history. Our survey
covers 11 clusters of galaxies and has so far resulted in the detection of at
least 25 submm sources. Here we present results on the brightest submm
source detected.

2 Observations and Results

In the field of Abell478 we have detected with SCUBA (JCMT, Hawaii) a
very bright submm source, $F_{850\mu m} = 25 \pm 3$ mJy and $F_{150\mu m} = 63 \pm 20$ mJy,
and possibly a fainter source of $F_{850\mu m} = 9 \pm 2$ mJy. The errors contain the
detection uncertainty and the calibration error. To identify the sources we have obtained a deep $I$–band image with FORS1 (VLT, Paranal). Our
optical identification of the bright submm source, which we henceforth refer
to as SMMJ04135+1027, is an $I = 20.5 \pm 0.1$ mag point source. There are no
obvious optical counterparts for the faint submm source. In Fig. 1 the $I$–band
image is shown overlayed by the SCUBA contours.

The Galactic extinction of A478 is $E(B – V) = 0.52$ mag (Schlegel et
al 1998). Hence, the corrected $I$ magnitude is $19.5 \pm 0.1$ mag assuming a
Milky Way type extinction law with $R_V = 3.1$. All the optical observations
presented in the rest of this paper have been corrected accordingly.

To determine the redshift and the nature of SMMJ04135+1027 we have
obtained an optical spectrum also with FORS1. The spectrum was observed
in MOS mode with resolution $R = 150$. The spectrum exhibits the characteris-
tica of high redshift quasars, such as broad emission lines (e.g. Lyα, CIV,
CIII and SIIIV), Lyman Forest absorption bluewards of the Lyα emission line,
Figure 1. The I–image of A478 overlayed with the contours of the SCUBA 850 µm data. The contours each represent a step of 4 mJy. SMMJ04135+1027 is the very bright SCUBA source located SE of the center of the cluster. The other fainter possible submm source is located NE of the quasar and nearby the very bright star.

and a power law continuum. The redshift has been measured using the CII line to be 2.83 ± 0.01, which is consistent with the other emission lines. The spectrum is shown in Fig. 2. If omitting the correction for Galactic extinction, the quasar appears very red. When corrected, as mentioned above, the quasar has a colour similar to optically selected quasars (Francis et al. 1992).

3 Discussion

3.1 Optical spectrum

The spectrum shown in Fig. 2 shows a number of unusual features when compared to the QSO sample of Francis et al. (1992). In the first place, Lyα is strongly suppressed. The origin of the suppression may be continuum absorption by dust, or Lyα absorption associated with the QSO. A higher resolution spectrum is needed to distinguish between these possibilities. Secondly, the CIV emission line is remarkably strong with an equivalent width of 110 Å.
3.2 The Far–IR SED

The fluxes quoted here have not been corrected for the weak magnification arising from the gravitational lensing caused by the intervening galaxy cluster. In this case, no arcs are detected in the vicinity of the quasar, hence the gravitational magnification is expected to be small and achromatic.

We have plotted the two SCUBA data points together with four known far–IR SEDs (Klaas et al 1999, Haas et al 1998, Sodroski et al 1997). The four SEDs have been redshifted to the redshift of the quasar and scaled to the quasar flux at $\lambda_{\text{obs}} = 850 \, \mu m$. We see that the data points correspond well to the SEDs of the two starburst galaxies, Arp220 and the Antennae, and to the low–z QSO PG0050+124. The cool Milky Way type of dust can easily be ruled out. Shorter wavelength data would be needed to see if the hot dust component that is found in low–z QSOs such as PG0050+124 is also present in SMMJ04135+1027. For an Arp220 SED, the total luminosity of SMMJ04135+1027 is $3 \times 10^{13}L_\odot$.

3.3 Contribution of AGNs to the submm samples

A number of well-studied submm sources exhibit AGN features in their optical spectra (e.g. Ivison et al. 1998). These are also typically the brightest submm sources in the samples. However, the fraction of AGNs in submm samples is still a debated issue. Optical spectroscopy of the fainter submm sources has
Figure 3. The 850 µm and 450 µm data points overlayed with the redshifted far–IR SEDs of the Milky Way, Arp220, the Antennae and PG0050+124.

turned out to be very challenging, therefore it will be difficult to fully characterize the submm population with optical spectroscopy alone. As shown by Fig. 3, shorter wavelength IR data may be used to find QSO–like dust emission. The most promising method for finding AGNs in submm samples is by hard X–ray observations. A recent study with Chandra and SCUBA of the relation between the resolved X-ray background and the resolved FIR background finds almost no overlap between the two populations, which suggest that SCUBA sources primarily are powered by starburst (Fabian et al. 2000). This result then suggests that the fainter submm sources contain relatively few AGNs, and that the AGNs, that are present in the submm samples, are to be found at the bright submm flux levels.

References

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