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Clarifying the nature of the brightest submillimetre sources: interferometric imaging of LH 850.02

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ABSTRACT

We present high-resolution interferometric imaging of LH 850.02, the brightest 850- and 1200-μm submillimetre (submm) galaxy in the Lockman Hole. Our observations were made at 890 μm with the Submillimetre Array (SMA). Our high-resolution submm imaging detects LH 850.02 at $\gtrsim 6\sigma$ as a single compact (size $\lesssim$1 arcsec or $\lesssim$8 kpc) point source and yields its absolute position to ~0.2-arcsec accuracy. LH 850.02 has two alternative radio counterparts within the Submillimetre Common User Bolometer Array (SCUBA) beam (LH 850.02N and LH 850.02S), both of which are statistically very unlikely to be so close to the SCUBA source position by chance. However, the precise astrometry from the SMA shows that the submm emission arises entirely from LH 850.02N, and is *not* associated with LH 850.02S (by far the brighter of the two alternative identifications at 24 μm). Fits to the optical–infrared (IR) multicolour photometry of LH 850.02N and LH 850.02S indicate that both lie at $z \approx 3.3$, and are therefore likely to be physically associated. At these redshifts, the 24-μm-to-submm flux density ratios suggest that LH 850.02N has an Arp 220-type starburst-dominated far-IR spectral energy distribution (SED), while LH 850.02S is more similar to Mrk 231, with less dust enshrouded star formation activity, but a significant contribution at 24 μm (rest frame 5–6 μm) from an active nucleus. This complex mix of star formation and active galactic nucleus (AGN) activity in multicomponent sources may be common in the high-redshift ultraluminous galaxy population, and highlights the need for precise astrometry from high-resolution interferometric imaging for a more complete understanding.

Key words: galaxies: formation – galaxies: high-redshift – galaxies: starburst – cosmology: observations – submillimetre.

1 INTRODUCTION

It has been well established that up to half of the far-infrared (IR) extragalactic background is produced by dusty starbursts and active galactic nuclei (AGNs; Dwek et al. 1998; Fixsen et al. 1998; Hauser et al. 1998; Pei, Fall & Hauser 1999). A significant fraction of this background was resolved at 850 μm into discrete point sources (Smail, Ivison & Blain 1997; Barger et al. 1998; Hughes et al. 1998) by the Submillimetre Common User Bolometer Array (SCUBA; Holland et al. 1999) on the 15-m James Clerk Maxwell Telescope (JCMT). These so-called submillimetre galaxies (SMGs)

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are thought to be high-redshift ultraluminous IR galaxies (ULIRGs) and hyperluminous IR galaxies (see Chapman et al. 2005) that represent massive systems in the process of formation (Scott et al. 2002; Blain et al. 2004), and may dominate cosmic star formation for nearly the first half of the lifetime of the Universe ($z \gtrsim 1$; Blain et al. 1999, 2002).

Since their discovery a decade ago, a series of surveys using SCUBA at 850 μm (Barger, Cowie & Sanders 1999; Eales et al. 1999, 2000; Borys et al. 2002; Chapman et al. 2002; Cowie, Barger & Kneib 2002; Scott et al. 2002; Borys et al. 2003; Serjeant et al. 2003; Webb et al. 2003; Wang, Cowie & Barger 2004; Coppin et al. 2006; Knudsen et al. 2006; Knudsen, van der Werf & Kneib 2008) and mm instruments at longer wavelengths (Dannerbauer et al. 2004; Greve et al. 2004; Laurent et al. 2005; Scott et al. 2006, 2008; Bertoldi et al. 2007) have amassed catalogues of hundreds of SMGs. Unfortunately, the detailed study of these objects has been hindered somewhat by the poor angular resolution (∼11–18 arcsec) of current submillimetre (submm)/millimetre (mm) telescopes. This problem was first addressed via deep radio continuum surveys, which exploited the radio–far-IR correlation (see Condon 1992, for a review) in combination with statistical arguments (e.g. Ivison et al. 2002, 2007) to associate 1.4-GHz sources with the submm emission. Radio counterparts allowed SMGs to be localized with subarcsec precision and hence allowed a more detailed study of their properties. Optical spectroscopy of these radio-identified samples confirmed that SMGs lie preferentially at high redshift (median $z \sim 2.3$; Chapman et al. 2005) and enabled CO spectroscopy which revealed them to be compact, massive, gas-rich, possibly merging systems (e.g. Neri et al. 2003; Sheth et al. 2004; Greve et al. 2005; Kneib et al. 2005; Tacconi et al. 2006).

Despite the undoubted success of deep radio imaging of SMGs, there is still a clear need for high-resolution *submm/mm* observations of at least a subset of the SMGs found in current, complete samples. Specifically, two classes of object require such observations to locate the source of the submm emission with the required astronomical precision for optical/IR follow-up.

First, because of the rapid dimming of the radio continuum with redshift ($I_\nu \sim (1+z)^{\alpha-3}$, $\alpha = -0.8$, where $I_\nu \propto \nu^\alpha$; Condon 1992), even the deepest existing radio imaging is relatively insensitive to SMGs at $z \gtrsim 3$; as a result, typically only around two thirds of SMGs have been detected at radio wavelengths (Ivison et al. 2002). Other techniques (Ashby et al. 2006; Pope et al. 2006) have been suggested, which make use of data from the Infrared Array Camera (IRAC; Fazio et al. 2004), in combination with 24-μm observations using the Multiband Imaging Photometer (MIPS; Rieke et al. 2004), on board the *Spitzer Space Telescope* to select counterparts. However, they too may have hidden biases which are difficult to quantify, and the only unambiguous way to select the correct optical counterparts for these radio-unidentified SMGs is via time-intensive submm/mm high-resolution interferometric imaging. Interferometric observations at mm (Downes et al. 1999; Frayer et al. 2000; Dannerbauer et al. 2002; Genzel et al. 2003; Greve et al. 2005; Tacconi et al. 2006; Dannerbauer, Walter & Morrison 2008) and submm (Iono et al.2006;Wang et al.2007, see also Iono et al., in preparation) wavelengths have successfully detected a growing catalogue of SMGs (in the process also confirming the reliability of the radio–submm association where an unambiguous radio counterpart has already been discovered). Most recently, Younger et al. (2007) followed up a flux-limited sample of seven mm-selected SMGs detected by the Astronomical Thermal Emission Camera (AzTEC; Wilson et al. 2008) at the JCMT – including five without reliable radio identifications – at 890 μm with the Submillimetre Array (SMA; Ho, Moran & Lo 2004), the counterparts of which suggested a population of very luminous SMGs at higher redshift than radio-identified samples (see also Yun et al., in preparation). That this bright (median 890-μm flux density 12.0 mJy), AzTEC-selected sample contains a significant high-redshift tail of SMGs supports earlier evidence that the brightest SMGs may be the most distant (e.g. Dunlop 2001; fig. 9 of Ivison et al. 2002).

Secondly, within the radio-identified subsamples of SMGs there remains some confusion. Specifically, there exists a statistically significant fraction of SMGs which possess more than one statistically robust radio counterpart (∼20 ± 5 per cent; Ivison et al. 2007). Monte Carlo simulations suggest that these associations are observed significantly more frequently than would be expected from chance associations. The nature of these multiply identified SMGs remains somewhat uncertain, although the steepness of the SMG number counts suggests that the bright submm sources are only rarely expected to arise from the blending/confusion of more moderate luminosity subcomponents. Interferometric imaging of the rest-frame far-IR continuum offers the best way to investigate the true nature of these interesting systems by precisely locating the source of the submm emission (see e.g. SMM J094303+4700 H6 and H7; Tacconi et al. 2006).

In this paper, we present high-resolution SMA 890-μm interferometric imaging of LH 850.02/LH 1200.04 (hereafter simply LH 850.02), the brightest source in both the Max-Planck Millimetre Bolometer (MAMBO) 1200-μm (Greve et al. 2004) and SCUBA 850-μm (Coppin et al. 2006) maps of the Lockman Hole (LH). In Section 3 we describe our observations and data reduction, and in Section 4 we discuss some possible implications of our results. Throughout this paper, we use the Vega magnitude system, and assume a flat concordance cosmology with $(\Omega_\mathrm{m}, \Omega_\Lambda, H_0) = (0.3, 0.7, 70\,\mathrm{km\,s^{-1}\,Mpc^{-1}})$.

2 TARGET SELECTION

SHADES (SCUBA Half Degree Extragalactic Survey) is a wide-area blank-field submm survey, covering both the LH and Subaru/*XMM–Newton* Deep Field (SXDF), undertaken using SCUBA on the JCMT between 2002 and 2005 (Dunlop 2005; Mortier et al. 2005). The map of the LH region covers an area of 485 arcmin^2, mostly to an rms noise level of 2.2 mJy beam^{-1}. The field has extensive complementary observations, including 1.4-GHz radio continuum imaging from the Very Large Array (VLA) to an rms noise level of 4.2 μJy beam^{-1} (Ivison et al. 2002, 2007; Biggs & Ivison 2006), *Spitzer*/IRAC and MIPS 3.6- and 24-μm imaging to 5σ sensitivity limits of 1.3 and 55 μJy, respectively (Egami et al. 2004, also in preparation; Huang et al. 2004), and *R*-band optical imaging with the 8-m Subaru telescope to a 3σ depth of 27.9 mag (in a 2-arcsec aperture; see Ivison et al. 2004). Finally, additional multifrequency optical (B, R, I, z) imaging of the LH has now been obtained with the Subaru 8-m telescope, and a *K*-band image is now available from Deep Extragalactic Survey component of the UKIRT (United Kingdom Infrared Telescope) Deep Infrared Sky Survey (see Dye et al. 2008 for details).

The target, LH 850.02, is the brightest SMG in the SHADES LH sample (deboosted flux density of $S_{850\,\mu\mathrm{m}} = 13.4 \pm 2.1$ mJy) and was detected at 6.8σ significance with SCUBA (Coppin et al. 2006). It was first discovered as a 5.7σ MAMBO source ($S_{1200\,\mu\mathrm{m}} = 5.7 \pm 1.0$ mJy; Greve et al. 2004), and was included in the Ivison et al. (2005) sample of 'robust' SMGs. It is also the brightest 1100-μm SHADES-AzTEC source in the area covered by both SCUBA and MAMBO (Austermann et al., in preparation), but is

Table 1. Optical–radio photometry for the two faint galaxies associated with the alternative radio counterparts to LH 850.2. Upper limits are quoted at the 3σ level.

Band	LH 850.02N (μJy)	LH 850.02S (μJy)
B	<0.04	0.72 ± 0.01
R	0.11 ± 0.01	0.29 ± 0.02
I	0.16 ± 0.01	0.44 ± 0.03
z	0.07 ± 0.03	0.55 ± 0.04
K	<7.0	<7.0
3.6 μm	6.3 ± 0.18	6.6 ± 0.17
4.5 μm	10.2 ± 2.3	9.8 ± 2.3
5.8 μm	9.1 ± 4.6	10.2 ± 4.9
8.0 μm	11.5 ± 4.8	11.1 ± 4.6
24 μm	<55	545 ± 31
850 μm	13400 ± 2400	. . .
890 μm	12800 ± 2000	<6000
1200 μm	5700 ± 1000	. . .
20 cm	40.7 ± 5.6	52.4 ± 5.2

not detected in the extremely deep (∼600 ks) *XMM–Newton* imaging of the LH (Brunner et al. 2008).

There are two candidate 1.4-GHz radio continuum counterparts within the SCUBA beam identified by Ivison et al. (2007): a northern candidate with flux density $S_{1.4\,\mathrm{GHz}} = 40.7 \pm 5.6\,\mu$ Jy (LH 850.02N: 3.5-arcsec offset, $P = 0.97$ probability of association), and a southern candidate with $S_{1.4\,\mathrm{GHz}} = 52.4 \pm 5.2\,\mu$ Jy (LH 850.02S: 3.5-arcsec offset, $P = 0.98$). Imaging at 610 MHz with the Giant Metrewave Radio Telescope (Ibar et al., in preparation) fails to separate the two 1.4-GHz emitters, but shows a clear detection with a peak flux density of 140 μJy beam^{-1} and total integrated flux of 277 μJy. In a matched-resolution 1.4-GHz image, we find a source with a peak flux density of 57 μJy beam^{-1} and total integrated flux of 97 μJy, making LH 850.02 a fairly steep spectrum radio source ($\alpha = -1.3$), marginally consistent with a starburst ($\alpha \approx -0.8$; Condon 1992), and possibly analogous to high-redshift radio galaxies (e.g. De Breuck et al. 2000), though orders of magnitude fainter.

Finally, we can exploit multiwavelength photometry (see Table 1) of the LH 850.02 system to gain some insight into the nature of SMGs with multiple radio counterparts, which make up ∼10 per cent of the SMG population (Ivison et al. 2002; Pope et al. 2006) and ∼20 per cent of radio-identified SMGs (Ivison et al. 2007). Photometric redshifts derived from optical and near-IR photometry (see Fig. 1; Dye et al. 2008) indicate that LH 850.02N ($z = 3.41^{+0.10}_{-0.15}$) and LH 850.02S ($z = 3.23^{+0.11}_{-0.47}$) may be physically associated. Furthermore, it is unlikely that LH 850.02N and S are duplicate images of a strongly lensed object because they have very different mid-IR spectral energy distributions (SEDs) – LH 850.02S has 24-μm emission – and their substantial relative separation (∼6 arcsec) would require a very strong lensing potential (see e.g. Grogin & Narayan 1996; Keeton et al. 2000).

While the slightly more northerly position of the MAMBO detection favours LH 850.02N (Ivison et al. 2005), statistical arguments and a strong MIPS detection favour LH 850.02S (e.g. Ashby et al. 2006; Pope et al. 2006); these ambiguous multiwavelength counterparts make LH 850.02 a compelling target for high-resolution submm imaging. As we will make use of it later in this work, we present the multiwavelength photometry for both LH 850.02N and LH 850.02S in Table 1.

3 OBSERVATIONS AND DATA REDUCTION

The SMA observations were performed during 2007 March in the compact configuration (beam size ∼2 arcsec) in excellent weather ($\tau_{225\,\mathrm{GHz}} \lesssim 0.08$) with a total on-source integration time of approximately 6 h. The upper sideband (USB) was tuned to 345 GHz, and combined with the lower sideband (LSB) for an effective bandwidth of ∼4 GHz at 340 GHz, which yielded a final synthesized image rms of 1.95 mJy. The pointing centre was the original SCUBA position from Coppin et al. (2006): α (J2000) = $10^{\mathrm{h}}52^{\mathrm{m}}57\overset{\mathrm{s}}{.}32$ and δ (J2000) = $+57^{\circ}21'05\overset{''}{.}8$. The data were calibrated using the MIR software package (Scoville et al. 1993), modified for the SMA. Passband calibration was done using 3C 84, 3C 111 and Callisto. The absolute flux scale was set using observations of Callisto and is estimated to be accurate to better than 20 per cent. Time-dependent complex gain calibration was done using 0958+655 (0.6 Jy, 21.8° away) and 0927+390 (1.8 Jy, 37.7° away). The calibrator 0958+655 was also calibrated independently using 0927+390 and used for empirical verification of the astrometric uncertainty and the angular size of the target. Positions and flux densities were derived from the calibrated visibilities using the MIRIAD (Sault, Teuben & Wright 1995) software package.

We detect LH 850.02 in the synthesized image at $\gtrsim 6\sigma$. The calibrated visibilities were best fit by a single point source (see Figs 2 and 3) with an integrated flux density of $S_{890\,\mu\mathrm{m}} = 12.8 \pm 2.0$ mJy at a position of α (J2000) = $10^{\mathrm{h}}52^{\mathrm{m}}57\overset{\mathrm{s}}{.}162$ and δ (J2000) = $+57^{\circ}21'07\overset{''}{.}97$, which is offset from the original SCUBA position by 3.28 arcsec. The astrometric uncertainties are $\Delta\alpha = 0.24$ arcsec

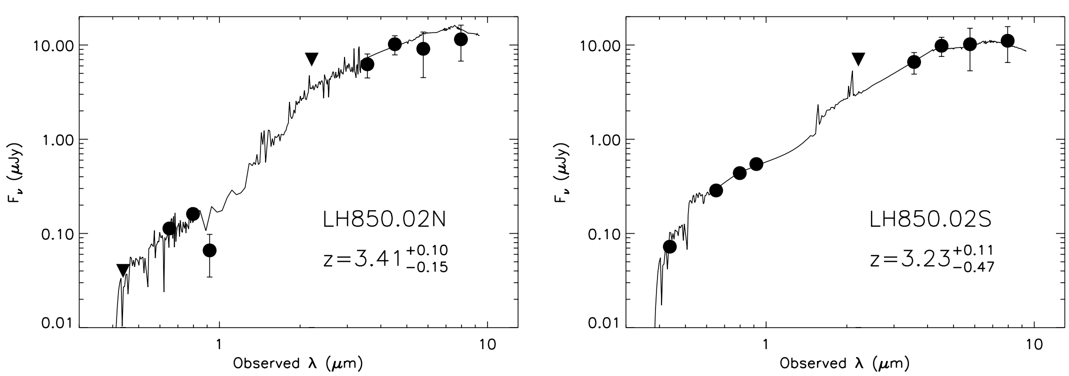

Figure 1. Optical and near-IR photometry for LH 850.02N and LH 850.02S, along with fits to their SEDs, and photometric redshifts (Dye et al. 2008). Downward arrows indicate upper limits.

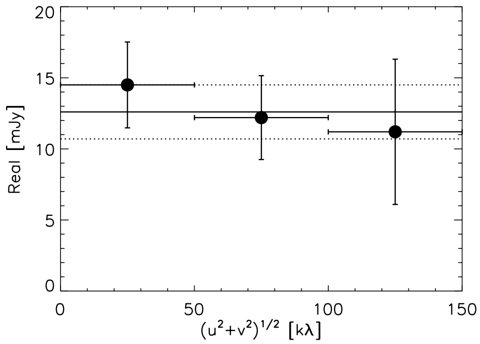

Figure 2. The real visibility amplitudes versus projected baseline $[(u^2 + v^2)^{1/2}]$, centred on the position of LH 850.02. They indicate that the submm emission is not resolved by the SMA out to $\sim$120 kλ. This sets an upper limit on the angular scale of the source to $\lesssim$1 arcsec.

(0.20 arcsec systematic; 0.13 arcsec statistical) and $\Delta\delta = 0.22$ arcsec (0.19 arcsec systematic; 0.10 arcsec statistical), in agreement with the expectations of Downes et al. (1999) and Younger et al. (2007).

4 DISCUSSION

The synthesized SMA image (see Fig. 3) clearly shows a single point source within the SCUBA beam. As noted in Section 3, this source is offset from the SCUBA centroid by 3.28 arcsec, as compared to the 1σ SCUBA positional uncertainty of 2.1 arcsec ($\sigma \sim 0.91\,\theta/(\mathrm{S/N})$, where θ is the SCUBA beam full width at half-maximum (FWHM) of 14 arcsec and S/N is the signal-to-noise ratio, corrected for flux boosting; Ivison et al. 2007). The point-source fit to the visibility data ($S_{890\,\mu\mathrm{m}} = 12.8 \pm 2.0$ mJy) is perfectly consistent with the expectation from the deboosted SCUBA flux of $S_{850\,\mu\mathrm{m}} = 13.4 \pm 2.1$ mJy (13.1 $\pm$ 2.3 mJy when centred on the SMA position), assuming a reasonable range of spectral slopes and temperatures ($S_\nu \propto B_\nu(T)\,\nu^\beta$; $\beta \approx 1-2$, $T \approx$ 20–60 K). This supports the compactness of the submm emission seen in the visibility function (see Fig. 2); virtually none of the flux seen in the SCUBA map has been resolved out.

In Fig. 3, we present (from left to right) the SMA 'dirty' map and the derived submm position overlaid on optical (*R* band), IRAC 3.6-μm, MIPS 24-μm and VLA 1.4-GHz imaging data. The SMA image clearly singles out the weaker of the two candidate radio counterparts, and this is the one which is *not* associated with the bright 24-μm source.[1] This is consistent with the photometric redshift of LH 850.02N if we assume a starburst-dominated mid-IR spectrum similar to local ULIRGs (e.g. Armus et al. 2007; Desai et al. 2007), analogous $z \sim 2$ systems (e.g. Weedman et al. 2006; Farrah et al. 2008, Huang et al., in preparation), or other SMGs (Lutz et al. 2005; Menéndez-Delmestre et al. 2007; Valiante et al. 2007).

The SCUBA and SMA imaging data – including upper limits at the location of LH 850.02S – are marginally consistent with the observed far-IR SEDs of two luminous starbursts at $z \sim 4$ (LH 850.02N) and $z \sim 2$ (LH 850.02S), respectively. However, SMA imaging in combination with optical/near-IR photometric redshifts for both sources favours a scenario in which the submm emission from LH 850.02 arises almost entirely from LH 850.02N and is not a blend of two lower luminosity sources. This is consistent with the predicted rarity of SMGs arising from confusion (Ivison et al. 2007). At these redshifts, their 24-μm-to-submm ratios (see also Wang et al. 2007) suggest that LH 850.02N has an Arp 220-type starburst-dominated far-IR SED, while LH 850.02S has a Mrk 231-type far-IR SED with a significant contribution from a warmer dust component such as a warm starburst (optically faint radio galaxies, OFRGs; Chapman et al. 2004b) or active nucleus. This is qualitatively similar to SMM J094303+4700 (Tacconi et al. 2006), in which only one of the two radio counterparts (H6; Ledlow et al. 2002) shows strong CO emission, which could be explained by AGN heating of the dust in the intrinsically CO poor radio source (H7). Therefore, LH 850.02 and, by analogy many other SMGs with multiple radio identifications, may be physically associated systems in which the SMG starburst phase is associated with a period of intense AGN activity (Sanders & Mirabel 1996; Page et al. 2004; Hopkins et al. 2006).

Furthermore, although the relatively low S/N ($\sim$6σ) limits the robustness of size measurements, the visibility function (Fig. 2) for LH 850.02 is consistent with a compact point source out to $\sim$120 kλ, from which we infer a maximum angular extent of $\lesssim$1 arcsec; similar to other SMGs detected by SMA at 890 μm (Iono et al. 2006; Wang et al. 2007; Younger et al. 2007) and others observed at mm wavelengths (Greve et al. 2005; Tacconi et al. 2006). At a redshift of $z \approx$ 3–3.5, this corresponds to a physical scale for the rest-frame far-IR continuum of $\lesssim$8 kpc, consistent with a merger-driven starburst analogous to local ULIRGs(Downes & Solomon 1998; Sakamato et al.1999; Sakamato, Ho & Peck 2006; Iono et al.2007,see also Iono et al., in preparation; Wilson et al., in preparation), and may be in conflict with cool, extended cirrus dust models (Efstathiou & Rowan-Robinson 2003; Kaviani, Haehnelt & Kauffmann 2003) or a monolithic collapse scenario. Our constraints on size are only barely consistent with extended ($\sim$1 arcsec) starbursts of the kind inferred from high-resolution radio imaging – though some sources are reported as compact even at $\sim$0.2 arcsec resolution (Chapman et al. 2004a; Biggs & Ivison 2008).

We can then use the observed submm-to-radio flux density ratio, coupled with photometric redshift and observed constraints on the physical scale of the rest-frame far-IR to infer some of the physical properties of the starburst. Fig. 4 shows the submm-to-radio flux density ratio $S_{890\,\mu\mathrm{m}}/S_{1.4\,\mathrm{GHz}}$ for LH 850.02, as compared to the possible high-redshift SMGs from Younger et al. (2007), SMGs with optical redshifts from Chapman et al. (2005), tracks for Arp 220, the models of Dale & Helou (2002) and the median radio-quiet quasar spectral energy distribution from Elvis et al. (1994). The observed submm-to-radio flux density ratio of LH 850.02N indicates a dust temperature of $\sim$60 K, which is consistent with the observed compactness of the submm emission (see Kaviani et al. 2003). Using the template SEDs of Dale & Helou (2002) for this best-fitting dust temperature at the photometric redshift of $z \approx 3.3$, we find that the observed submm emission of $S_{890\,\mu\mathrm{m}} = 12.8$ mJy corresponds to a total IR luminosity of $L \sim 2 \times 10^{13}\,\mathrm{L}_\odot$, which – assuming a Salpeter (1955) initial mass function (IMF) – indicates a total star formation rate (SFR) of $\sim$3000 $\mathrm{M}_\odot\,\mathrm{yr}^{-1}$ (Kennicutt 1998; Bell 2003). Should even higher resolution imaging place tighter limits on the physical scale of the submm emission in LH 850.02N, such a confined, luminous starburst may have important physical consequences; Eddington arguments (e.g. Murray, Quataert & Thompson 2005; Thompson, Quataert & Murray 2005) suggest a minimal scale for such regions.

Finally, considering its far-IR luminosity and compactness, the lack of detectable 24-μm emission, and its observed submm-to-radio

[1] There is a $\sim$2σ peak nearly coincident with LH 850.02S; the 3σ upper limit is listed in Table 1. However, we note that the primary detection accounts entirely for the SCUBA flux.

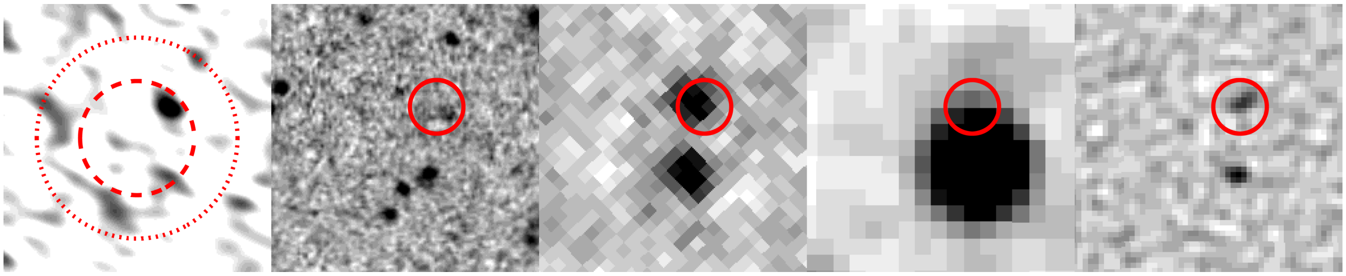

Figure 3. Postage stamp images, centred on the SMA phase centre position of LH 850.02, which is the original SCUBA centroid from Coppin et al. (2006). From left to right: SMA 890-μm, Subaru *R* band, IRAC 3.6-μm, MIPS 24-μm and VLA 1.4-GHz imaging. The red dotted line indicates the FWHM of the SCUBA beam, and the red dashed line indicates the 2σ positional uncertainty (Ivison et al. 2007). The synthesized beam size is 2.3 × 1.3 arcsec^2 with a position angle of 60°. The red circle is 4 arcsec in diameter, roughly twice the SMA beam size, and the stamps are 20 arcsec on a side. The SMA clearly identifies one compact point source as the origin of the submm emission.

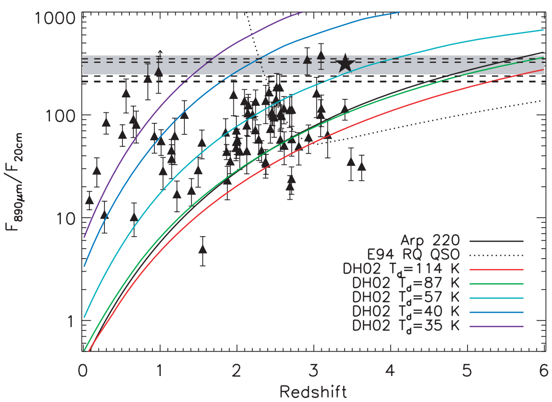

Figure 4. The submm-to-radio flux density ratio versus redshift for LH 850.02 (grey region), and possible high-redshift SMGs (dashed lines) from Younger et al. (2007). For comparison, we show the model track for Arp 220 (black line), and the models of Dale & Helou (2002) for a range of dust temperatures: $T_{\rm dust} = 114$, 87, 57, 40 and 35 K, where $T_{\rm dust}$ is inferred from the $F_{60\,\mu\rm m}/F_{100\,\mu\rm m}$ flux density ratio. The shaded region shows the observed flux density ratio of LH 850.02N, and the star indicates its photometric redshift. The black triangles are SMGs with optical redshifts from Chapman et al. (2005). Also shown is a model track (dotted line) for the median radio-quiet quasar from Elvis et al. (1994).

flux density ratio, we find that LH 850.02 appears to share many of the observed characteristics of other putative high-redshift SMGs (Iono et al. 2006; Wang et al. 2007; Younger et al. 2007; Dannerbauer et al. 2008). As discussed in more detail in Younger et al. (2007), the existence of such a population provides tight constraints on models of galaxy formation and evolution, and on dust production. In addition, it fuels speculation that the brightest SMGs may be the most distant (see also Ivison et al. 2002) and suggests significant and rapid down-sizing (e.g. Cowie et al. 1996) in the SMG population over a relatively short interval in cosmic time (see also Wall, Pope & Scott 2008).

5 CONCLUSION

We present high-resolution 890-μm interferometric imaging of LH 850.02, a bright SMG in the LH, with the SMA. We detect LH 850.02 at $\gtrsim 6\sigma$ as a single compact (size $\lesssim 1$ arcsec, or $\lesssim 8$ kpc) point source, and determine a position accurate to $\sim$0.2 arcsec. From this, we identify multiwavelength counterparts and find that only one (LH 850.02N) of two candidate radio counterparts is associated with the submm emission. The nearby radio source with strong 24-μm emission (LH 850.02S) does *not* contribute significantly to the submm flux. In this case, and by analogy other SMGs with multiple radio counterparts, the radio continuum more reliably locates the source of the submm – and with it the properties of the associated starburst – than does the mid-IR; similar to the results of Younger et al. (2007). Since both radio sources have similar photometric redshifts, and therefore may be physically associated, their respective 24-μm-to-submm suggest that LH 850.02N has an Arp 220-type starburst-dominated far-IR SED, while LH 850.02S has a Mrk 231-type SED with a significant mid-IR contribution from an active nucleus.

As a result of the relatively shallow, wide-field surveys conducted to date with the AzTEC – wherein objects of this type were first found in significant numbers (Younger et al. 2007) – existing 1100-μm samples are typically $\gtrsim 2\times$ brighter than samples selected with SCUBA or MAMBO. We suggest that the recent prevalence of candidate high-redshift SMGs is more closely related to their high flux densities than to the long survey wavelength, a tendency noted by Ivison et al. (2002) and Wall et al. (2008). It is therefore perhaps not surprising that we have here constrained the brightest source in the SHADES of the LH, LH 850.02, to lie at high redshift $z \gtrsim 3$.

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