Erratum:``The spatial clustering of ultraluminous infrared galaxies over 1.5 < z < 3" (ApJ 641, L17 [2006])

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ERRATUM: "THE SPATIAL CLUSTERING OF ULTRALUMINOUS INFRARED GALAXIES OVER $1.5 < z < 3$" (ApJ 641, L17 [2006])

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In the above-mentioned Letter, an error in the conversions between A and r_0 was pointed out to us by E. Daddi. The original correlation lengths were quoted for a different value of H_0 and were computed including a spurious factor of $1 + z$. The correlation lengths for the B2 and B3 galaxies should be $r_0 = 9.40 \pm 2.24$ and $r_0 = 14.40 \pm 1.99\ h^{-1}$ Mpc, respectively. As a result, some aspects of the abstract and discussion need correcting. The revised abstract should read as follows:

"We present measurements of the spatial clustering of galaxies with stellar masses $\gtrsim 10^{11}\ M_\odot$, infrared luminosities $\gtrsim 10^{12}\ L_\odot$, and star formation rates $\gtrsim 200\ M_\odot$ yr^{-1} in two redshift intervals: $1.5 < z < 2.0$ and $2 < z < 3$. Both samples cluster very strongly, with spatial correlation lengths of $r_0 = 14.40 \pm 1.99\ h^{-1}$ Mpc for the $2 < z < 3$ sample and $r_0 = 9.40 \pm 2.24\ h^{-1}$ Mpc for the $1.5 < z < 2.0$ sample. These clustering amplitudes are consistent with both populations residing in dark matter halos with masses of $\sim 6 \times 10^{13}\ M_\odot$, making them among the most biased galaxies at these epochs. We infer, from this and previous results, that a minimum dark matter halo mass is an important factor for all forms of luminous, obscured activity in galaxies at $z > 1$, both starbursts and active galactic nuclei. Adopting plausible models for the growth of dark matter halos with redshift, the halos hosting the $2 < z < 3$ sample will likely host the richest clusters of galaxies at $z = 0$, whereas the halos hosting the $1.5 < z < 2.0$ sample will likely host poor to rich clusters at $z = 0$. We conclude that ultraluminous infrared galaxies (ULIRGs) at $z \gtrsim 1$ signpost stellar buildup in galaxies that will reside in clusters at $z = 0$, with ULIRGs at increasing redshifts signposting the buildup of stars in galaxies that will reside in increasingly rich clusters."

The last two paragraphs of the discussion should read as follows:

"Considering these uncertainties, care must be taken when comparing the models to observed galaxy correlation lengths. With this in mind, we use Figure 2 to explore the relationships between our samples, the underlying dark matter (DM), and other galaxies. Considering first other measured or predicted correlation lengths at the same redshift, both samples are very strongly clustered, with correlation lengths much higher than that predicted for the overall DM distribution at their respective epochs. Both B2 and B3 sources cluster significantly more strongly than optical QSOs at their respective epochs, and B3 sources cluster more strongly than submillimeter-selected galaxies. Based on the Matarrese et al. (1997) models, we derive *approximate* 1 σ halo mass ranges of $10^{13.7} < M_\odot < 10^{14.1}$ for the B3 sources and $10^{13.5} < M_\odot < 10^{13.9}$ for the B2 sources.

The most interesting comparison, however, is between the two samples themselves. The clustering evolution of QSOs with redshift (Croom et al. 2005) may mean that there is a 'minimum' host halo mass for QSO activity, below which no QSO is seen, of $\sim 5 \times 10^{12}\ M_\odot$. The correlation lengths for the B2 and B3 samples are consistent with the same conclusion but for a higher halo mass, tracing the clustering line for a $\sim 6 \times 10^{13}\ M_\odot$ DM halo. Interestingly, from Figure 2 we would draw a similar conclusions for optically faint Lyman break galaxies (LBGs), albeit for a halo mass of $\sim 10^{12}\ M_\odot$ (see also Adelberger et al. 2005). Taken together, these results imply that a minimum halo mass is an important threshold factor for *all* forms of very luminous activity in galaxies, both starbursts and active galactic nuclei (AGNs). It is also interesting to speculate on what the host halos of B2 and B3 sources contain at lower and higher redshifts. We might expect that a halo hosting a B3 source could contain an optically bright LBG at $z \sim 4$ when its mass is $\sim 10^{13.2}\ M_\odot$, followed by a B3 at $z \sim 2.5$ once the halo has reached $\sim 10^{14}\ M_\odot$, possibly accompanied by other (near-IR–selected) star-forming systems (Daddi et al. 2004, 2005), before evolving into host an extremely rich galaxy cluster at low redshifts, with a halo mass substantially exceeding $10^{15}\ M_\odot$. The occupants of a halo hosting a B2 galaxy, however, would probably be different. We would expect that such a halo could contain an SMG at $z \sim 2.5$ and optically fainter LBGs at $4 < z < 5$ (although probably not LBGs at $z \sim 3$). At lower redshifts, such a halo might host a radio-bright AGN and/or ERO at $z \sim 1$, and a (poor to rich) cluster at $z = 0$. These evolutionary paths for the B2 and B3 sources are consistent with semianalytic models and numerical simulations (Governato et al. 1998; Nagamine 2002) predicting that LBGs at high redshift evolve into local clusters. We conclude that ULIRGs at $z \gtrsim 1.5$ as a class likely signpost stellar buildup in galaxies in clusters at $z = 0$, with higher redshift ULIRGs signposting stellar buildup in galaxies that will reside in more massive clusters at lower redshifts. These predictions, however, are sensitive to the assumed form of DM halo growth and should be regarded with caution."

We also include a revised version of Figure 2.

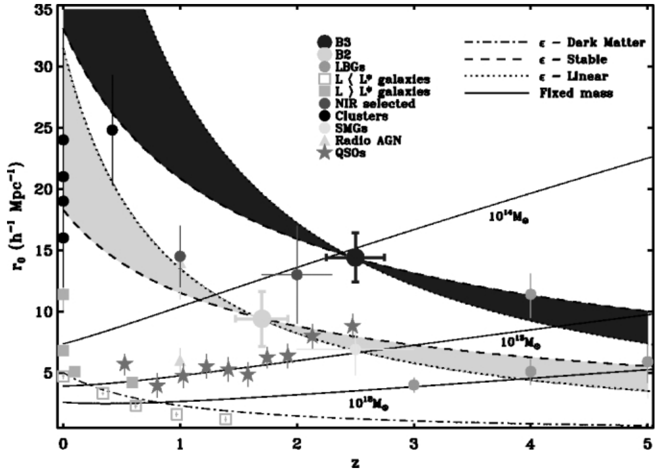

FIG. 2.—Comoving correlation length, r_0, vs. redshift. Other data are taken from Moscardini et al. (1998), Overzier et al. (2003), Daddi et al. (2004), Blain et al. (2004), Ouchi et al. (2004), Adelberger et al. (2005), Croom et al. 2005; Georgakakis et al. (2005), and Allen et al. (2005). The fixed mass lines show the predicted clustering amplitude of halos of a given mass at any particular redshift, whereas the ϵ lines show the predicted clustering amplitude of an individual halo for three halo growth models, described in the text. The stable and linear lines give a qualitative indicator of the range of how DM halos may grow with redshift, and we have normalized stable and linear lines to the clustering amplitudes of the B2 and B3 sources. The shaded regions therefore indicate what these halos may host at lower and higher redshifts—the halos hosting B3 sources may contain an optically bright LBG at $z \simeq 4$ (*upper green circle*) and may grow to host very rich galaxy clusters at $z = 0$, whereas the halos hosting B2 sources may contain optically fainter LBGs at $4 < z < 5$, SMGs at $z \sim 2.5$, radio-bright AGNs (*upper pink triangle*) and (old) EROs at $z \simeq 1$, and poor to rich clusters at $z = 0$. [*See the electronic edition of the Journal for a color version of this figure.*]

Online material: color figure

REFERENCES

Adelberger, K. L., Steidel, C. C., Pettini, M., Shapley, A. E., Reddy, N. A., & Erb, D. K. 2005, ApJ, 619, 697
Allen, P. D., Moustakas, L. A., Dalton, G., MacDonald, E., Blake, C., Clewley, L., Heymans, C., & Wegner, G. 2005, MNRAS, 360, 1244
Blain, A. W., Chapman, S. C., Smail, I., & Ivison, R. 2004, ApJ, 611, 725
Croom S. M., et al. 2005, MNRAS, 356, 415
Daddi, E., et al. 2004, ApJ, 600, L127
———. 2005, ApJ, 631, L13
Georgakakis, A., Afonso, J., Hopkins, A. M., Sullivan, M., Mobasher, B., & Cram, L. E. 2005, ApJ, 620, 584
Governato, F., Baugh, C. M., Frenk, C. S., Cole, S., Lacey, C. G., Quinn, T., & Stadel, J. 1998, Nature, 392, 359
Matarrese, S., Coles, P., Lucchin, F., & Moscardini, L. 1997, MNRAS, 286, 115
Moscardini, L., Coles, P., Lucchin, F., & Matarrese, S. 1998, MNRAS, 299, 95
Nagamine, K. 2002, ApJ, 564, 73
Ouchi, M., et al. 2004, ApJ, 611, 685
Overzier, R. A., Röttgering, H. J. A., Rengelink, R. B., & Wilman R. J. 2003, A&A, 405, 53