SED diagnostics of submillimetre galaxies

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Abstract

We apply an evolutionary SED model of starbursts to submm galaxies, in order to predict the present-day colour, magnitude, and size of submm galaxies. The reproduced colour-magnitude and size-magnitude relation of present-day descendants of submm galaxies suggest that they are progenitor of L^* elliptical galaxies on average, if the IMF of submm galaxies is slightly flatter than the Salpeter IMF.

1 Introduction

Submillimetre (submm) galaxies are thought to be the most plausible candidate of progenitors of elliptical galaxies at high redshifts. The comoving number density of submm galaxies with the 850 μm flux of > 8 mJy is comparable to that of present-day ellipticals with $L \sim 3 - 4\ L^*$ (Scott et al. 2002). A tentative detection of strong clustering also indicates the evolutionary link between submm galaxies and elliptical galaxies (see the contribution by Blain et al.). In this paper, we present a new clue to the evolutionary link between submm galaxies and elliptical galaxies, by using an evolutionary model of spectral energy distribution (SED) for starbursts [1]. This model is verified with observations of nearby starbursts. We derive the colour-magnitude and the size-magnitude relation of present-day descendants of submm galaxies. These scaling relations should be consistent with those of elliptical galaxies if submm galaxies are the real progenitors of elliptical galaxies.

2 Evolutionary SED Model of Starbursts

We approximated the star formation history of submm galaxies with the gas infall model, and solved the chemical evolution. The starburst regions were as-

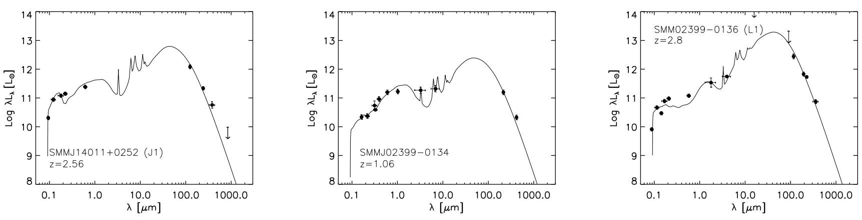

Figure 1: Example of the result of SED fitting

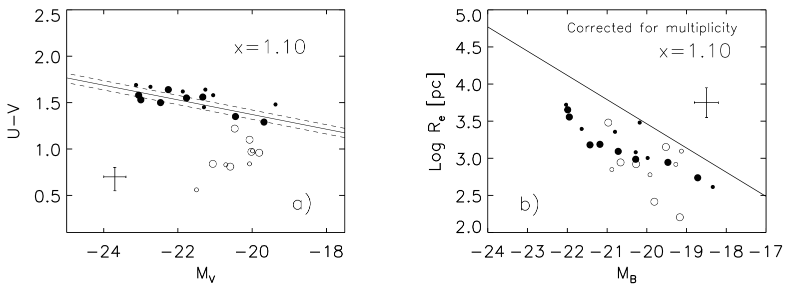

Figure 2: The reproduced scaling relations of the present-day descendants of submm galaxies. Solid lines indicate the observed scaling relations of elliptical galaxies. (a) The colour-magnitude relation. Solid and open circles indicate older submm galaxies with age of $t/t_0 > 1.0$, where t_0 is the evolutionary time-scale of starbursts, and younger ones ($t/t_0 \leq 1.0$), respectively. Larger and smaller circles indicate the samples with the spectroscopic redshift and those with the photometric redshift, respectively. (b) The size-magnitude relation. The symbols are the same as (a). The derived sizes are corrected for the multiplicity of starburst regions in massive submm galaxies.

sumed to have centrally concentrated stars and homogeneously distributed dust. With this geometry, we solved the equations of radiative transfer, considering the temperature fluctuation of very small grains. The main parameters of this SED model are the starburst age and the size of the starburst region.

3 Results and Conclusions

We analysed 30 submm galaxies, including extremely red objects and host galaxies of gamma ray bursts, of which 18 have spectroscopic redshifts. Examples of the result of SED fitting are shown in Fig.1. From the SED fitting, we derived the intrinsic properties of starbursts in submm galaxies, such as the starburst age, the stellar mass, and the mean stellar metallicity.

Based on the results of the SED fitting, we derived the colour-magnitude and the size-magnitude relation of present-day descendants of submm galaxies. We assumed that the effect of star formation after the observed epoch is not significant. This assumption is safe specifically for older submm galaxies.

We found that the present-day colours and magnitudes of older submm galaxies are consistent with the colour-magnitude relation of elliptical galaxies (Fig.2a), if the initial mass function (IMF) of submm galaxies has the power-law index of $x = 1.10$ ($x = 1.35$ for the Salpeter IMF). The mean present-day magnitude of submm galaxies corresponds to that of L^* elliptical galaxies. From the comparison of the size-magnitude relation, we found that massive submm galaxies tend to be smaller than elliptical galaxies with the similar mass. This suggests that massive submm galaxies may consist of multiple starbursts, which could eventually merge into more diffuse stellar systems. Once the effect of multiplicity is corrected, the present-day size-magnitude relation of submm galaxies becomes similar to that of elliptical galaxies (Fig.2b). These reproduced scaling relations suggest that submm galaxies are quite likely to evolve into elliptical galaxies after the starburst.

References

[1] T. Takagi, N. Arimoto, H. Hanami: MNRAS **340**, 813