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NEAR-INFRARED FAINT GALAXIES IN THE SUBARU DEEP FIELD: IMPLICATIONS FOR EBL AND EROS

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RESUMEN

El Campo Profundo del Subaru (CPS) proporciona la muestra más profunda de galaxias de alto z seleccionadas en K. Se comparan los recuentos del CPS, los colores y la distribución de tamaños en las bandas del infrarrojo cercano con los modelos de evolución pura de luminosidad (EPL) y con modelos CDM de fusión jerárquica (FJ). El flujo integrado de los recuentos es apenas la tercera parte del flujo reportado para la radiación cósmica difusa en la misma banda, sugeriendo que puede ser necesaria una nueva y distinta fuente para esa luz faltante. Descubrimos objetos rojos extraños que son aún mas rojos que la población de EROS conocida. Una interpretación plausible -la única viable entre las que examinamos- es que sean brotes polvosos de formación estelar a altas z ($z \sim 3$), cuya densidad por número es comparable con la de las galaxias elípticas o esferoidales actuales y con la de las fuentes sub-milimétricas débiles. Nuestros resultados plantean una pregunta a los modelos FJ: cómo formar, por medio de brotes estelares, objetos masivos a altos z, los cuales evolucionarán presumiblemente hacia las galaxias elípticas y los bulbos galácticos actuales.

ABSTRACT

The Subaru Deep Field (SDF) provides the currently deepest K-selected sample of high-z galaxies ($K' \sim 23.5$ at 5σ). The SDF counts, colors, and size distributions in the NIR bands are carefully compared with pure-luminosity-evolution (PLE) as well as CDM-based hierarchical merging (HM) models. The flat faint-end slope of the SDF K count indicates that the bulk (more than 90%) of cosmic background radiation (CBR) in this band is resolved, even if we take into account every known source of incompleteness. The integrated flux from the counts is only about a third of the reported flux of the diffuse CBR in the same band, suggesting that a new distinct source of this missing light may be required. We discovered unusually red objects with colors of $J - K \gtrsim 3$–4, which are even redder than the known population of EROs, and difficult to explain by passively evolving elliptical galaxies. A plausible interpretation, which is the only viable one among those we examined, is that these are dusty starbursts at high-z ($z \sim 3$), whose number density is comparable with that of present-day ellipticals or spheroidal galaxies, as well as with that of faint submillimeter sources. The photometric redshift distribution obtained by $BVRIz'JK'$ photometries is also compared with the data, and the HM model is found to predict too few high-z objects at $K' \lesssim 22$ and $z \lesssim 2$; the PLE model with reasonable amount of absorption by dust looks more consistent with the data. This result is apparently in contradiciton with some previous ones for shallower observations, and we discuss the origin of this. These results raise a question for the HM models: how to form massive objects with starbursts at such high z's, which presumably evolve into present-day elliptical galaxies or bulges?

Key Words: **COSMOLOGY: OBSERVATIONS — GALAXIES: HIGH-REDSHIFT**

1. INTRODUCTION

The Subaru Deep Survey is a systematic project of the 8.2m Subaru telescope to study the deep extragalactic universe. The Subaru Deep Field was selected near the north Galactic pole, avoiding large Galactic extinction and nearby galaxy clusters, and the airmass of this field is smaller than that of the Hubble Deep Field at Mauna Kea (Maihara et al. 2000). The wide field near-infrared (NIR) camera CISCO took a very deep NIR $2' \times 2'$ iamge in J and K' bands, with 5σ magnitude limits of 25.1 and 23.5. This is the deepest image in the K band taken so far, providing a unique K-selected sample of galaxies which should be useful for studying of faint, high-z galaxies. The field was also followed-up by optical instruments of FOCAS and Suprime-Cam. Here

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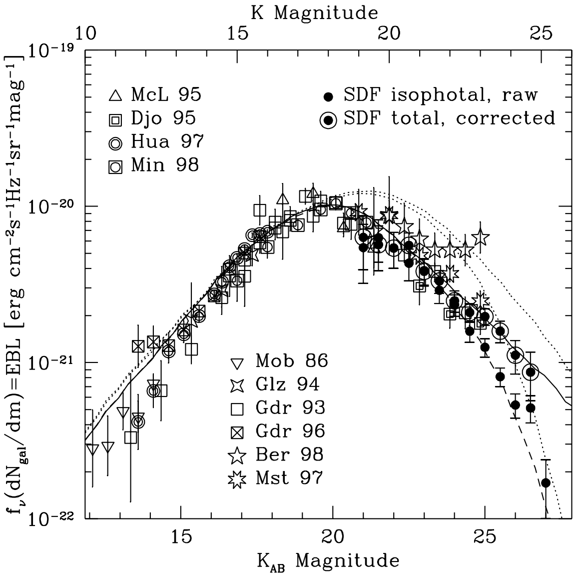

Fig. 1. The contribution to EBL by galaxies in the K band. The filled circles are the raw SDF counts in isophotal magnitude, while the symbols $\odot$ are the counts in total magnitude which are corrected for incompleteness assuming point sources (Maihara et al. 2000). The dashed line is the prediction by a PLE model for which the selection effects under the observational conditions of SDF are taken into account, fitting to the raw counts. The solid line is the same prediction, but the selection effects are not included. For detail, see Totani et al. (2001a). The two dotted lines are model predictions with and without selection effects, using the same PLE model but including a simple number evolution of $\eta = 1$.

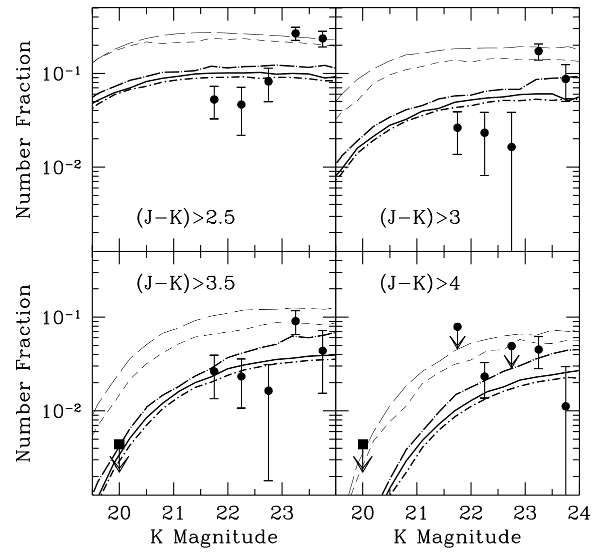

Fig. 2. Number fraction of galaxies redder than several threshold $J - K$ colors (indicated in each panel), as a function of K magnitude. Filled circles are the data of the SDF. The error bars are 1σ, while the upper limits shown by arrows are at the 95% confidence level. The upper limit at $K = 20$ is from Scodeggio & Silva (2000, filled square). The solid line is the model prediction with the formation redshift $z_F = 3$ and our standard dust-extinction normalization. See Totani et al. (2001b) for the detail for other curves.

we review some interesting implications obtained from these data, focusing on NIR galaxy counts, colors, and photometric-redshift distribution, as compared with some theoretical models of galaxy formation and evolution. A comprehensive study on SDF galaxy counts, colors, and size distribution is given in Totani et al. (2001c). The contribution of resolved galaxies to the cosmic background radiation and a comparison with the measurements of diffuse CBR are made in Totani et al. (2001a), with particular attention to the incompleteness. We discovered unusually red objects with $J - K >$ 3–4, even redder than typical EROs; possible theoretical interpretations are given in Totani et al. (2001b). More recent results on the photometric redshift distribution of K-selected SDF galaxies and the comparison with theoretical models are found in Kashikawa et al. (2002).

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