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SIX CONSTRAINTS (OR INPUTS) FROM THE NORTHERN HDF FOR THEORETICAL GALAXY FORMATION MODELS

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RESUMEN

Se presentan seis constricciones sobre los modelos de formación de galaxias. Dos de ellas se relacionan con la elección entre formación jerárquica y evolución pasiva. Tres constricciones tienen que ver con la función de luminosidad y su evolución. La última constricción se refiere a la función de distribución de la intensidad específica de formación estelar. Todas estas constricciones son resultado de observaciones en el NHDF.

ABSTRACT

Six constraints on models of galaxy formation are presented. Two constraints pertain to the choice between hierarchical formation and passive evolution. Three constraints pertain to the luminosity function and its evolution and a final constraint addresses the specific star formation intensity distribution function. All of the constraints result from observations in the NHDF.

Key Words: **GALAXIES: FORMATION, FUNDAMENTAL PARAMETERS, HIGH-REDSHIFT**

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1. INTRODUCTION

Before the epoch of wide scale surveys and narrow deep surveys such as the Hubble Deep Fields (HDF) the overlap between observational constraints and theoretical predictions of galaxy formation processes was relatively minimal. The advent of these new observations now greatly increases the overlap and produces meaningful constraints on theories of galaxy formation. We present six examples of constraints derived from the observations in the Northern HDF (NHDF). The data set is a combination of archival WFPC2 and NICMOS observations of the NHDF. Unfortunately many of the theoretical predictions are oriented toward the near infrared K band which is not the highest signal to noise band in the NHDF. The observation constraints in this poster mainly utilize the NICMOS F160W band which provides the deepest images of high redshift galaxies. Due to space limitations the first two and the sixth tests are described but no figures are shown.

2. KAUFFMANN AND CHARLOT TESTS

The Kauffmann and Charlot (1998) tests discriminate between hierarchical galaxy formation and passive evolution. The first test bins galaxies by K magnitude and plots the fraction of galaxies with redshifts less than or equal to z in each magnitude bin. The second test bins galaxies by redshift and plots the histogram of the number of galaxies per Mpc^3 versus K magnitude. The equivalent observations in the NHDF utilize the 1.6μm F160W magnitudes rather than the 2.2μm K magnitudes. Although the tests emphasize bright galaxies and low redshifts whereas the NHDF emphasizes faint galaxies and high redshift it is clear that the observations favor a hierarchical galaxy formation process.

3. LUMINOSITY FUNCTION CONSTRAINTS

There are three constraints derived from the luminosity distributions. The first two are total luminosity constraints and the third is a F160W magnitude distribution.

3.1. *Total Luminosity Histogram*

The total luminosity histograms show the distribution of luminosities in unit redshift bins. The total luminosity is calculated from the filter fluxes, redshift, extinction and template SEDs found by the analysis procedure described in Thompson, Weymann and Storrie-Lombardi (2001). The decrease in the number of low luminosity galaxies with redshift is just due to dimming. The percentage of high luminosity galaxies seems constant with redshift. High z galaxies tend to have very late SEDs and low extinction so they are of lower mass than early galaxies of the same luminosity. The low number at z = 5 here and in the next figure may be a void.

4. LUMINOSITY FUNCTION EVOLUTION

The luminosity functions in redshift bins of 1.0 are calculated in 0.2 dex bins of the number per cubic Mpc divided by the luminosity bin size. The roll off at low luminosity is just due to surface brightness dimming. To first order the shapes of the functions appear to be independent of redshift. The extension to luminosities above 10^{11} is determined from a small

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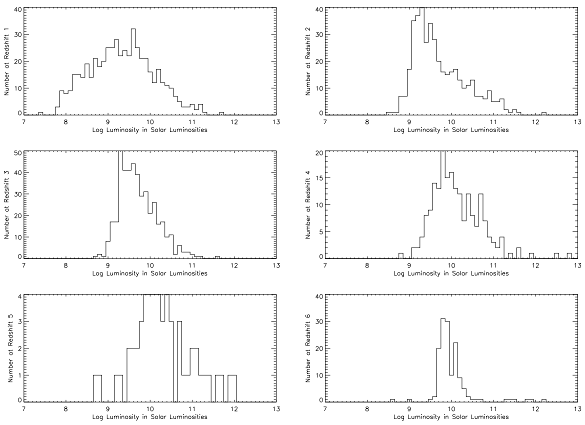

Fig. 1. Total luminosity histogram.

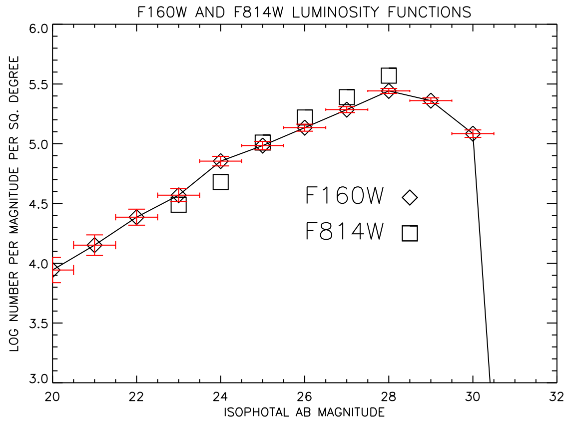

Fig. 3. 1.6 μm luminosity function.

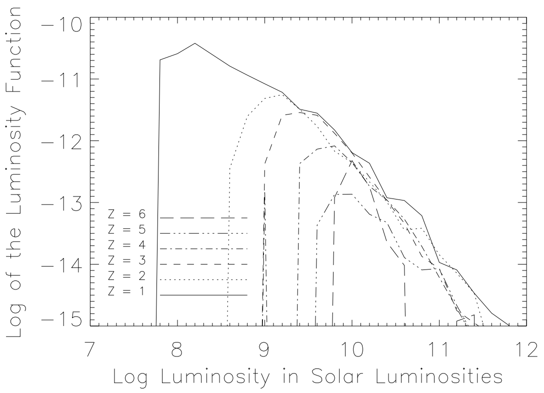

Fig. 2. Evolution of the luminosity function.

number of galaxies. Although the luminosity functions are similar, the predominantly later, younger and hotter SEDs of the high redshift galaxies make them consierably less massive than their low z counterparts at the same luminosity.

5. CLASSIC CONSTRAINT

The F160W broad band filter luminosity functions is a classic constraint on predictions from galaxy formation models. This function represents the faintest sample of high redshift galaxies except for the limited number sample in the NICMOS deep HDF field. It is compared to the WFPC2 F814W filter function from Williams et al. 1996. The vertical error bars are determined from number statistics only. The horizontal bars are just the width of the magnitude bin.

6. STAR FORMATION INTENSITY DISTRIBUTION

The star formation intensity is the star formation rate per proper square kpc. The distribution h(x) is the sum of all of the proper areas in a redshift bin divided by the x bin width and the comoving volume of the redshift bin. The integral of xh(x)dx gives the star formation rate in the redshift bin. The distribution was developed by Lanzetta et al. 1999, and Barkana (2002) points out that it is an important constraint on galaxy formation models. Although h(x) is dependent on cosmology through the comoving volume, x is independent of cosmology since it is determined from the UV surface brightness. Because x is determined for each pixel, h(x) is not dependent on the definition of the aperture. Thompson et al. 2001 and Lanzetta et al. 2002 use the shape of the function to correct for surface brightness dimming but it is essential to use the extinction corrected h(x). Use of the uncorrected h(x) leads to false trends in the star formation rate.

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