The Number and Mass Densities of Star-forming and Quiescent Galaxies at 0 < z < 2.2

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① We use the unique photometric dataset provided by the NEWFIRM Medium-Band Survey to study the color and stellar mass distributions of 27,000 galaxies up to z = 2.2. The NMBS provides the best-sampled SEDs and most precise photometric redshift estimates at z > 1 available to date, which greatly improves the quality of rest-frame properties (colors, masses, stellar population parameters) derived from the photometry. We find that nearly all galaxies with log M/Msun > 10.5 have red rest-frame $U-V$ colors up to z = 2. Using a two-color method, supported by MIPS 24μm photometry, we identify a bimodal galaxy population consisting of a quiescent sequence with relatively low star-formation rates and a distinct star-forming sequence that becomes increasingly dusty with increasing stellar mass.

② Separating the evolution of the mass function by star formation rate, we find that it is driven by the rise of quiescent galaxies from z = 2 to z = 0. The mass function of star-forming galaxies is remarkably similar at all redshifts considered, whereas the quiescent galaxies show strong, mass-dependent, evolution. Quantifying this evolution, we find that number and stellar mass densities of all galaxies with log M/Msun > 10 evolve by ~0.5 dex per unit redshift. Considering separately the density evolution of star-forming and quiescent galaxies with M > 10^{11} Msun, we find that the density of star-forming galaxies is nearly flat out to z = 2, and the density of quiescent galaxies decreases by a factor of ~10 from z=0 to z=2.

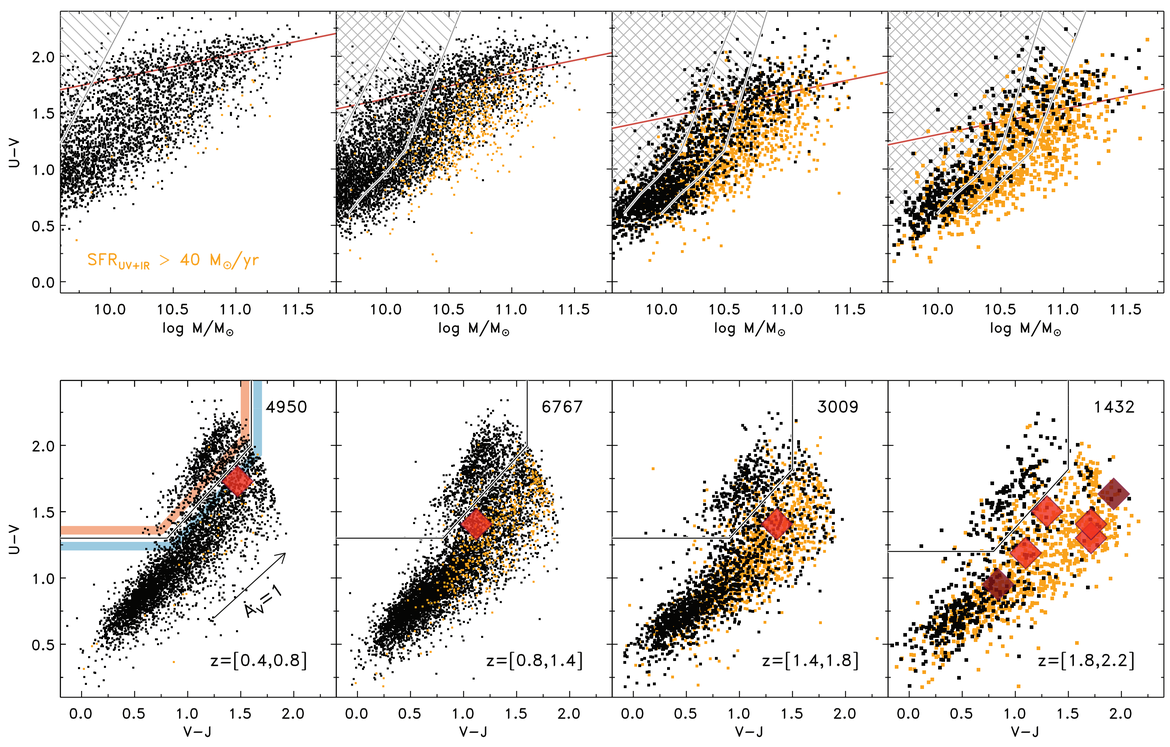

Figure 1: *Top*: Color mass diagrams from z=0.4 to z=2.2. Actively star-forming galaxies are shown in orange, with star-formation rates estimated from the rest-frame UV and IR luminosities. *Bottom*: "UVJ" diagram (Labbé et al. 2007, Williams et al. 2009) that enables the empirical separation of quiescent and star-forming galaxies. The large red diamonds indicate NMBS galaxies matched to sub-mm sources from the COSBO survey (Bertoldi et al. 2007).

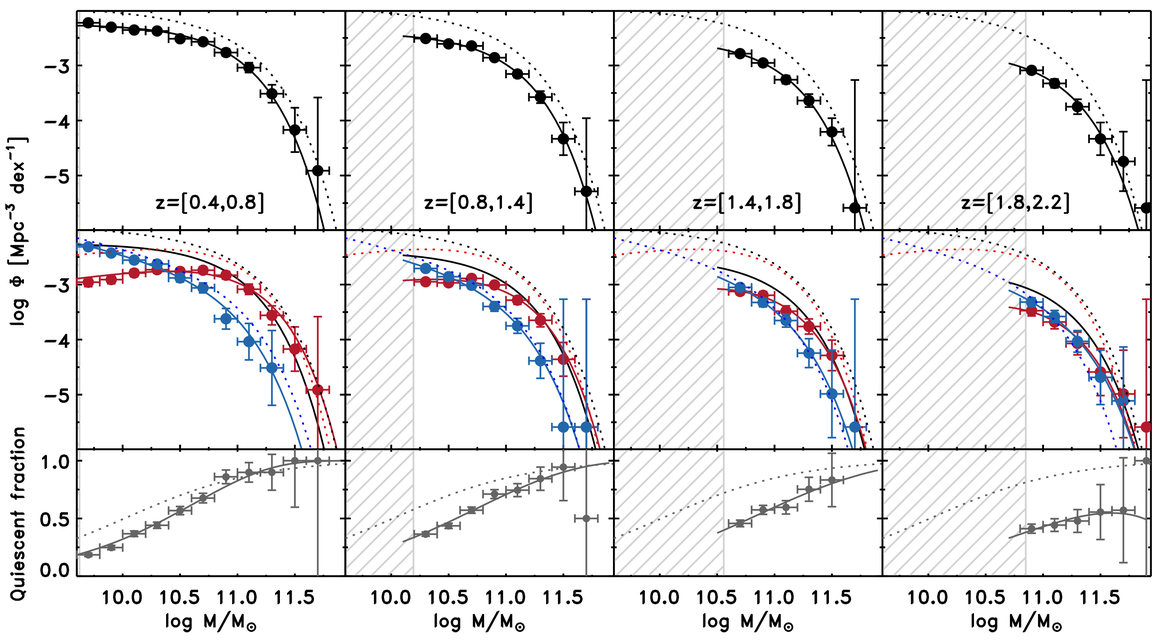

Figure 2: Stellar mass functions for all galaxies (*top panels*) and quiescent/star-forming galaxies (*bottom panels*) selected as in Fig. 1. Measurements of the local mass function taken from Bell et al. (2003) are shown with dashed lines. The number density at the extreme massive end does not evolve significantly from z=2.2 to z=0 (see also Marchesini et al. 2009, 2010). The evolution of the shape of the mass function is dominated by the buildup of quiescent galaxies.

③ Using an empirical argument based on selecting subsamples based on their cumulative number density, we show that the average mass in individual quiescent galaxies with M > 10^{11} Msun grows by a factor of ~2 from z=2 to z=0 (see also van Dokkum et al. 2010). If we assume that most of this mass growth is due to mergers, we find that a simple calculation based on the shape of the mass function is able to explain much (at least 50%) of the number density evolution of galaxies with M > 10^{11} Msun. This model is unable to account for the density evolution of less massive quiescent galaxies, which we argue are formed primarily via transformations from the star-forming population. In general, our results bring together a large variety of results from the literature—based on disparate samples selected at different wavelengths and redshifts—into a coherent picture extended up to z = 2.2, thus demonstrating the utility of large, uniformly-selected surveys for the study of galaxy formation and evolution.

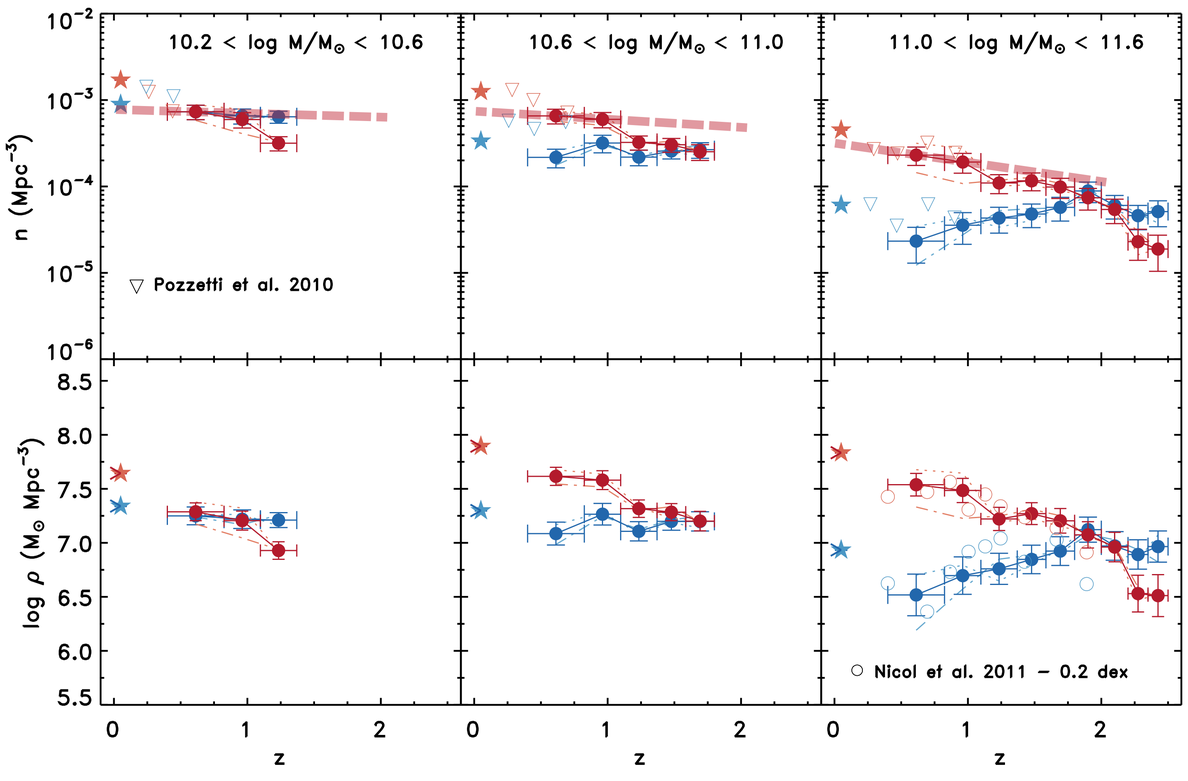

Figure 3: Number and stellar-mass densities of star-forming and quiescent galaxies as a function of redshift for three mass bins. Values integrated from the Bell et al. (2003) z=0 mass functions are indicated with stars. Only redshift bins where the NMBS sample is complete at the indicated stellar masses are shown. The dashed lines indicate the expected number density evolution when assuming that the z=2 mass function simply grows by a factor of 2 at all masses.

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