Evolution of the Galaxy Merger Rate from $z=0$ to $z=0.5$

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1. Introduction

The galaxy merger rate and its evolution with time provide important tests for models of galaxy formation and evolution. Evolution in the merger rate can be estimated by comparing nearby and distant samples of close ($< 20h^{-1}$ kpc) galaxy pairs. We have developed new techniques for applying this method to redshift surveys. Here we report on new results obtained using two sizable surveys: CNOC2 ($\sim 3000$ galaxies with $0.1 < z < 0.55$) and SSRS2 ($\sim 5500$ galaxies with $z < 0.1$). These large redshift samples allow us to use close dynamical pairs ($\Delta V \leq 500$ km/s) to probe merger rate evolution out to $z \sim 0.5$.

2. Data

The Second Southern Sky Redshift Survey (da Costa et al. 1998; hereafter SSRS2) covers 1.70 steradians, with redshifts for all 5369 galaxies brighter than $B=15.5$. We utilize galaxies with $0.005 \leq z \leq 0.05$. The CNOC2 Field Galaxy Redshift Survey (Yee et al. 1998) covers four patches on the sky ($1.5$ deg$^2$), with redshifts for 5000 galaxies with $0.1 \leq z \leq 0.55$. Redshifts (with carefully determined selection weights) are available for approximately 50% of the galaxies brighter than $R = 21.5$. In the following analysis, we use data from the two CNOC2 patches that have been reduced to catalog form.
3. Earlier Estimates of the Galaxy Merger Rate Using Close Pairs

Close dynamical pairs of galaxies are the most probable places to find imminent (< 1 Gyr) galaxy mergers. Many galaxies in close pairs are found to be morphologically distorted by their neighbors (cf. Arp & Madore 1987). Resemblance of observed features to those seen in simulations (e.g. Barnes 1988) implies that gravitational interaction drives this process. One can use close pair statistics to measure redshift evolution in the merger rate, parameterized as \((1 + z)^m\). The general approach is to assume that the merger rate is proportional to the fraction of galaxies in close pairs. Several groups have attempted this, finding values of \(m\) ranging from roughly 0 to 5 (e.g. Zepf & Koo 1989; Carlberg, Pritchet & Infante 1994; Patton et al. 1997). These estimates of pair statistics have a number of shortcomings: Low redshift samples have been poorly defined, and are not directly comparable to those at higher redshift. In addition, we have found that the traditional pair fraction is very sensitive to the way one defines the sample, and is not strictly valid for flux limited samples.

4. A New Approach and Preliminary Results

We introduce two new pair statistics, which provide robust estimates of the pair fraction and more straightforward comparison between disparate samples. \(N_c\) gives the number of companions per galaxy, while \(L_c\) gives the luminosity in companions. If all galaxies are drawn from a sample with absolute magnitudes \(M \leq M_1\), then these statistics are directly related to the correlation function \(\xi(r)\) and luminosity function \(\phi(M)\). If one assumes clustering is independent of luminosity (appropriate for reasonable ranges in luminosity), then these statistics may be applied to flux-limited surveys, provided one specifies \(M_1\) and renormalizes the statistics using the observed selection function. We stress that earlier pair fraction/merger rate estimates did not account for this. In two forthcoming papers, we outline these new methods and apply them to SSRS2 and CNOC2. For \(M_1(B) = -19\), preliminary results indicate a local pair fraction of 0.83% at \(z = 0.015\), rising to 1.19% at \(z = 0.27\). This leads to a merger rate evolution of approximately \((1 + z)^{1.7 \pm 1.7}\).

References

Section I. Galaxy Formation