Galaxies and the Universe

Figures + Tables for Lecture 4 on Th Jan 31
Galaxy Luminosity Functions
A Schechter LF fitted to data for bright galaxies only gives $\alpha \sim -0.7$

The resulting SLF with $\alpha = -0.7$ under-predicts the no of faint galaxies

*Figure 4.12* Luminosity function as derived from the Las Campanas Redshift Survey, together with the Schechter function that best fits the data at points brighter than $M = -17.5$ (with parameters $\alpha = -0.70 \pm 0.05$ and $M^*_{R} = -20.29 \pm 0.02 + 5 \log h$.) The component luminosity functions of emission-line and non-emission-line galaxies in the survey are also shown. [After Lin *et al.* (1996) from data kindly provided by H. Lin]
Typical B-K color of Sa to Sc~. 3 to 4.5 mag
Expect $M_{K^*}$ in luminosity function to be brighter than $M_{B^*}$
Schechter LF only fits roughly the overall shape of the cluster LF (with a steep slope alpha=-1.3) but fails to fit the detailed shape (e.g. dip at $M(B) = -16 + 5 \log h$) or the very bright end ($L>10L^*$).

Figure 4.13 Number of galaxies as a function of absolute magnitude [$\propto \Phi(M)$] found in the central regions of the Virgo, Centaurus and Fornax clusters [From data published in Jerjen & Tammann (1997)]
Acc. to Schechter LF (SLF), no of galaxies with $L > 10 \, L^*$ (e.g., cD galaxies) are ~inexistent
SLF fails in center of very rich clusters, such as Coma, whose center contains a cD galaxy.
Table 3.1. Characteristic values for elliptical galaxies. $D_{25}$ denotes the diameter at which the surface brightness has decreased to 25 B-mag/arcsec$^2$, $S_N$ is the “specific frequency”, a measure for the number of globular clusters in relation to the visual luminosity (see (3.13)), and $M/L$ is the mass-to-light ratio in Solar units (the values of this table are taken from the book by Carroll & Ostlie, 1996)

<table>
<thead>
<tr>
<th></th>
<th>S0</th>
<th>cD</th>
<th>E</th>
<th>dE</th>
<th>dSph</th>
<th>BCD</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_B$</td>
<td>$-17$ to $-22$</td>
<td>$-22$ to $-25$</td>
<td>$-15$ to $-23$</td>
<td>$-13$ to $-19$</td>
<td>$-8$ to $-15$</td>
<td>$-14$ to $-17$</td>
</tr>
<tr>
<td>$M(M_\odot)$</td>
<td>$10^{10}$ to $10^{12}$</td>
<td>$10^{13}$ to $10^{14}$</td>
<td>$10^8$ to $10^{13}$</td>
<td>$10^7$ to $10^9$</td>
<td>$10^7$ to $10^8$</td>
<td>$\sim 10^9$</td>
</tr>
<tr>
<td>$D_{25}$ (kpc)</td>
<td>10–100</td>
<td>300–1000</td>
<td>1–200</td>
<td>1–10</td>
<td>0.1–0.5</td>
<td>&lt; 3</td>
</tr>
<tr>
<td>$\langle M/L_B \rangle$</td>
<td>$\sim 10$</td>
<td>$&gt; 100$</td>
<td>10–100</td>
<td>1–10</td>
<td>5–100</td>
<td>0.1–10</td>
</tr>
<tr>
<td>$\langle S_N \rangle$</td>
<td>$\sim 5$</td>
<td>$\sim 15$</td>
<td>$\sim 5$</td>
<td>$4.8 \pm 1.0$</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
Morphology-density relation

The frequency of early-type galaxies is higher in high density environments (clusters) than in low density environments (field)

Frequency of E+S0:Sp
- = 40%+50% :10% in cluster
- = 10%+10%: 80% in field

Frequency of dE wrt dIrr
- higher in cluster than in field

The MDR is reflected in the LF of the field and cluster, when the LF is ‘decomposed’ into the separate LFs of galaxies of different morphological types.

Figure 4.14 Luminosity functions for galaxies of various morphological types. The top panel shows the separate functions at arbitrary normalization, while the lower panels show approximately how these components combine to produce the total luminosity function in the field and in clusters.
Morphology-density relation

In core A 1689 cluster
E/S0 dominate over spirals

Spirals visible in outskirt of cluster and in field
Coma = nearest, rich, regular cluster, at a distance of ~100 Mpc

MDR: Early type galaxies (E) dominate over spirals in the core of the Coma cluster

Figure 6.25 Coma cluster: solid dots show elliptical galaxies; open stars are spirals. Contours show the intensity of X-rays: the diffuse emission is from hot cluster gas; the point sources are distant active galaxies – M. van Haarlem.