Galaxies and the Universe

Figures + Tables for Lecture 21 on Tu Apr 22

(Scaling Relations in Galaxies)
**Tully-Fisher Relation for Spirals**

Fig. 3.19. The Tully–Fisher relation for galaxies in the Local Group (dots), in the Sculptor group (triangles), and in the M81 group (squares). The absolute magnitude is plotted as a function of the width of the 21-cm profile which indicates the maximum rotation velocity (see Fig. 3.20). Filled symbols represent galaxies for which independent distance estimates were obtained, either from RR Lyrae stars, Cepheids, or planetary nebulae. For galaxies represented by open symbols, the average distance of the respective group is used. The solid line is a fit to similar data for the Ursa-Major cluster, together with data of those galaxies for which individual distance estimates are available (filled symbols). The larger dispersion around the mean relation for the Sculptor group galaxies is due to the group's extent along the line-of-sight.

Fig. 3.20. 21 cm profile of the galaxy NGC 7331. The bold dots indicate 20% and 50% of the maximum flux; these are of relevance for the determination of the line width from which the rotational velocity is derived.

(Credit: EAC)
**Baryonic Tully-Fisher Relation for Spirals**

Fig. 3.21. Left panel: the mass contained in stars as a function of the rotational velocity $V_c$ for spirals. This stellar mass is computed from the luminosity by multiplying it with a suitable stellar mass-to-light ratio which depends on the chosen filter and which can be calculated from stellar population models. This is the “classical” Tully–Fisher relation. Squares and circles denote galaxies for which $V_c$ was determined from the 21-cm line width or from a spatially resolved rotation curve, respectively. The colors of the symbols indicate the filter band in which the luminosity was measured: H (red), K’ (black), I (green), B (blue). Right panel: instead of the stellar mass, here the sum of the stellar and gaseous mass is plotted. The gas mass was derived from the flux in the 21-cm line, $M_{gas} = 1.4M_{HI}$, corrected for helium and metals. Molecular gas has no significant contribution to the baryonic mass. The line in both plots is the Tully–Fisher relation with a slope of $\alpha = 4$

(Credit: EAC)
**Faber-Jackson Relation for Ellipticals**

![Graph showing the Faber-Jackson relation between log(σ₀) km/s and M_B.

**Fig. 3.22.** The Faber–Jackson relation expresses a relation between the velocity dispersion and the luminosity of elliptical galaxies. It can be derived from the virial theorem.

(Credit: EAC)
Fundamental Plane for Ellipticals

Fig. 3.23. Projections of the fundamental plane onto different two-parameter planes. Upper left: the relation between radius and mean surface brightness within the effective radius. Upper right: Faber–Jackson relation. Lower left: the relation between mean surface brightness and velocity dispersion shows the fundamental plane viewed from above. Lower right: the fundamental plane viewed from the side – the linear relation between radius and a combination of surface brightness and velocity dispersion.

(Credit: EAC)
Fig. 3.7. Left panel: effective radius $R_e$ versus absolute magnitude $M_B$; the correlation for normal ellipticals is different from that of dwarfs. Right panel: average surface brightness $\mu_{avg}$ versus $M_B$; for normal ellipticals, the surface brightness decreases with increasing luminosity while for dwarfs it increases.

Relationship for Es+ Bulges vs dE+dSphs
- between Half light radius $r_e$ and $M_B$
- between mean surface brightness and $M_B$