EarlyType Galaxies: Data

Presentation
by
Ytsen Haringa
Outline

• Early-type galaxies in the present
• The fundamental plane of early-type galaxies
• Evolution of early-type galaxies
• Balmer absorption line strength evolution
• Progenitor bias
Early-type galaxies in the present

- Mostly pop II stars, some old pop I stars
- Low dust content
- Dominated by random motion
- Vary in mass, size and luminosity
- “Dynamically hot”
Fundamental plane

- $I \sim V^2/GR(M/L)$ Virial theorem
- Central velocity dispersion
- Effective radius
- Effective surface brightness
Evolution of early-type galaxies

- Tilt of the FP
- Mass dependence

Fig. 1.— Top panels: edge-on view of the FP in redshift bins. The solid line represents the FP for the Coma cluster. Bottom panel: offset from the Coma FP, coded by dynamical mass demonstrating the stronger evolution for smaller masses. Typical errors are < 0.1 dex on the vertical axis. Dotted lines represent passive evolutionary trends for single burst models at various formation epochs ($z_f$).
Frosting model

- Z-plane
- Metallicity
- Time
- Velocity dispersion

**Fig. 4.** Face-on view of the Z-plane in hyper-space (points as in Fig. 1). At fixed velocity dispersion (dashed lines), younger galaxies have higher metallicities than older galaxies. The solid error ellipse in the top right-hand corner is typical of the G93 sample; the dotted ellipse is typical of the highest quality data in the Lick/IDS galaxy sample (TWF999). The slope of the error ellipse is nearly identical to the slope of lines of constant velocity dispersion, indicating that poor data can masquerade as real trends.
Single star burst scenario

Fig. 10.—Time evolution of galaxies in the Z-plane for pure SSPs. Points are coded by environment (see Fig. 7). Lines are loci of constant velocity dispersion: from bottom to top, \( \sigma_0 = 50, 150, 250, 350 \) km s\(^{-1}\) (see Fig. 4). (a) Metallicity hyperplane 5 Gyr ago. (b) Metallicity hyperplane today. (c) Metallicity hyperplane 5 Gyr from now. Note the strong curvature in lines of constant \( \sigma \) in panels (a) and (c).
Double star burst scenario

Fig. 12.—Schematic two-burst models. Three models are shown: (a) 17 Gyr, \([Z/H] = +0.15\) dex, \([E/Fe] = +0.25\) dex progenitor (typical of the oldest giant ellipticals in the sample) with a 1 Gyr, \([Z/H] = +0.75\) dex, solar-neighborhood abundance ratio burst, meant to cover the stellar populations of the high-\(\sigma\) galaxies (solid line); (b) 17 Gyr, \([Z/H] = -0.25\) dex, solar-neighborhood abundance ratio progenitor with a 1 Gyr, \([Z/H] = +0.5\) dex, solar-neighborhood abundance ratio burst, meant to cover the stellar populations of the low-\(\sigma\) galaxies NGC 221 (M32), NGC 4489, and NGC 7454 (short-dashed line); and (c) a 17 Gyr, \([Z/H] = -0.25\) dex, \([E/Fe] = +0.25\) dex progenitor with a 1 Gyr, \([Z/H] = +0.5\) dex, \([E/Fe] = -0.25\) burst dex, meant to represent possible star formation after a metal-enriched wind in a low-\(\sigma\) galaxy (dot-dashed line). Bursts of 10\%, 20\%, 40\%, 60\%, and 80\% (open squares) and 50\% (filled circles) by mass are shown. Open circles represent the progenitor (lower) and burst (upper) populations. Filled squares are the G93 galaxies; compare with Fig. 1.
Balmer line absorption

Fig. 3.—The (H$\delta$ + H$\gamma$)$_{\alpha}$ zero-point evolution as a function of redshift, with single-burst stellar population models of Vazdekis et al. (1996; dashed lines) and Worthey (1994; Trager et al. 2000; shaded regions). The model curves, shown for formation epochs of $2 \leq z_f \leq 10$, are insensitive to the shape of the IMF. Together, the data and models provide lower 95% confidence limits for the mean epoch of star formation of $z_f > 2.9$ and $z_f > 2.4$ using the Worthey and Vazdekis et al. models, respectively, for $\Omega_m = 0.3$ and $\Omega_\Lambda = 0.7$. 
Fig. 1.—Illustration of the evolution of early-type galaxies in traditional models (a and b) and in models with morphological evolution (c and d). Lines in (a) and (c) show the evolution of individual galaxies with a range of ages. The dashed sections of the curves in (c) indicate that the galaxies are not yet recognized as early-type galaxies. Panels (b) and (d) show the evolution of the mean $M/L$ ratio in these two models. The scatter is indicated by the width of the hatched regions. The dashed line shows the evolution of a single-age stellar population formed at $z = 0$. In models with morphological evolution, the mean $M/L$ ratio evolves slowly and the scatter is roughly constant because more and more young galaxies drop out of the sample at high redshift.
References

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