STAR formation history in Local Group dwarfs

Q What might you use to trace the star formation history in a dIrr? a dSph?

- compare galaxy's color-magnitude diagram with predictions of stellar models (as good as the models are)

- Wolf-Rayet stars
  - very high mass
  - lots of mass loss

⇒ vigorous star formation in past 10^7 yr

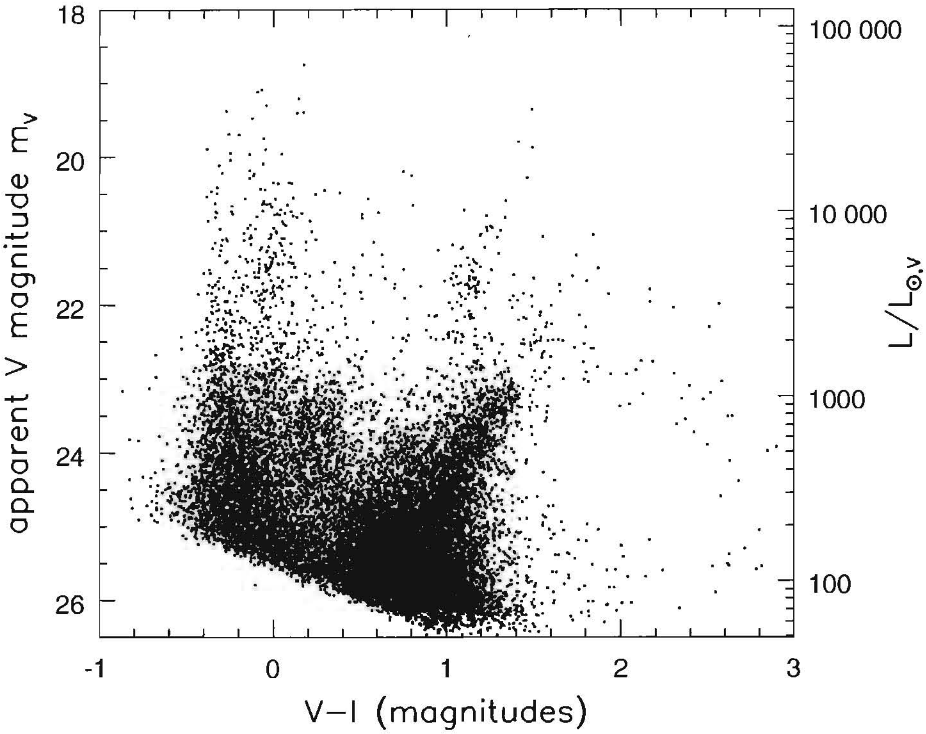


Figure 4.20 Color-magnitude diagram for the dwarf irregular galaxy Sextans A: its luminosity $L_V \approx 4 \times 10^7 L_\odot$ at a distance $d = 1400$ kpc. The bluest near-vertical 'plume' of stars, rising from $V - I, m_V \approx (-0.3, 25)$, is the main sequence. Stars in the slightly redder plume beside it, at $V - I \sim 0$, are blue supergiants: massive stars with $\mathcal{M} \gtrsim 2\mathcal{M}_\odot$, burning helium in their cores. The red giant branch rises from the red clump, at $V - I, m_V \approx (0.8, 26)$; the stars with $L \gtrsim 1000 L_\odot$ and $V - I \sim 1$ are red supergiants – R. Dohm-Palmer *et al.*

supergiants on the parallel plume at $V - I \sim 0$. The mass of stars at $V - I \sim 0.8$ at the base of the figure is the red clump; the red giant branch rises from it. Star formation has gone on for $\gtrsim$1 Gyr; lately, it has been especially vigorous, increasing at least threefold over the past 50–100 Myr.

Some dwarf galaxies, such as Phoenix and LGS3, are classified as intermediate between dwarf irregulars and dwarf spheroidals. Almost all their stars are more than a few gigayears old, but they contain a little gas and a few young stars. A few stars as young as 500 Myr have been found in Fornax, so this dwarf spheroidal galaxy must have had some gas until quite recently. The Carina dwarf spheroidal made most of its stars in a few discrete episodes (see Figure 4.9); at times of peak starbirth, it may have been a miniature version of Sextans A. Because of their similar structures, small irregulars like the Pegasus dwarf may be at an early stage, while dwarf spheroidals represent the late stages, in the life of a similar type of galaxy. In the dwarf spheroidals, which orbit close to the Galaxy or M31,

(c)

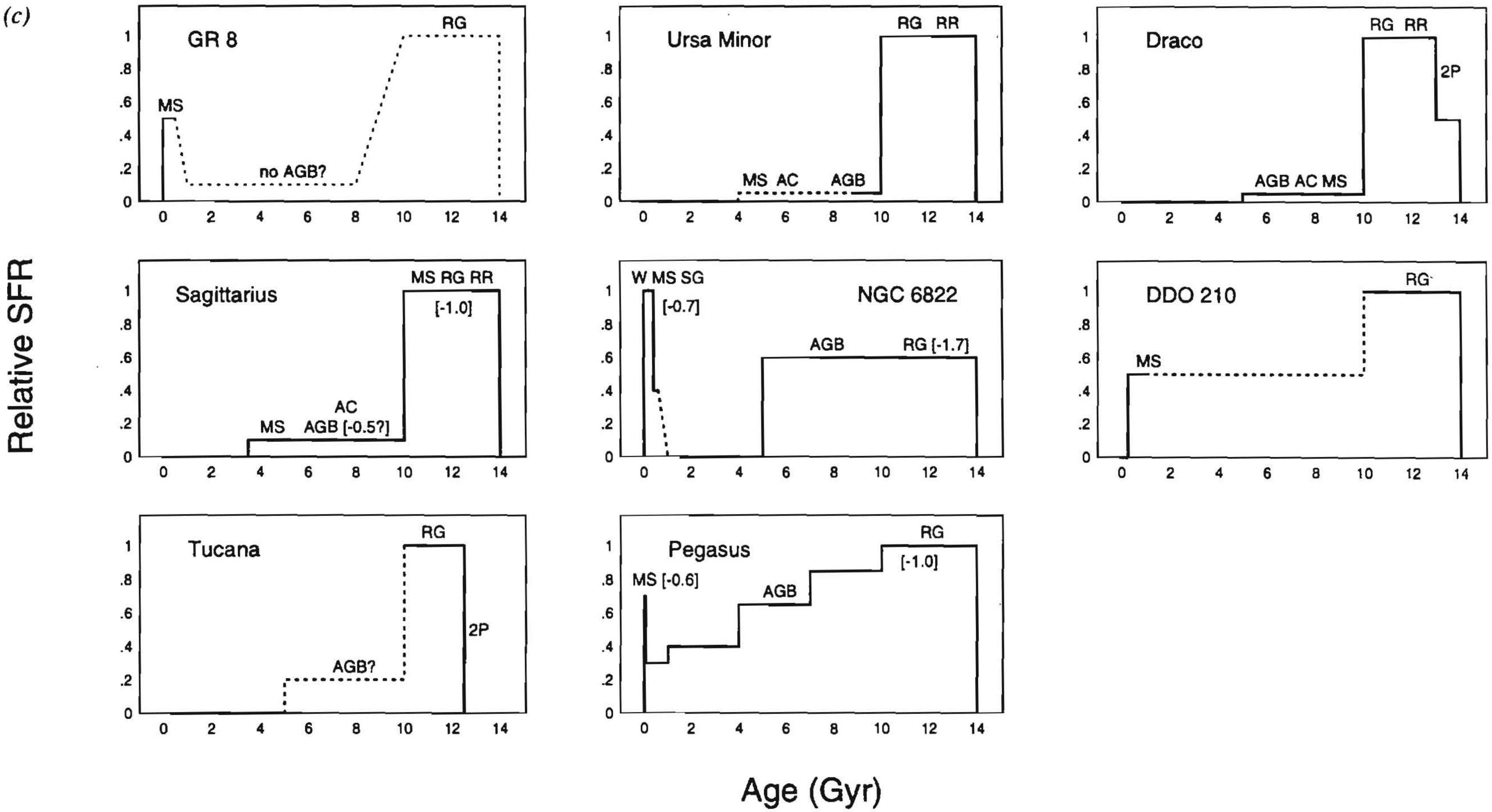


Figure 8 Schematic plots of the star-formation histories of all Local Group dwarfs with sufficient data. The *labels within the individual panels* specify the nature of the stellar indicators used to infer the presence of a given age component: MS = main-sequence stars; AGB = asymptotic giant branch stars; RG = red giants; RR = RR Lyr variables; AC = anomalous Cepheids; SG = blue and red supergiants; W = Wolf-Rayet stars; PN = planetary nebulae. "2P" means that the galaxy has an anomalously red horizontal-branch (HB) population for its (low) metallicity—*that is, the galaxy exhibits*

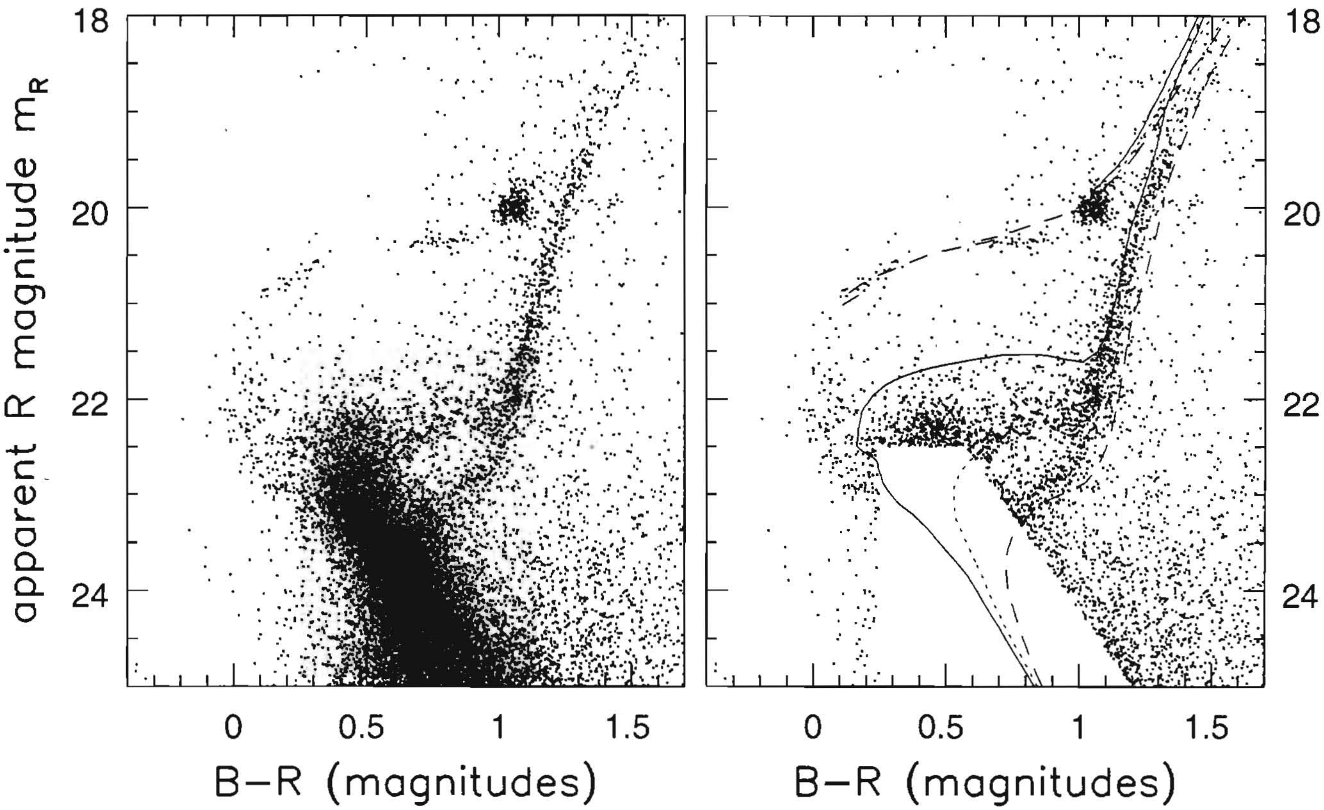


Figure 4.9 Left, color-magnitude diagram for the Carina dwarf spheroidal galaxy. Right, superposed isochrones give the locus of metal-poor stars ($Z = Z_{\odot}/50$) at ages of 3 Gyr (solid), 7 Gyr (dotted), and 15 Gyr (dashed); we see young red clump stars close to $B - R$, $m_R = (1, 20)$, and old stars on the horizontal branch. Carina's distance modulus is taken as $(m - M)_0 = 20.09$; dust reddening is assumed to dim stars by 0.108 magnitudes in B and 0.067 magnitudes in R – T. Smecker-Hane; A. Cole, Padova stellar tracks.

Summary of dwarf star formation

→ No two Local Group dwarfs have the same star formation history

→ No galaxy (except UMi) has only stars older than 10 Gyr

→ Some (like M32) may have no stars older than 10 Gyr

(a)

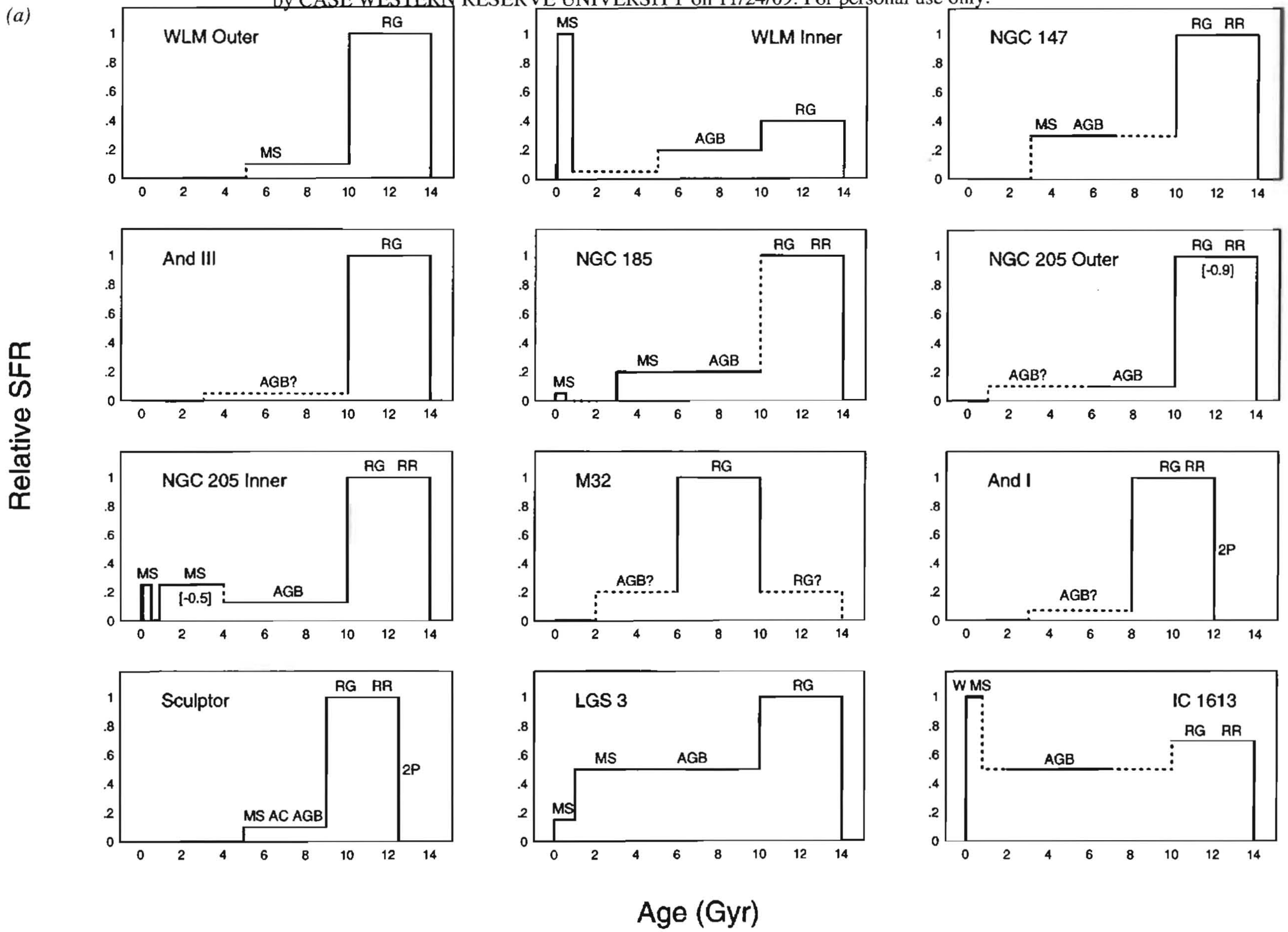
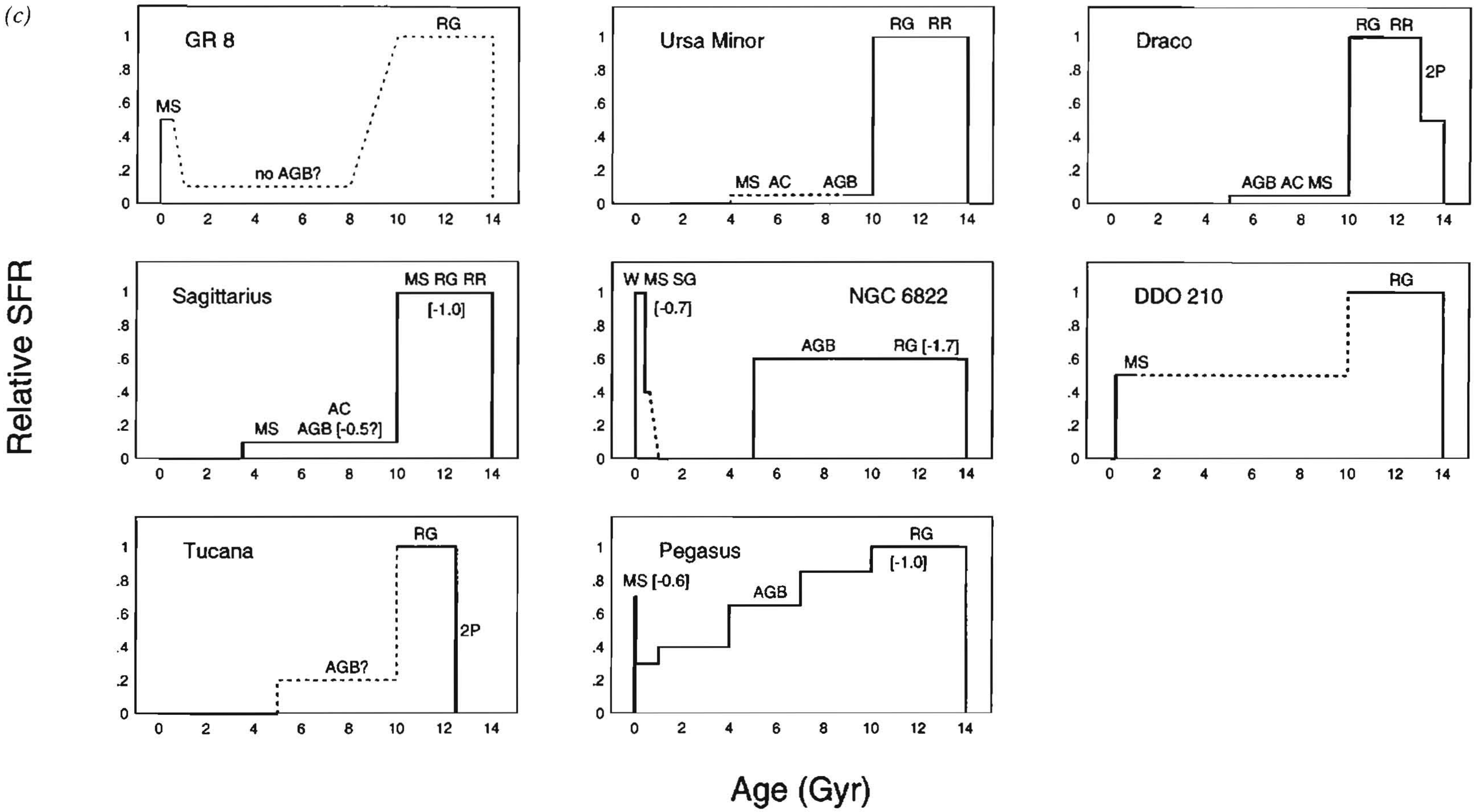


Figure 8 (*Continued*)



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Star formation history of dSph galaxies can be complex

[Q] What do you think the Carina dSph's color-magnitude diagram implies about its star formation history?

[Q] Do bursts of star formation make sense in a system of low mass with no current gas content?

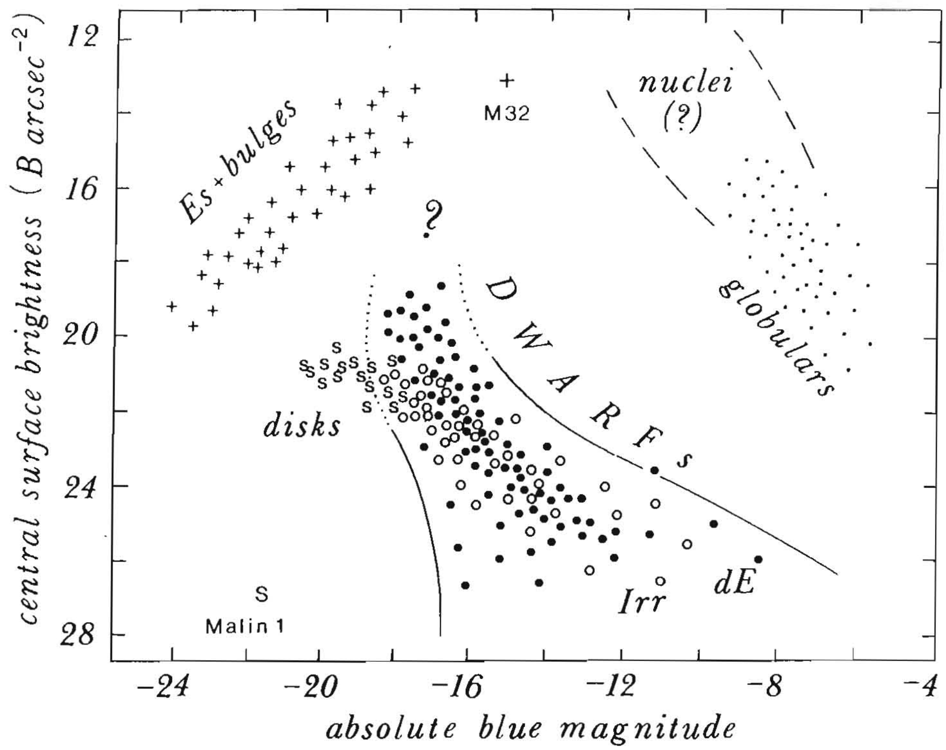

Figure 4.18 Dwarf and giant galaxies occupy different regions in a plot of absolute V-magnitude and measured central surface brightness; because of 'seeing', the true peak brightness may be higher. At left, luminous elliptical galaxies and the bulges of disk systems have very high surface brightness at their centers. The rightmost of the 'dE' points (filled circles) represent what this text calls dwarf spheroidals; open circles mark irregular and dwarf irregular galaxies. Disks of spiral galaxies are marked 'S'. Malin 1 is a low-surface brightness galaxy; see Section 5.1 – B. Binggeli.

dwarf galaxies do not have $R^{1/4}$ law density distributions : they are well fit by exponential distributions

They are also VERY dark matter dominated