5 Stellar populations

5.1 The disk

The thin disk of the Milky Way contains many relatively young stars with high metallicity, referred to as ***population 1***. The ages of disk galactic clusters and individual stars (from isochrone fitting) range from 0.1 to $\sim$ 10 Gyr (eg. McClure & Twarog, 1977). The Galactic disk has a radial abundance gradient – the inner disk has [Fe/H] $\simeq$ 0, the outer disk has [Fe/H] $\simeq -0.3$ (Figure 5.1).

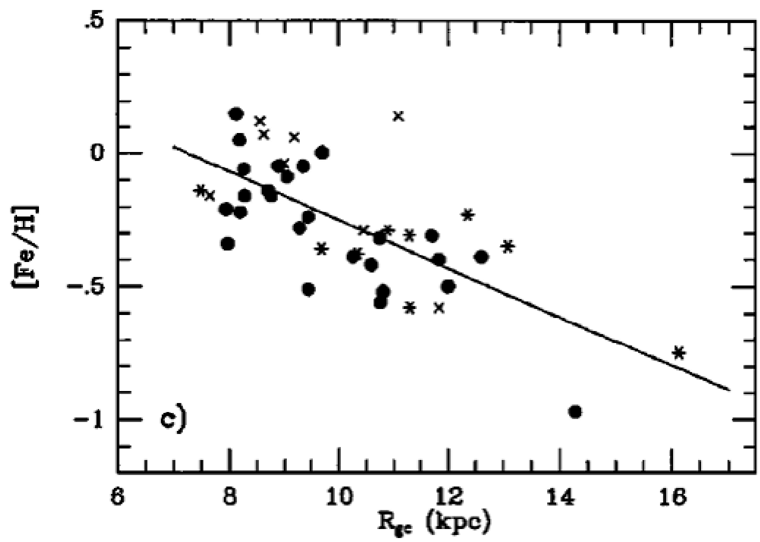


Figure 5.1: Abundance gradient exhibited by galactic clusters in the Galactic disk (from Freeman & Bland-Hawthorne 2002).

There is no clear evidence for an age-metalicity relation (eg. Friel 1995, see Figure 5.2), however, the velocity dispersion increases with age (Figure 5.3).

5.2 The bulge

The bulge is generally assumed to be old – the presence of RR Lyrae stars and ages derived from colour-magnitude diagrams (CMDs) support this. However, the Galactic bulge is metal rich, [Fe/H] $\simeq -0.25$, which is closer to the disk than to the halo.

How can this be if metallicity increases with time? The bulge has short dynamical time so metal content can increase more rapidly.

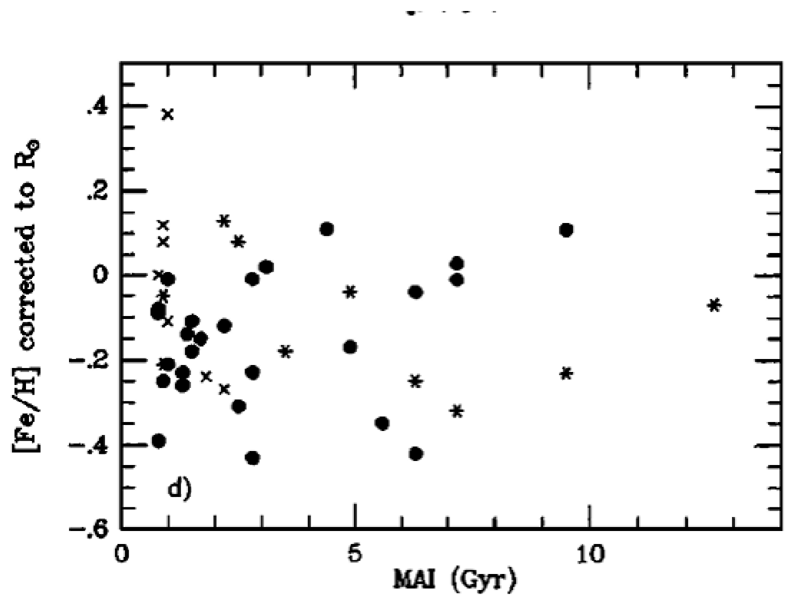


Figure 5.2: Abundance vs. age for Galactic clusters. The radial metalicity gradient has been removed. There is no evidence for an age-metalicity relation (from Freeman & Bland-Hawthorn 2002).

5.3 The stellar halo

The stellar halo of the Milky Way consists primarily of old stars referred to as population 2 that have metallicities as low as $[Fe/H] \simeq -5$.

There are two populations of globular clusters in the Galaxy, a metal-poor ($[Fe/H] < -0.8$) halo population and a metal-rich ($[Fe/H] > -0.8$) disk population in rapid rotation.

The range of metallicity of galactic globular clusters is comparable to that of stars in the thick disk $-2.2 \leqslant [Fe/H] \leqslant -0.5$. However, globular clusters have ages up to ~ 13 Gyr, older than the oldest disk stars, Old age does not mean low metallicity! Young globular clusters have been detected in interacting galaxies, so at least some globular clusters formed recently.

Kinematic streams of stars have been identified in the halo which presumably are due to capture and disruption of dwarf galaxies (eg. Saggitarius Dwarf).

5.4 Spheroids

The light from elliptical galaxies is dominated by red giants, there are no young hot stars. The determination of age and metallicity is complicated by age-metalicity degeneracy which affects integrated colours (Figure 5.4).

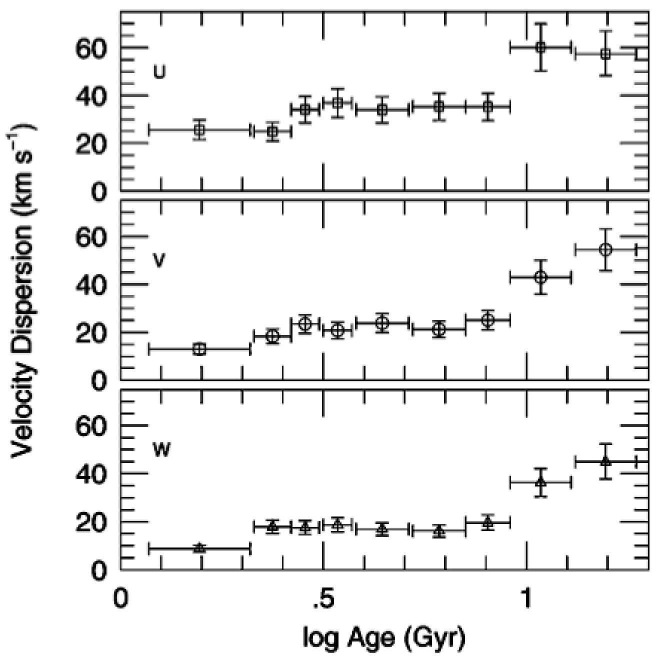


Figure 5.3: Components of velocity dispersion for Galactic disk stars as a function of age. Stars with ages between 2 and 10 Gyr belong to the thin disk. Stars with ages of 10 Gyr or more belong to the thick disk and have higher velocity dispersion (Freeman & Bland-Hawthorne 2002).

Spectroscopic studies indicate that elliptical galaxies have a range of metallicities with $-1.2 \leqslant [Fe/H] \leqslant 0.3$.

Elliptical galaxies are redder in the centre, due to higher metalicity (metals absorb blue light) Metalicity is found to decrease with radius, by roughly 0.2 per decade (Kormendy & Djorgovski 1989).

On the other hand, dSph galaxies tend to be bluer in the centre (Vader et al 1988).

Observations and population synthesis studies indicate that at least some dSph have an extended star formation history (eg. Gallart 1999)

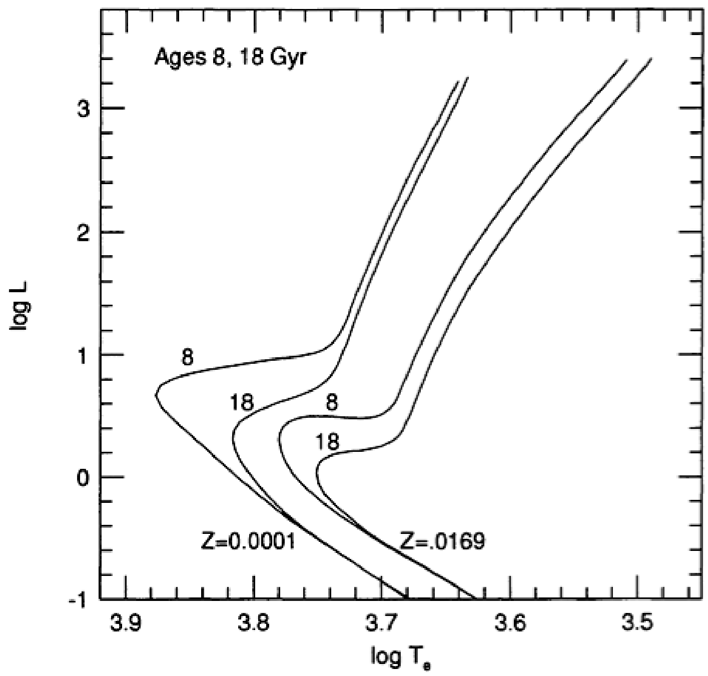


Figure 5.4: Age-metalicity degeneracy. Variations in age and metallicity affect stellar isochrones in similar ways (Worthey 1993).

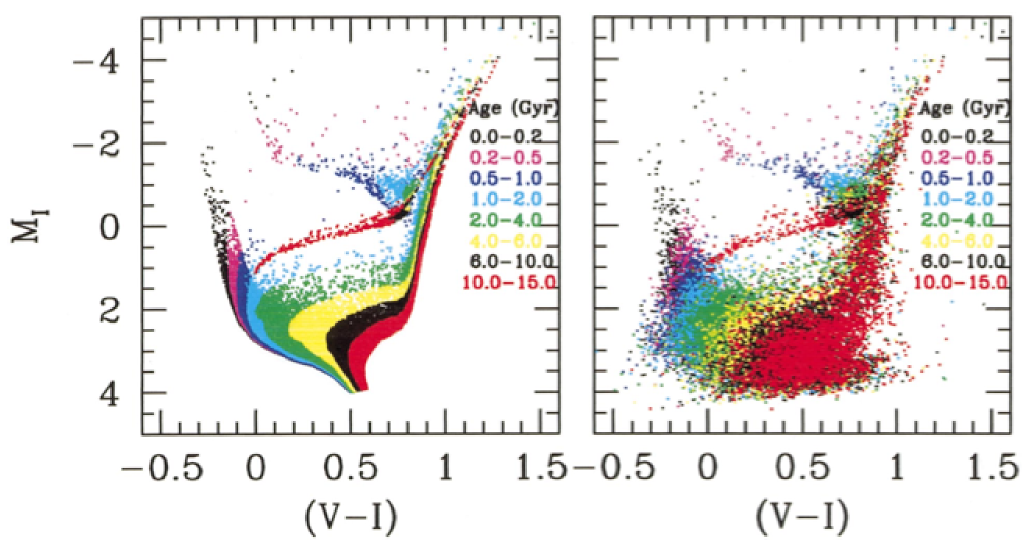
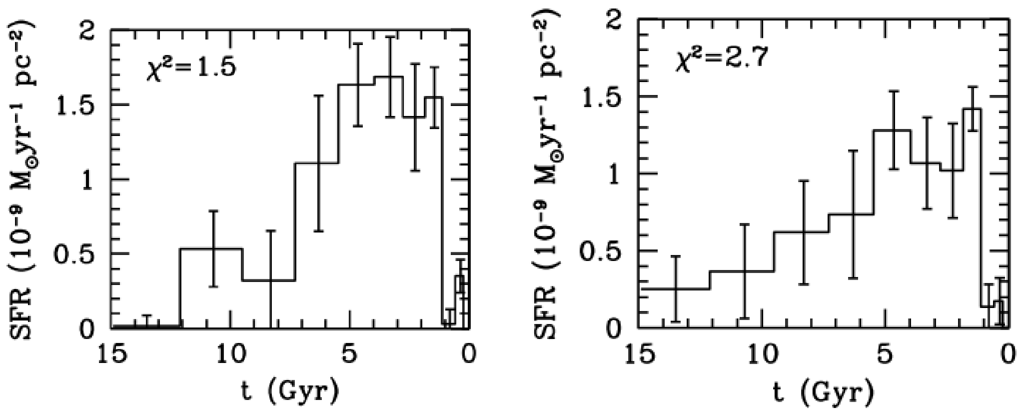


Figure 5.5: Synthetic colour-magnitude diagrams for the Leo 1 dSph galaxy. Different colours indicate different ages. Left: no noise, right: noise added to simulate HST observations (Gallart et al. 1999).



(a) (b)

Figure 5.6: Two possible star formation histories for the Leo 1 dSph galaxy. The data are inconsistent with a single burst of star formation at any past epoch (Gallart et al. 1999).