Colour-magnitude diagrams of resolved stellar populations

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Sombrero galaxy closest Sa

HST resolution 64 mas
GMT resolution 13 mas
Fig. 3.— Metallicity distribution of the detected red giants in NGC 4594.
3. Chemical evolution

Since the time of Pagel & Patchett (1975) the MDF has been used to constrain the chemical evolution of galaxies, starting with the Milky Way. With deviations from the closed box chemical enrichment assumption it is possible to fit a metal rich distribution like that of the solar neighborhood with $dA/dS \rightarrow \alpha$, where $A$ is the mass of accreted gas, $S$ is the mass of stars made, and $\alpha$ is the fraction of low mass long-lived stars formed in a generation of star formation. Hartwick (1976) showed that a metal poor MDF, such as that of Galactic halo globular clusters, could be formed with gas loss from the system, all with standard values of the yield, $p$, the fraction of heavy elements, $Z$ created in a generation of star formation and return to the interstellar medium. His equation (7) can be differentiated to yield:

$$\frac{dS}{dZ} \propto e^{-(\alpha+c)Z/p}$$

where $c$ is the ratio of gas lost to stars formed, when star formation is complete. The resulting MDFs for different values of $c$ are shown in Figure 4.

We also consider a somewhat more general case in which the MDF can be used to
Fig. 4.— Metallicity distribution in the simple model of chemical evolution with gas loss. The ratio of gas lost to stars formed takes the values for distributions from left to right of 32, 16, 8, 4, 2, 0.
\[ \mu(t) = 1 - \alpha S(t) + A(t) \]

If \( Z' \) is the \( Z \) of the accreted gas, heavy element accounting (equation (6) of Pagel & Patchett (1975)) gives us:

\[ \mu dZ = \alpha p dS - (Z - Z') dA \]

Then the MDF can be written as:

\[ \frac{dS}{dZ} = \frac{\mu}{\alpha p - (Z - Z') dA / dS} \]

So, given the star formation history, \( S(t) \), the accretion history, \( A(t) \), and the Schmidt-Kennicutt law, \( dS/dt \propto \mu^n \), \( 1 < n < 2 \), one can predict the MDF and compare with observations. An alternative way to proceed is to use \( Z(t) \) as a proxy for time and parameterize the gas depletion history.

\[ \mu = e^{-Z/(px)} \]

We can then use the MDF directly to calculate the accretion rate.

\[ (Z - Z') \frac{dA}{dZ} = \alpha p \frac{dS}{dZ} - \mu \]

Figure 5 shows the solution for the Sombrero’s MDF. The accreted gas metallicity was taken to be \( Z' = 0.0005 \) and \( x \) was put equal to 0.5. The interesting results are that there is an early burst of accretion and that \( dZ/dt \) is fairly steady, consistent with the assumption
Fig. 5.— The accretion rate as a function of metallicity (top left) in NGC 4594. The independent variable, $[\text{Fe/H}] = \log Z/Z_\odot$, can be considered to be a proxy for time. The assumed gas depletion rate is depicted in the top right. The chemical enrichment rate (arbitrary units) is at the bottom left, and the star formation rate (arbitrary units) at the bottom right.
Diffraction limited JHK performance of GMT

Gemini NIRI + ALTAIR 20% percentile image quality

S/N = 5 in one hour

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>J = 24.8</td>
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<tr>
<td>H = 22.9</td>
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<td>K = 23.2</td>
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NGS

Diffraction limited aperture = \( \frac{1}{D} \)

Background thru aperture = \( D^2 \frac{1}{D^2} t \)

Signal to noise: \( \frac{S}{N} = \frac{FD^2 t}{\sqrt{t}} = FD^2 \sqrt{t} \)
Diffraction limited JHK performance of GMT

GMT has a $\frac{7 \left( \frac{8.4}{8.1} \right)^2}{\gamma}$ advantage = 2.2 mag

$J = 27.0$

$H = 25.1$

$K = 25.4$

$S/N = 10$ would require 4 times longer, 14400 sec

Tip of the Red Giant Branch in Virgo is

$m_{\text{bol}} = 31 - 3.6 = 27.4 = K + 3$

$K = 24.4$
Stellar populations in the Virgo Cluster

Investigate star formation history, chemical enrichment history in the local laboratory of galaxy formation.