Stellar Populations - Planning for the Next Decade
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SMART for the Next Decade

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Abstract. SMART is a model to derive both star formation history and chemical evolution simultaneously from color-magnitude diagrams of resolved stars in a galaxy. We present current progress and discuss the prospects of SMART for the next decade.

Keywords. galaxies: dwarf, Local Group, galaxies: stellar content, galaxies: evolution

1. Introduction

Chemical evolution and star formation history of a galaxy have been two key subjects in the field of stellar populations for long, and they have been developed separately (see Dolphin *et al.* 2005; Matteucci 2008; Tolstoy *et al.* 2009 for review). However they are just two different aspects of the same galaxy. It is needed to deal with both for better understanding of the stellar populations in a galaxy.

Recently we started a SMART project to study the evolution of resolved galaxies. SMART is a model to derive both star formation history and chemical evolution simultaneously from the comparison of the color-magnitude diagrams of resolved stars in a galaxy and the theoretical stellar evolution models. A major strength of SMART is that it calculates chemical evolution for a given star formation history so that it does not suffer from the well-known degeneracy problem for age and metallicity (Yuk & Lee 2007).

2. Current Status

Dwarf galaxies in the Local Group, especially those around the Milky Way Galaxy, are ideal targets to apply SMART. We applied SMART to two dwarf galaxies: Sextans dwarf spheroidal galaxy (dSph), a satellite of our Galaxy, and IC 1613, dwarf irregular galaxy in the Local Group, deriving the star formation history and chemical evolution of these two galaxies (Yuk & Lee 2007; Lee *et al.* 2009). We describe only the results for Sextans, as an example.

The Sextans dSph is metal-poor, shows a radial variation of stellar populations, and has a large number of blue straggler stars (Lee *et al.* 2003; Shetrone *et al.* 2001). Fig. 1 displays the star formation history for four different regions at various distance from the center of the Sextans dSph, derived for Case A (where blue stragglers were considered as younger main-sequence) and Case B (where blue stragglers were excluded) using SMART and VI photometry of Sextans (Lee *et al.* 2003). Most of the stars in this galaxy were formed in the beginning, but for an extended period of several Gyrs rather than in a single burst. Star formation history for Sextans varies depending on the galacto-centric distance. Star formation was more active in the inner region in the early phase. This shows that star formation is a main driver for population gradients. The nature of blue stragglers is still controversial. If blue stragglers are considered as younger main-sequence, they were formed from 7 to 4 Gyrs ago.

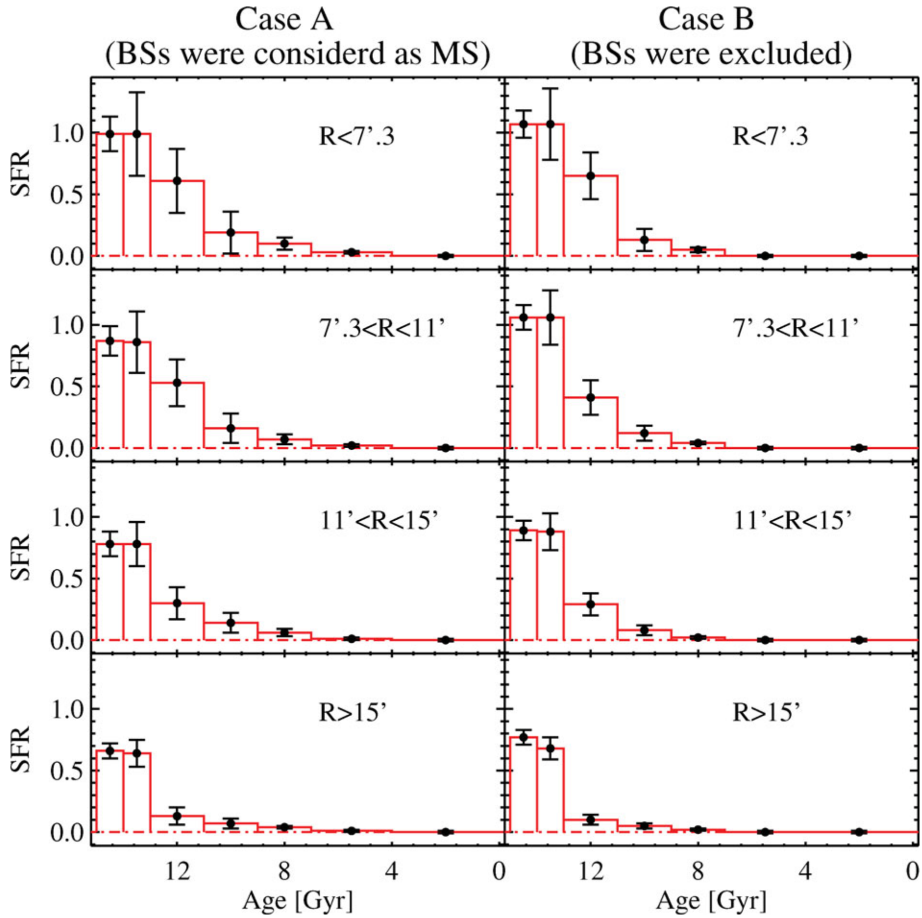

Figure 1. Star formation history for four regions ($R < 7'.3$, $7'.3 < R < 11'$, $11' < R < 15'$, $R > 15'$) in the Sextans dSph derived for Case A (where blue stragglers were treated as younger main sequence stars)(left panel) and Case B (where blue stragglers were excluded)(right panel) using SMART. Note that the star formation was not in single burst, but for an extended period of time in the early phase.

Figs. 2 and 3 show that the values of the abundance ratio for several elements derived from SMART turned out to be in good agreement with the observational data derived from the high resolution spectra for giants in Sextans in the literature (Shetrone *et al.* 2001; Aoki *et al.* 2009). It is noted that calculated [Cr/Fe] is slightly higher than the observation value. The chemical evolution for Sextans was calculated adopting a closed-box model. These results are in contrast with the results given by Lanfranchi *et al.* (2006) who found that the observational data for some dSphs in the Milky Way Galaxy could be explained by chemical evolution models including a significant infall with a low star formation efficiency. It needs further studies to understand the effects of infall in the chemical evolution of dwarf galaxies.

3. Future

Recently several large spectroscopic programs using 8m class telescopes are going on to derive chemical abundances and kinematics for a larger number of bright stars in nearby

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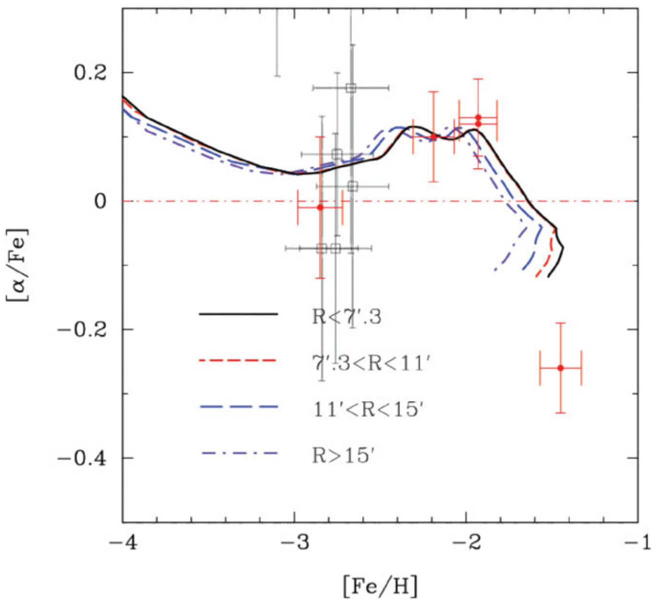

Figure 2. [α/Fe] versus [Fe/H] for the Sextans dSph. Lines represent the SMART results for four different regions in the Sextans dSph (Case B). Circles and squares are observational data from Shetrone *et al.* (2001) and Aoki *et al.* (2009), respectively.

galaxies in the Local Group (e.g., Koch *et al.* 2008; Gullieuszik *et al.* 2008; Cohen & Hwang 2009, Aoki *et al.* 2009), while deep photometry based on Hubble Space Telescope or large ground-based telescopes are available for many of the nearby galaxies (e.g., Okamoto *et al.* 2009). When giant telescopes like GMT, TMT, or eELT are ready, the boundary for this kind of study will be much larger than now.

On the other hand, there have been a good progress in the models for chemical evolution, photometric evolution, and dynamical evolution of galaxies as well as in the models of stellar evolution with improved AGB components (Recchi *et al.* 2008, Calura *et al.* 2008, Calura & Menci 2009, Revaz *et al.* 2009).

We expect that SMART will be SMARTER in the future, and that the star formation history and chemical evolution will be derived for many of these resolved galaxies in the nearby universe using SMART for the next decade. Then we will have a better understanding of the detailed evolution of galaxies.

Acknowledgements

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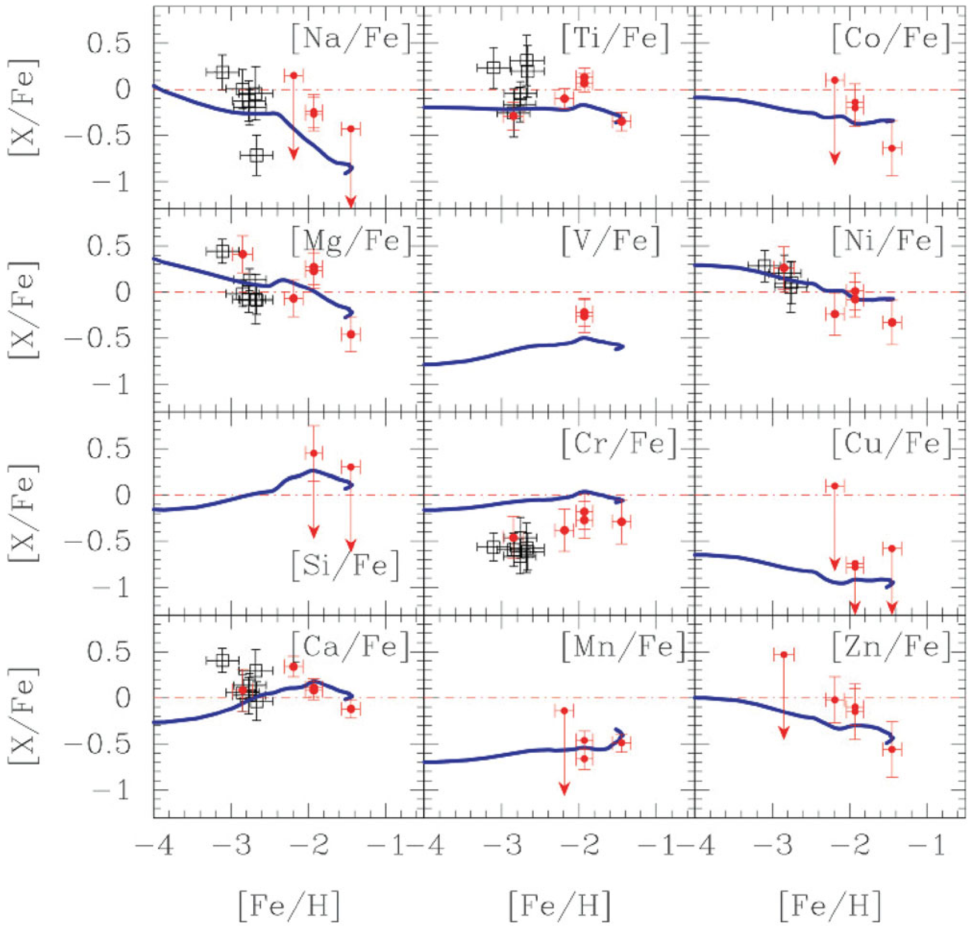

Figure 3. Abundance ratios for the Sextans dSph. Lines represent the SMART results for four different regions in the Sextans dSph (Case B). Circles and squares are observational data from Shetrone *et al.* (2001) and Aoki *et al.* (2009), respectively. Note the good agreement of the SMART results with the observational data.

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