Scientific Requirements for Extremely Large Telescopes
Proceedings IAU Symposium No. 232, 2005
P. Whitelock, M. Dennefeld & B. Leibundgut, eds.

doi:10.1017/S174392130600113X

Summary on stellar populations

Jeremy Mould

National Optical Astronomy Observatory, PO Box 26732, Tucson AZ 85726, USA
email: jmould@noao.edu

Abstract. ELTs will bring galaxies within 5 Mpc or more "as close as the Magellanic Clouds". This is why stellar populations is such an exciting subject for ELTs. We can resolve galaxies into stars and learn their history (1) from the "fossil record" of old stars and (2) looking back in time. The confrontation of these two views will bring important new insights in the star formation history of galaxies and stellar evolution, at the same time.

Keywords. Telescopes, Galaxies: stellar content, Stars: neutron

1. Colour magnitude diagrams (CMD)

Stromgren photometry simulations have been carried out for a range of distances and population characteristics. These show that apertures smaller than 40 metres are not good for measuring ages and metallicities for galaxies at the distance of the Virgo cluster. Star clusters in external galaxies provide suitable targets for minimal field adaptive optics systems. JHK photometry simulations for somewhat closer galaxies can distinguish the star formation histories of spiral disks from those of bulges. Such photometry would also distinguish for the Leo group ellipticals whether they formed at $z = 2$ or $z = 10$. A cautionary note was also issued that CMD evolutionary modelling is still ambiguous and that more work is required, especially in the red giant branch and thermal pulsing asymptotic giant branch evolutionary phases.

A further motivation for resolving galaxies into stars at the distance of Virgo is to study star/galaxy formation in higher density regions in the Universe. It is certainly desirable to go deep in the CMD. The star formation history is unambiguous if one can reach the main sequence turn off.

The chemical enrichment history is unambiguous if one has spectroscopy of the Calcium triplet. To go beyond a one dimensional chemical enrichment history, one needs high resolution spectroscopy. ELTs would be capable of measuring an abundance of the elements A(Z) to the distance of Centaurus A with 100 metre aperture.

2. Galactic archaeology

Chemical enrichment history and star formation history are intertwined, however. Star-by-star reconstruction of the formation of the Milky Way has already begun. Formation substructure retains signatures in the chemical element distribution, the kinematic and age distributions. With ELTs chemical and kinematic 'tagging' will be possible for significant samples of thin disk, thick disk and halo stars in all the galaxies of the Local Group. Sample sizes could be a million stars (a factor 10^4 beyond the present) with elemental abundances for r-, s-, and α- process elements and accurate kinematics.

A good populations framework for analyzing galaxies is shown in Table 1. The population component is in column (1); relevant issues in the star formation history and chemical evolution history are shown in columns (2) & (3) respectively.

Population	**Star formation history**	**Chemical enrichment history**
Halo Globular clusters	Accretion history Population II	Substructure
Bulge SM black hole	Massive and M* systems	Presence of Pop III ?
Disk thin or thick	L* and dwarf systems	Spatial and chemical inhomegeneities

Star formation histories are also frequently entangled with assumptions about the initial mass function. With ELTs the Magellanic Clouds offer a low mass laboratory for studying the behaviour of the initial mass function. Simulations are in progress.

Starbursts are another phenomenon of recently appreciated importance in understanding star formation histories. ELTs will be able to resolve super star clusters (SSC). They are compact ($<0.05''$ in M82). We need to understand starburst processes. Galaxies often support global outflows or winds. Are SSCs the source? What is the connection between outflows, starbursts and the formation of bulges?

3. Neutron stars and pulsars

We need to reach 28-30 mag to measure the radii of the 7 radio quiet ROSAT sources. This is beyond HST's capabilities. The goal is to measure the radius and constrain the neutron star equation of state. The spectral energy distribution and parallax are also required, as are model atmospheres. ELTs could also quantify synchrotron self- absorption in pulsars and determine whether Anomalous X-ray Pulsars are magnetars.

4. Summary

Speakers in the stellar populations session offered six messages to the ELT projects.

1) Plan for periods when adaptive optics is not operable.
2) Provide full wavelength coverage from the UV through the thermal IR.
3) Support high resolution spectroscopy.
4) Include polarization performance in the science requirements for the project.
5) Stellar populations / galaxy evolution science is strongly dependent on aperture.
6) Study the tradeoff with interferometers.

Acknowledgements

I would like to thank all the speakers in two days of stellar populations presentations.

Discussion

Hook: Did your session include a discussion of the FoV requirements for stellar populations work? (This was raised in the Galaxy Evolution and Cosmology session when we discussed wide-field science).

Mould: Top priority is resolution to deal with crowded field conditions. MCAO is the principal instrument for CMD work in stellar populations. If the field is limited, I expect observers to mosaic their images. Spectroscopy (MOS) has different requirements.

Crampton: You implied that Strömgren photometry will be essential, but AO doesn't work nearly as well in the visible region. Could you clarify?

Mould: The point that was being made in the session was that Stellar Population studies at 16 Mpc require a telescope at the high end of the apertures under consideration. AO performance in the UV is a very distant goal, but the immediate point is fairly wavelength independent.