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Concluding Remarks: Recent Achievements and Future Challenges in Stellar Population Studies

Stephane Charlot[1,2]

[1]UPMC Univ Paris 06, UMR7095, Institut d'Astrophysique de Paris, F-75014, Paris, France
[2]CNRS, UMR7095, Institut d'Astrophysique de Paris, F-75014, Paris, France
email: charlot@iap.fr

Abstract. To conclude this exciting conference on *Stellar Populations: Planning for the Next Decade*, we have sacrificed the traditional 'conference summary' for an opinion poll among all invited speakers on two issues: the most important achievements in the field of stellar populations over the past few years; and the most important challenges for the coming decade. The answers to this poll were remarkably uniform, indicating that the field of stellar populations has a clear future in the era when several new major research facilities are coming online.

1. Recent Achievements

The following were considered to rank among the most significant research achievements of the past few years in the field of stellar populations:

- The inclusion of updated physics in the treatment of all the main stellar evolutionary phases and in particular the asymptotic giant branch (AGB) stage (e.g., opacity for C-rich mixtures), combined with major efforts to describe the wind physics of thermally pulsing (TP) AGB stars.
- The complete sampling of TP-AGB stars in the Magellanic Clouds (with detailed information on luminosities, colors, chemical type, pulsation periods, mass-loss rates, dust mineralogy) from near- and mid-infrared photometric surveys and microlensing experiments.
- The development of a first generation of fully spectroscopic models of stellar population synthesis for alpha-enhanced chemical mixtures.
- Detailed imaging and spectroscopic studies of spatially resolved stellar populations in the Milky Way and nearby galaxies, and the reconstruction of the associated star formation histories.
- The improved modeling of supernova feedback and chemical evolution in numerical simulations of galaxy formation.
- The creation of large databases of theoretical models and spectro-photometric galaxy observations, which can be queried and cross-linked to allow panchromatic studies of stellar populations.
- The use of stellar population models to link huge amounts of new spectral data from galaxy surveys at all redshifts to simulations of galaxy formation.
- Major advances in our understanding of the mass assembly history of galaxies from stellar population studies.
- The acquisition of the first extremely deep infrared spectra of distant galaxies giving access to detailed rest-frame optical fits of high-redshift galaxies.

2. Future challenges

The following stand out as primary challenges for stellar population studies over the next decade:

- The development of well-calibrated and extensively tested models of stellar population synthesis at ultraviolet, optical and near-infrared wavelengths.
- Accurate models of the "late" phases of stellar evolution (such as blue horizontal branch stars, TP-AGB stars, etc.) using the most recent constraints available from observations of nearby stellar populations.
- The improvement of stellar population synthesis models with non-solar metal abundance ratios, to constrain the chemical evolution of stellar populations.
- Systematic studies of the uncertainties in model predictions.
- The extension of detailed imaging and spectroscopic studies of spatially resolved stellar populations to outer galaxies (in particular, with *Gaia*, the *James Webb Space Telescope*, and the Extremely Large Telescopes).
- Observational and theoretical studies of the first generations of (presumably massive, population III) stars at high redshift.
- The exploitation of new constraints on the gas content of galaxies (from, e.g., the Large Millimeter Telescope, the Atacama Large Millimeter/Submillimeter Array, the Expanded Very Large Array, the Square Kilometer Array) in the context of stellar population studies.

The exploration of these research areas over the next few years will likely be modulated by the emergence of new opportunities triggered by future discoveries. All these studies can only improve our understanding of the way in which galaxy formation has shaped the stellar populations we see today. Appointment is taken for a similar meeting ten years from now to find out in which way, more precisely, progress will have been made!

We deeply thank all the participants for making this meeting such an exciting one.