IAU S343: Summary of Scientific Highlights

The symposium built a bridge between research on AGB stars and its application to the modelling of stellar populations and the chemical evolution of galaxies and the Universe as a whole. Despite major efforts, our knowledge in this context is still deficient in crucial areas, and the uncertainties in our understanding of AGB stars directly propagate into the field of extragalactic astronomy. The achievements and challenges within the nine topics covered during the conference were:

- Stellar structure and evolution to, on, and past the AGB: Unfortunately, the uncertainties of modelling the earlier evolutionary stages are inherited by the AGB models. There is progress, but it is slow as spatial and temporal resolutions required in the models are formidable. The main uncertainties are convection and mass loss. 3D modelling is making progress that leads to insight, but it is difficult to test assumptions and approximations. Post-AGB evolution is predicted to be significantly faster by new models of single stars.

- Nucleosynthesis, mixing, and rotation: Much improved stellar yields and abundances from AGB models are available, but many observations still challenge the models. The need for the intermediate neutron capture process (*i*-process) as a source of heavy elements has been identified, but the nuclear physics uncertainties are more extreme than for the *s*-process.

- Pulsation, dynamical atmospheres, and dust formation: Viable wind and atmosphere models exist for both M- and C-type AGB stars in the form of large grids. A number of model developments and improvements lie ahead, including extending the model grids to more extreme stellar parameters and to other metallicities. In this context, the nucleation and growth of silicates remain a challenge.

- Circumstellar envelopes of AGB stars and their progeny, planetary nebulae: Interferometry and extreme adaptive optics, at a breadth of wavelengths, resolve surfaces of nearby AGB stars and map gas/dust in their extended atmospheres and their circumstellar envelopes. Multi-epoch observations, can follow the movement of convective cells and the emergence of hot spots. Mass-loss rate and wind expansion velocity distributions for essentially complete samples of M-, S-, and C-stars provide constraints on wind models.

- Binarity, planets, and disks: Post-AGB binaries show unexpected dynamical behaviour (period distributions and orbital eccentricities), and circumbinary disks and high-velocity outflows, or jets, are common features in these systems. Similar characteristics are found for post-RGB binaries. The dramatic change in the shape and speed of mass ejection when the essentially spherical AGB stars and their envelopes become PNe is most likely due to the presence of a nearby companion star (or planet), but mass transfer in such a system, a giant star and a companion, is not well described by theory at this time.

- AGB stars in the cosmic matter cycle: AGB stars are significant contributors of C, N, F, ^{25,26}Mg, and *s*-process (and *i*-process?) elements. Global dust production estimates suggest that for galaxies like the MW and LMC, AGB stars are not the main providers of dust, but considerable uncertainties remain in such estimates. In galactic chemical evolution models, binaries are only partially included.

- Resolved and unresolved AGB populations: Resolved stellar populations anchor our knowledge of the Universe, the AGB stars being tracers of the underlying populations that were formed from about 0.1 - 10 Gyr prior to their appearance. Observations of Mira variables in dwarf irregulars show that AGB dust is produced also at low metallicities. The role which massive AGB stars play in the formation of multiple populations in globular clusters has been clarified. Mira variables with $\mathrm{P} < 400^{\mathrm{d}}$ offer a viable alternative to Cepheids for distance-scale studies.

- Galaxy evolution, including the first AGB stars: The AGB contribution to galaxy integrated light and the ionization from post-AGB objects appear significant. PN population studies produce good constraints on galactic chemical evolution, e.g., how galactic metallicity gradients change with time. Unfortunately, estimates of mass loss rely on numerous uncertain assumptions, and hence there is no clear consensus on the role metallicity plays in mass loss, dredge up, and dust production.

- New and future observational perspectives: Large-area, multi-band, time-domain, deep-sky surveys will provide huge amount of data, e.g., LSST will provide about 800 epochs of observations on 40×10^9 stars. JWST and ELTs will provide resolved stellar populations to much larger distances than presently possible.