Tests and discussion on the solution uniqueness of population synthesis methods

Alex A. Schmidt,[1,2] Marcus V.F. Copetti,[1,3] Danielle Alloin[4] and Pascale Jablonka[4]

[1] *Universidade Federal de Santa Maria, Depto. de Matemática, 97119 Santa Maria - RS, Brazil*
[2] *Astronomy Centre, University of Sussex, Falmer, Brighton, BN1 9QH, UK*
[3] *Royal Greenwich Observatory, Madingley Road, Cambridge CB3 0EZ, UK*
[4] *Observatory de Paris - URA 173 du CNRS, Département d'Astrophysique Extragalactique et de Cosmologie, F-92195 Meudon, France*

Population synthesis is a powerful tool to study stellar populations where the analysis of the stellar content of a composite system is based on the results of breaking down into components (of a given base) the spectrum of the observed system. Such process constitutes an inverse problem which can have a multitude of possible or "acceptable" solutions. This degenerative character of the synthesis rises mainly from observable errors and from the base of components itself with respect to its internal consistency and its (in)capacity to fully embrace all the free parameters involved.

In this work we present the results of a series of tests (26 pre-defined problems in terms of age and population content) for a constraint-free formulation of the synthesis problem based on a minimization technique that sweeps the entire space of solutions seeking for a representative solution instead of an optimal solution (for a complete discussion see Schmidt et al, 1991). A representative solution is obtained from a series of minimization cicles in which, through an analysis of the statistical distribution of the solutions, it is sought the reduction of the *natural domain* of each problem (obtained from random search) in a gradual convergent process. The star cluster data set from Bica (1988) (35 components, each representing a evolutionary stage in the age-metallicity plane), found to have a high degree of internal correlation allowing artificial combinations between components to mimic acceptable solutions, was reduced to 12 components after a multivariate analysis of the base (in order to minimize such effects) to compose our base.

The results of the tests can be summarized as follow: for old metal-rich dominant populations (elliptical galaxies, spiral galaxy bulges) the agreement between true and obtained proportions is very good; for young, intermediate-age and metal-poor dominat populations proportions less than 20% are not always recovered in a satisfactory way, however we note that the correct age is properly recovered while the metallicity determination is more uncertain. Nevertheless, strong contributions (larger than or equal to 30%) are easily discernible.

The degenerative effects due to measurement errors and internal dependence between base components constitute very serious difficulties in the solution of the population synthesis problem, and the multiplicity of solutions is an unavoidable characteristic that must be carefully taken into account. Nevertheless, the above results show that an accuracy better than 5% can be obtained for old metal-rich populations (composite systems most frequently observed), although less accurate results, up to a factor of 3, should be expected for cases when observable constraints are not restrictive enough, such as in blue composite populations. Yet a substancial improvement is to be expected from small observable errors and from the addition to the base of new features in the ultraviolet range to better represent the hot, blue contributions.

Bica, E., 1988, *Astr. Astrophys.*, **195**, 76.
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