A Massive Star Odyssey, from Main Sequence to Supernova
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Measuring the evolution of H II and starburst galaxies

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Abstract. The evolution of starbursts and their young stellar populations is usually studied using evolutionary population synthesis and photo-ionization calculations. We give a more empirical approach to this issue by appling empirical population synthesis techniques to samples of starburst and H II galaxies, to measure their evolutionary state and correlate the results with their emission line properties. The results are presented using an evolutionary diagram whose axis are the strengths of the young, intermediate and old age components of the population mix. We also recover the long known prediction that the $W_{H\beta}$ and the gas extinction decrease as the starburst ages.

1. Introduction

Starburst galaxies are important laboratories to study the evolution of massive stars and the physical processes associated with the early stages of galaxy formation. The hot, massive stars of the young starbursts photo-ionize the surrounding gas, producing an emission-line spectrum, which can be used to study the age, mass, metallicity and star-formation rate of the burst. The most explored technique to address such problems is evolutionary population synthesis (Mas-Hesse & Kunth 1991; Olofsson 1995; Leitherer *et al.* 1999), which uses stellar spectral libraries with different masses and suitable choices for the initial mass function, star-formation rate and chemical evolution.

2. The data and the method

We present a more empirical approach to address such problems by applying empirical population synthesis (EPS) techniques (Cid Fernandes *et al.* 2001), to make quantitative and qualitative assesments of the evolutionary stages of star-forming galaxies. The EPS-code is feeded with just five observables: the W's of Ca II K, CN, and the G-band, plus the F_{3660}/F_{4020}, F_{4510}/F_{4020} continuum colors. The main output of the code is a vector $\vec{x} = (x_Y, x_I, x_O)$, used to build evolutionary diagrams whose axis are the strengths of the $x_Y \leq 10^7$ yr (young age), $x_I = 10^8$ yr (intermediate age), and $x_O \geq 10^9$ yr (old age) components. The normalization requirement sets $x_Y + x_I + x_O = 1$, with all components ≥ 0. The data are a set of 63 spectra of starburst and H II galaxies.

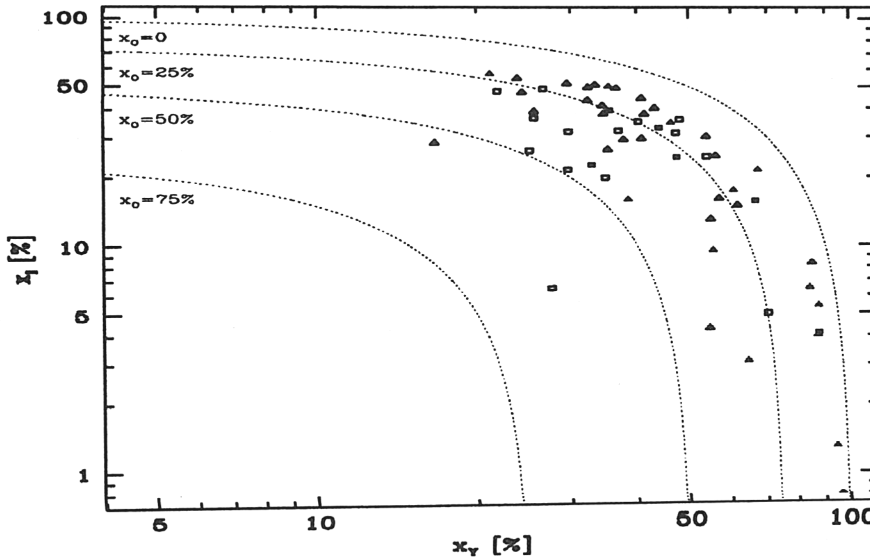

Figure 1. Results of the empirical population synthesis analysis for the 63 galaxies, condensed in an evolutionary diagram. The horizontal axis x_Y is the fraction of light at $\lambda_0 = 4020\,\text{Å}$ due to stars in the 10^6 yr and 10^7 yr age bins, while the fraction x_I due to 10^8 yr stars is plotted along the vertical axis. H II galaxies are plotted as triangles and starburst nuclei as squares. Filled symbols correspond to galaxies with WR features.

3. Results and conclusions

We retrieve two main results: (*i*) the evolutionary stage and proportions of the population mix can be studied using the diagram in Figure 1; and (*ii*) $W_{H\beta}$ and the gas excitation decrease as the starburst ages. This result is expected because the hot, ionizing, massive stars are the first to die. However, this is the first time that $W_{H\beta}$, which has been used as an age indicator, has its utility confirmed by empirical tecniques. Our results also show that H II galaxies have a smaller spread in age than starburst galaxies, due to previous episodes of star-formation and thus a more complex population mix.

For more details on the method, procedures and results, please refer to Cid Fernandes *et al.* (2002) and references therein. We acknowledge support from the Brazilian agencies CNPq and FUNEVEN-UFSC.

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