What hydrodynamical simulations tell us about the radial properties of the stellar populations in Ellipticals

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Abstract. Elliptical galaxies probably host the most metal rich stellar populations in the Universe. The processes leading to both the formation and the evolution of such stars are discussed by means of a new gas dynamical model which implements detailed chemical evolution prescriptions. Moreover, the radial variations in the metallicity distribution of these stars are investigated by means of G-dwarf-like diagrams.

By comparing model predictions with observations, we derive a picture of galaxy formation in which the higher is the mass of the galaxy, the shorter are the infall and the star formation timescales. The galaxies seem to have formed outside-in, namely the most external regions accrete gas, form stars and develop a galactic wind very quickly (a few Myr) compared to the central core, where the star formation can last up to 1 Gyr.

We show for the first time a model able in reproducing the mass-metallicity and the color-magnitude relations as well as the radial metallicity gradient, and, at the same time, the observed either positive or negative slopes in the [α/Fe] abundance ratio gradient in stars.

1. The model

We present preliminary results from a new class of hydrodynamical models for the formation of single elliptical galaxies (Pipino, D’Ercole, & Matteucci, 2007) in which we implement detailed prescriptions for the chemical evolution of H, He, O and Fe. Our aims are: i) to test and improve our previous predictions of an outside-in formation for the majority of ellipticals in the context of the supernovae-driven wind scenario, by means of a careful study of gas inflows/outflows; ii) to explain the observed slopes, either positive or negative, in the radial gradient of the mean stellar [α/Fe], and their apparent lack of any correlation with all the other observables (Melhert et al. 2003; Annibali et al. 2006; Sanchez-Blazquez et al. 2007).

We adopted a one-dimensional hydrodynamical model which follows the time evolution of the density of mass, momentum and internal energy of a galaxy, under the assumption of spherical symmetry. In order to solve the equation of hydrodynamics with source term we made use of an improved version of the
2. Results

All the models run undergo an outside-in formation as suggested by Pipino, Matteucci, & Chiappini (2006), in the sense that star formation stops earlier in the outermost than in the innermost regions, owing to the onset of a galactic wind. We find that the predicted variety of the gradients in the \([\alpha/Fe]\) ratio can be explained by physical processes, generally not taken into account in simple chemical evolution models, such as metal–enhanced radial flows coupled with different initial conditions.

We find [Fe/H] gradient slope in the range -0.5 – -0.2 dex per decade in radius and -0.3 dex per decade in radius for [Z/H], in agreement with the observations (e.g. Annibali et al. 2007).

Once transformed into predictions on the line-strength indices, these gradients in the abundances lead to \(d\text{Mg}/\log(R_{\text{eff},*}/R_{\text{core},*})\) \(\sim -0.06\) mag per decade in radius, again in agreement with the typical mean values measured for ellipticals by several authors and confirming the Pipino et al. (2006) best model predictions. The remarkable exception of some model with a steeper gradient seems to go in the direction of a few massive objects in the Ogando et al. (2005) sample.

By analysing typical massive ellipticals, we find that all the models that show values for their chemical properties, including the \(<\text{Fe/H}>=\nu\) and the total metallicity gradients, within the observed ranges, show a variety of gradient in the \([\alpha/Fe]\) ratio, either positive or negative, and one as no gradient at all.

The build-up of the gradients is very fast and we predict non significant evolution after the first 0.5 - 1 Gyr.

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