Ph.D. Project

Exploring the early Universe through the First Stars

PhD: Martina Rossi - martina.rossi@unifi.it
Tutor: Stefania Salvadori - stefania.salvadori@unifi.it

One of the key goals of modern Cosmology is to understand the properties of the first stars. The **first stars** formed about 13 Gyr ago when the Universe consisted only of hydrogen and helium and no heavy elements were present. For this reason the first stars are expected to be **metal-free**. The chemical elements heavier than helium, called **"metals"** in Astrophysics, were synthesized by the first stars and, following their death, they were expelled into the surrounding environment through the supernovae (SN) explosions. The first stars are therefore extremely important to understand how the Universe has transformed from a state of initial simplicity, i.e consisting only hydrogen and helium gas, into one with an extreme variety of chemical elements. The main questions regarding the first stars are: What are their properties and in particular their **masses**. What was their **mass distribution**? In my Ph.D. project, I'd like to extend my research on the first stars in different ways:

Global constraints on the low-mass end of the first stars

In my Master's thesis I modelled only a single **isolated** Ultra-Faint Dwarf galaxy and I compared my results with the properties of the *Boötes I* galaxy: the metallicity distribution function, the star formation history, and the Iron-stellar luminosity relation. However, these data are available for many Milky way's dwarf galaxies satellites, which have different luminosities and so different masses. The ΛCDM model predicts that the galaxies observed today formed by aggregation of smaller objects. Hence **brighter** dwarf galaxies, i.e. more massive ones, are the result of multiple mergers of small objects. To describe these systems I need to account for the **cosmological context**. This can be possible, for example, by combining my own model with cosmological codes which reconstruct the possible hierarchical histories of the Milky Way and its satellites using a Monte Carlo approach (e.g GAMETE, (GAlaxy MErger Tree & Evolution) [Salvadori et al., 2015]).
This would allow me to make predictions about how many pristine stars I expect to find in dwarf galaxies with different luminosities and hence to give **global**, i.e **stronger**, constraints on the **low-mass end** of the first stars mass distribution.

First star mass and chemical imprint

The first stars with mass greater than the Sun have short lifetimes and cannot survive until today. However, they leave their chemical **imprint** on their **descendants**, i.e. **ancient** metal-poor stars. In my Master's Thesis model of an Ultra-Faint dwarf galaxy, I followed the chemical evolution of Iron and then I obtained the stellar metallicity distribution function which I compared with that of *Boötes I*. For several metal-poor stars there are many other **chemical abundances** data available, from Carbon to Zinc. I would like to further develop my cosmological model to follow the evolution of these elements into the Milky Way and its dwarf satellites across cosmic times. I will be able to predict what are the **key elements** to identify the **descendants** of the first stars. Not only that, since the **chemical elements** produced by the first stars depend on their **mass**, I could give strong constraints on **mass distribution** (shape and mass range) of the first stars.