Radiation-hydrodynamics of galaxy formation in the Local Group

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Radiation is responsible for the last great cosmological transition, the reionization, that occurred 1 billion years after the Big Bang. It marks the end of the so-called dark ages, where the first stars created in the Universe a few hundred millions years after the Big Bang emitted an ionizing UV radiation in an environment full of neutral hydrogen and helium. The clustering of these sources and their continuous apparition led to a network of HII regions which eventually merged between redshifts z=13-6. In 200 millions years, the Universe went from a neutral state to a mostly ionized one, with a 0.01% residual neutral fraction at z=6. The resulting UV background influenced the formation of galaxies in a now transparent Universe, increased the temperature of the intergalactic medium and partly suppressed the star formation it originated from. Being intrinsically related to the starting point of the growth of galaxies, this primeval UV emission is of major importance to understand the properties of the objects we see today. Recently, reionization has also been considered as a potential solution to several of the puzzles of the properties of local galaxies. The UV light emitted by the first stars could be powerful enough to starve the progenitors of z=0 galaxies and their satellites of their own gas, thus quenching or delaying their star formation history. This implies that the observed luminosity function of local satellite galaxies populations is actually the result of a competition between star formation and the destructive effect of UV radiation. It would provide a way to reconcile the CDM predictions for the mass function of a MW-like halo to the actual luminosity function, thus solving partly the so-called « Missing Satellites » problem [1]. Future surveys such as LSST will provide additional constrains by collecting data at the faint-end of the luminosity function and hopefully increase our understanding of the relevance of the local reionization for the local population of satellites.

The PhD project aims at studying the formation of galaxies while taking into account the influence of radiation, especially during the epoch of reionization. It will be mainly focused on the properties of the Local Group galaxies, but the impact on the general population of galaxies can also be considered. These investigations will be mostly driven by numerical simulations, but with an emphasis on the reproduction of observable properties such as the spatial distribution of ultra-faint dwarves, their local luminosity function and their structural and kinematical properties. The candidate will work within the Galaxies team of the Observatoire de Strasbourg, under the supervision of D. Aubert and P. Ocvirk. The project will involve state-of-the art numerical tools to assess galaxy formation in a radiative environment such as EMMA [2], a homebrew AMR code driven by GPUs. Access to important computing resources, locally in Strasbourg and on Tier-0 international facilities will also be granted. Moreover, the 2 supervisors have exclusive access to Cosmic Dawn I and II, the largest hydro-radiative simulations of the reionization of the Local Group ever performed [3]. These simulations ran on the Titan supercomputer (top 2) in 2013 and 2016 on up to 16384 GPUs simultaneously, adding up to more than 100 million core hours, producing 2 Petabytes of data.

The student will take a central role in the analysis of this unique, massive dataset. Possible subjects include the radiative suppression of star formation in future satellite galaxies and its impact on the faint end of the UV luminosity function of high redshift galaxies, its dependence on environment and host mass, as well as the thermal history of gas filaments, and their radiatively-induced destruction. These resources will be strong assets for achieving the goals of the PhD project. Moreover, the international nature of the collaboration (US/UK/GER/FRA/CH/SPA) producing this exceptional set of data will provide a high level and stimulating context for the student.

[1] Ocvirk, P. & Aubert, D., MNRAS 417L, 93 (2011)
[2] Aubert, D., Deparis, N., Ocvirk, P., MNRAS 454, 1012 (2015)
[3] Ocvirk, P. et al., MNRAS 463, 1462 (2016)