Radiation-coupled Primordial Chemistry in Simulations of the First Galaxies

Sean Barrett[*1], Harley Katz[2], Julien Devriendt[2], and Adrianne Slyz[3]

[1]Sub-department of Astrophysics, University of Oxford, Keble Road, Oxford OX1 3RH, UK – United Kingdom
[2]Oxford University – United Kingdom
[3]University of Oxford – United Kingdom

Abstract

The weakly constrained primordial magnetic field (PMF), and the streaming velocity between baryons and dark matter both impact the matter power spectrum before recombination, and thus the formation of structures that could host the first stars. Such primordial haloes are only allowed to cool by molecular hydrogen in an as yet metal-free environment, so the formation of H2 (and HD) dictates the formation of Population III stars. These stars begin the process of reionizing the universe, and enrich their host haloes with metals so that the next generation of stars can form. Modelling the formation of primordial H2 in radiation-hydrodynamical simulations requires a non-equilibrium treatment of a large system of chemical reactions. We have modified RAMSES-RT to solve this chemical network, coupling it via photoreactions to the radiative transfer solver, and include a model for the formation of and radiation from population III stars. We generate initial conditions for a suite of zoom simulations of dwarf galaxies that take into account baryon streaming and varying configurations of the PMF, and thereby investigate the effect of these phenomena on the formation of the first stars and their host galaxies, with a fully self-consistent model of the chemistry involved. These processes may enhance the observability of such galaxies with JWST, possibly giving them constraining power on the PMF.

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[*]Speaker