New radiative transfer methods in numerical simulations of galaxy formation: application to the epoch of reionization

The epoch of reionization takes place starting 150 My after the big bang, and ends approximately around 1 Gyr after the big bang (redshift 20 to 6). During this period of our universe's history, its entire gas content gets ionized by the recently formed galaxies and stars. However, details about how this reionization took place are still debated, and observational constraints for this period, such as the ones that will be brought by SKA, are still a long way from now. Numerical simulations may offer insight into the epoch of reionization and help us prepare future observational campaigns. Most of them currently use the same model for radiative transfer, the moment model M1, which has an analytic closure allowing it to be easily computed. However, this model comes with approximations that could change the output of the simulations and alter our understanding of the epoch of reionization; for example, as M1 approximates photons as a fluid, two colliding fronts of photon waves tend to create pseudo sources that should not exist. This could be one of the reasons why the M1 model tends to under estimate the photoionization rate at small scales (Wu et al., 2009), but, at this point, we don’t really know what could be the scale of the effects of this property of the M1 model on numerical simulations. My thesis mainly aims at implementing and comparing competing models of radiative transfer, mainly the Pn model, already in use in many other fields of physics, to see if it could be a replacement or a complementary model to M1. We can observe quite easily that it doesn't have the issue of the pseudo sources in colliding front, however it cannot guarantee the positivity of the energy, and reacts quite badly to impulse sources, while being more constitutionally expensive than M1. However, tested on standardized tests for RT models (defined in Iliev et al. 2006, 2009), we can observe that the Pn model performs as well as the M1 model on classic examples met in simulations such as the ionization of gas surrounding a continuous source, or the ionization of a clump of dense gas. Thus, the Pn model seems to be a promising alternative to the M1 model, despite some flaws.