Abstract

We see many different galaxies today and we wish to understand how they were formed. In this thesis we focus on the formation of galaxies in halos similar to the one of the Milky Way. Throughout this thesis we analyse numerical simulations of individual galaxies. It is crucial to use realistic numerical models that accurately describe physical processes in these simulations. Therefore, we introduce and describe new numerical models that we have implemented into the RAMSES code for supernova feedback, turbulence and star formation. We use the so-called multi-freefall model for star formation that allows for locally varying efficiencies depending on the turbulent state of the gas. We apply these new models to cosmological simulations and in the first project, we study the formation of an early-type galaxy. We find that strong feedback regulates the available gas mass inside the galaxy. Furthermore, we find high star formation efficiencies during starburst regimes and low star formation efficiencies during quiet times. At low redshift, the model produces quenched galaxies without further depletion of the remaining gas.

In the second project, we study the origin of extended and thin discs. We analyse two galaxies forming within Milky Way like halos with almost identical mass accretion histories and halo spin parameters. However, the two resulting galaxies end up with very different bulge-to-disc ratios, with one galaxy ending up as a bulge-dominated galaxy and the other as a disc-dominated galaxy. Both galaxies feature an epoch, called the Grand Twirl, where an initial disc is formed in a very short time. We find that the different morphologies at $z = 0$ are a result of the subsequent cold gas accretion patterns on the initially formed disc. The disc-dominated galaxy accreted mostly co-rotating and co-planar gas which added positive angular momentum to the disc whereas the bulge-dominated galaxy accreted mostly counter-rotating gas which effectively removed angular momentum from the disc. We find that for the disc-dominated galaxy, the rapid growth of the disc reduces the star formation rate surface density which makes feedback inefficient and explains the transition from an outflow-dominated regime to a quiescent regime.

In the third project, we find that the assumption of Jeans and hydrostatic equilibrium are valid in massive galaxies. We provide prescriptions to evaluate the dynamical mass of galaxies from kinematic measurements of stars or gas. This is done separately for the cases of resolved and unresolved kinematics. Furthermore, we show that the assumption of self-gravitating gas discs is not valid.

Finally, we address the puzzling observational indications for very cold galactic discs at redshifts $z \gtrsim 3$, an epoch when discs are expected to be highly perturbed. We see that the simulated galaxy experiences an extended epoch of large rotation-to-dispersion ratio. This is enabled by a period without mergers and by the accretion of co-rotating and co-planar gas. We further study the dependence of the measured rotation-to-dispersion ratio on the gas tracer and find that using molecular tracers largely enhances the values in comparison to the ones obtained using atomic gas.