

The threshold for primordial black holes: dependence on the shape of the cosmological perturbations

Ilia Musco

Abstract: Primordial black holes could have been formed in the radiative era of the early Universe from the collapse of large enough amplitude perturbations of the metric. These correspond to non linear energy density perturbations characterized by an amplitude larger than a certain threshold, measured when the perturbation re-enters the cosmological horizon. The process of primordial black hole formation is studied here numerically within spherical symmetry, using the gradient expansion approximation in the long wave length limit, where the pressure gradients are small, to set the initial conditions. In this regime it is possible to understand how the threshold for primordial black holes depends on the initial shape of the initial energy density profile, clarifying the relation between local and an averaged measures of the perturbation amplitude. Although there is no universal threshold for primordial black hole formation, the averaged mass excess of the perturbation depends on the amplitude of the energy density peak, and it is possible to formulate a well-defined criterion to establish when a cosmological perturbation is able to form a black hole in terms of these two crucial quantities. This gives understanding of how the abundance of primordial black holes depends on the shape of the the inflationary power spectrum of cosmological perturbations.