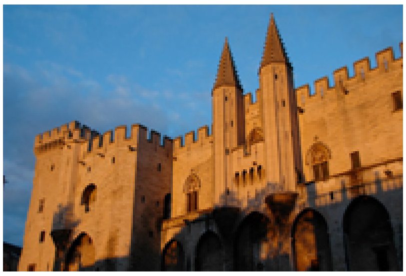

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Beyond single stream with the Schrödinger method

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We investigate large scale structure formation of collisionless dark matter in the phase-space description based on the Vlasov (or collisionless Boltzmann) equation whose nonlinearity is induced solely by gravitational interaction according to the Poisson equation. Determining the time-evolution of density and peculiar velocity demands solving the full Vlasov hierarchy for the moments of the phase-space distribution function. In the presence of long-range interaction no consistent truncation of the hierarchy is known apart from the pressureless fluid (dust) model which is incapable of describing virialization due to the occurrence of shell-crossing singularities and the inability to generate higher cumulants like vorticity and velocity dispersion. Our goal is to find a phase-space distribution function that is able to describe regions of multi-streaming and therefore can serve as theoretical N-body double. We use the coarse-grained Wigner probability distribution obtained from a wavefunction fulfilling the Schrödinger equation and show that its evolution equation bears strong resemblance to the Vlasov equation but cures the shell-crossing singularities. This feature was already employed in cosmological simulations of large-scale structure formation by Widrow & Kaiser (1993). The coarse-grained Wigner ansatz allows to calculate all higher moments from density and velocity analytically thereby incorporating nonzero higher cumulants in a self-consistent manner. On this basis we are able to show that the Schrödinger method automatically closes the corresponding hierarchy such that it suffices to solve a Schrödinger equation in order to determine density and velocity and thereby all higher cumulants.

Primary author: Mrs UHLEMANN, Cora (Arnold Sommerfeld Center for Theoretical Physics, LMU)

Co-authors: Mr KOPP, Michael (Arnold Sommerfeld Center for Theoretical Physics, LMU); Mr HAUGG, Thomas (Arnold Sommerfeld Center for Theoretical Physics, LMU)

Presenter: Mrs UHLEMANN, Cora (Arnold Sommerfeld Center for Theoretical Physics, LMU)

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