Study of Self-similar Solution of Self-gravitating Non-relativistic Fluids

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Motivation

- The properties and existence of the dark matter is one of the most fascinating question in cosmology.
- Our main goal of this research is to find **scaling solutions** of the gravitational fields, which can be good candidates to describe the evolution of the Universe or collapse of compact astrophysical objects
- We present a **dark fluid model** described as a non-relativistic and self-gravitating fluid
- We studied these coupled **non-linear differential equation** systems using self-similar time-dependent solutions

The Model

We consider a set of coupled non-linear differential equations, which describes the **non-relativistic dynamics** of a compressible fluid with zero thermal conductivity and zero viscosity.

$$\partial_t \rho + \nabla(\rho \boldsymbol{u}) = 0$$

$$\partial_t \boldsymbol{u} + (\boldsymbol{u}\nabla)\boldsymbol{u} = -\frac{1}{\rho}\nabla p + \boldsymbol{g}$$

$$p = p(\rho)$$

Equation of State (Polytropic and Chaplygin gas)

$$p = -w\rho^n \qquad\qquad p = -\frac{A}{\rho^\alpha}$$

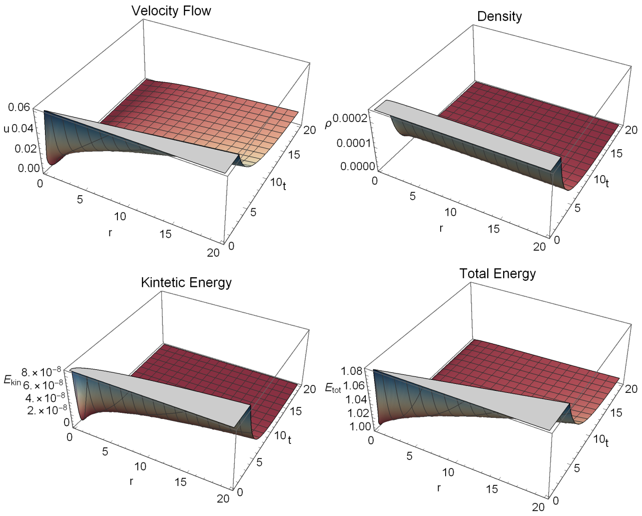
Sedov-Taylor Ansatz

- We are reducing the PDE system into ODE system using Taylor *ansatz*:

$$u(r,t) = t^{-\alpha} f\left(\frac{r}{t^{\beta}}\right) \quad \rho(r,t) = t^{-\gamma} g\left(\frac{r}{t^{\beta}}\right)$$
$$\Phi(r,t) = t^{-\delta} h\left(\frac{r}{t^{\beta}}\right),$$

- (f, g, h) **shape-functions** only depend on $\zeta = rt^{-\beta}$
- $\alpha, \beta, \gamma, \delta$ similarity exponents
- The β describes **the rate of spread** of the spatial distribution
- Other exponents describe the **rate of decay** of the intensity of the corresponding field

Result:


Velocity Flow
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r
t
Density
ρ
Potential
ϕ
Kintetic Energy
E_kin
Total Energy
E_tot