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Exercise 1

1) $\vec{v} = H \vec{r}$ $\left(H = \frac{\dot{a}}{a}\right)$

$$\frac{d\rho}{dt} = -\rho \nabla \cdot \vec{v}$$

$$\frac{\partial \rho}{\partial t} + \vec{v} \nabla \rho = -\rho \nabla \cdot \vec{v}$$

$$\frac{\partial \rho}{\partial t} + H \vec{r} \nabla \rho = -\rho \nabla \cdot H \vec{r}$$

$$\dot{\rho} = -\rho \nabla (H \vec{r}) - H \vec{r} \cdot \nabla \rho$$

$$= -\rho \nabla \frac{\dot{a}}{a} \vec{r} - \frac{\dot{a}}{a} \vec{r} (\nabla \rho) = 0 ?$$

$$= -\nabla \rho \frac{\dot{a}}{a} \vec{r}$$

$$= -\frac{\dot{a}}{a} \nabla \cdot \vec{r}$$

$$= -\frac{\dot{a}}{a} \nabla \cdot \rho \vec{r}$$

$$d\rho = -\frac{da}{a} \nabla \cdot \rho \vec{r} = -\frac{da}{a}\left(\rho \nabla \cdot \vec{r} + \vec{r} \cdot \nabla \rho\right)$$

$$= -\frac{da}{a} \rho 3$$

$$\ln \rho \Big|_{t=t_0}^{t} = -3 \ln a$$

$$\ln \frac{\rho(t)}{\rho(t_0)} = -3 \ln a$$

$$\frac{\rho(t)}{\rho(t_0)} = a^{-3}$$

$$\boxed{\rho(t) = \rho(t_0)\, a^{-3}}$$

if $\nabla \rho = 0$

this is valid, but

I don't see why it should...