E 266B - Spectral Methods
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1 Navier Stokes with viscosity

1.1 Parabolic profile

I simulated a parabolic flow between two plates with the following initial condition

$$\begin{aligned} V_x &= (1+z)(1-z) \\ V_y &= 0 \\ V_z &= 0 \end{aligned} \tag{1}$$

with $\nu = 0.2$ and $\rho = 1$ for incompressible flow with $\nabla.\mathbf{V} = 0$ and boundary condition of $V_z|_{z=\pm 1} = 0$. Number of Fourier modes in x and y direction is $N_x = N_y = 16$ and number of Chebyshev modes in z direction is $N_z = 17$. We have periodic boundary condition in x and y direction. Energy of this system is decreasing as

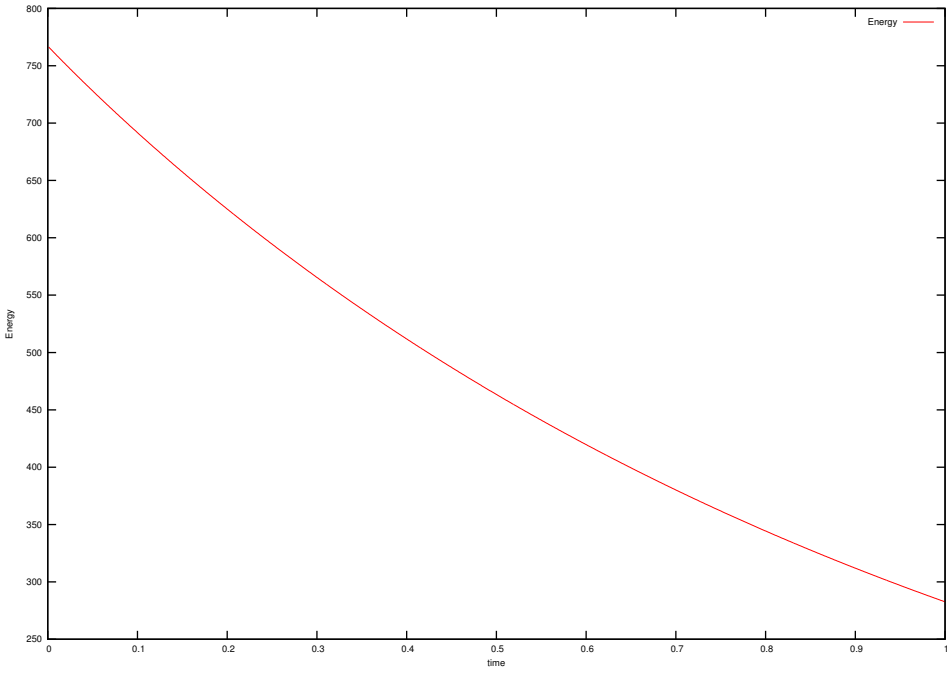

Figure 1: Energy over time

The velocity profile in the z direction and as time pass is

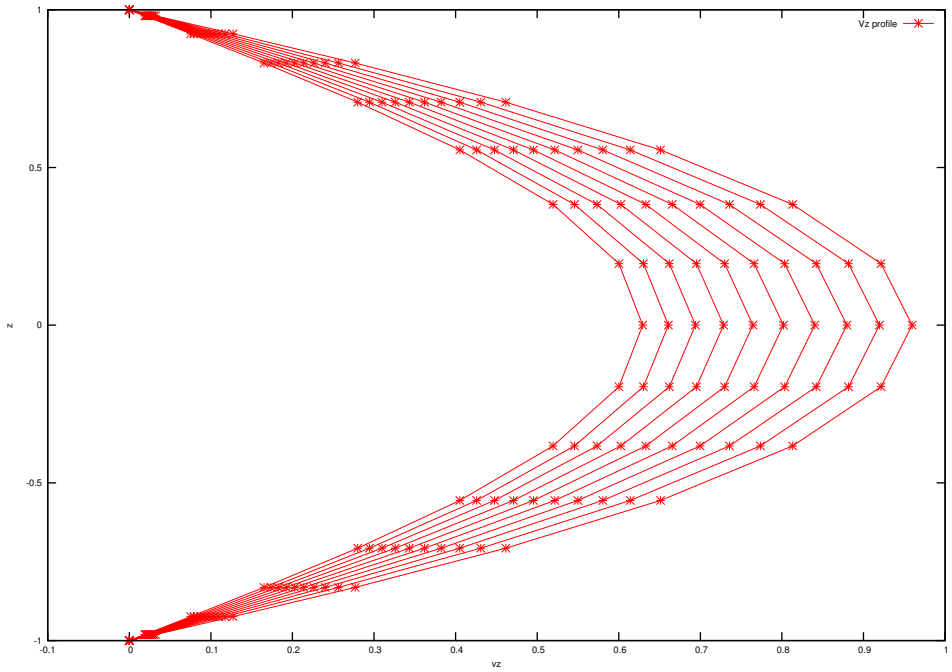

Figure 2: Velocity profile as at different times

Infinity norm of divergence in the field is

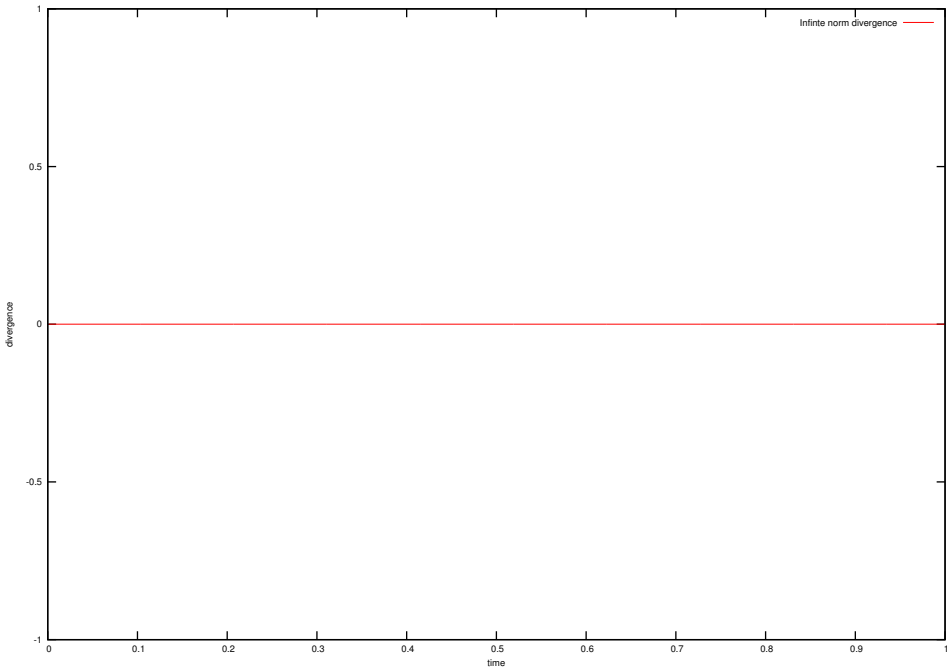

Figure 3: Infinity norm of divergence of velocity at different times

and Vz at end points, should be always zero as shown in the following figure

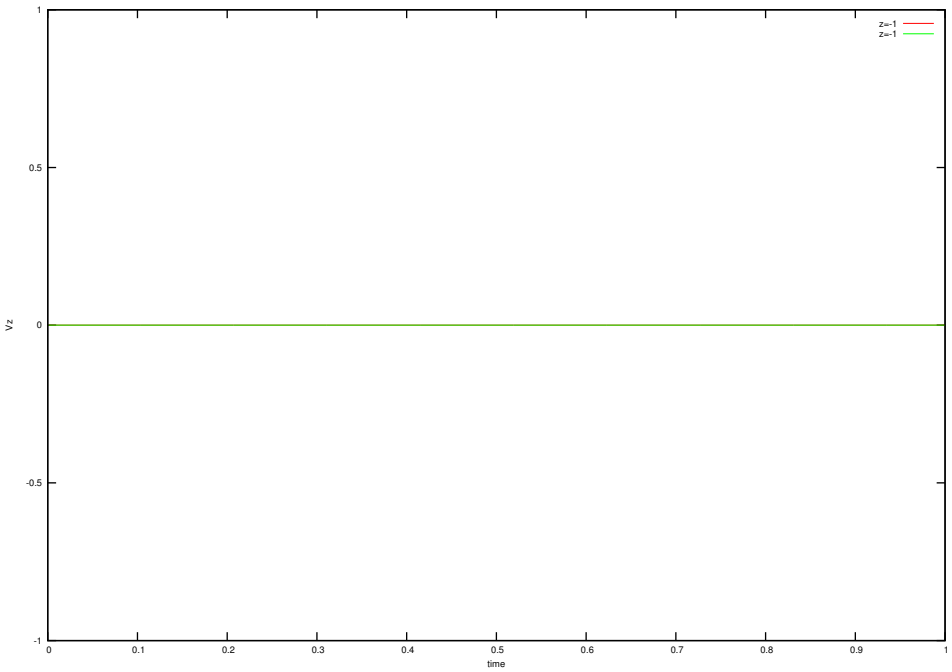

Figure 4: V_z at end points over time

1.2 Parabolic profile with perturbation

I used parabolic profile over the whole region except at the first and the last planes. Results are as follows

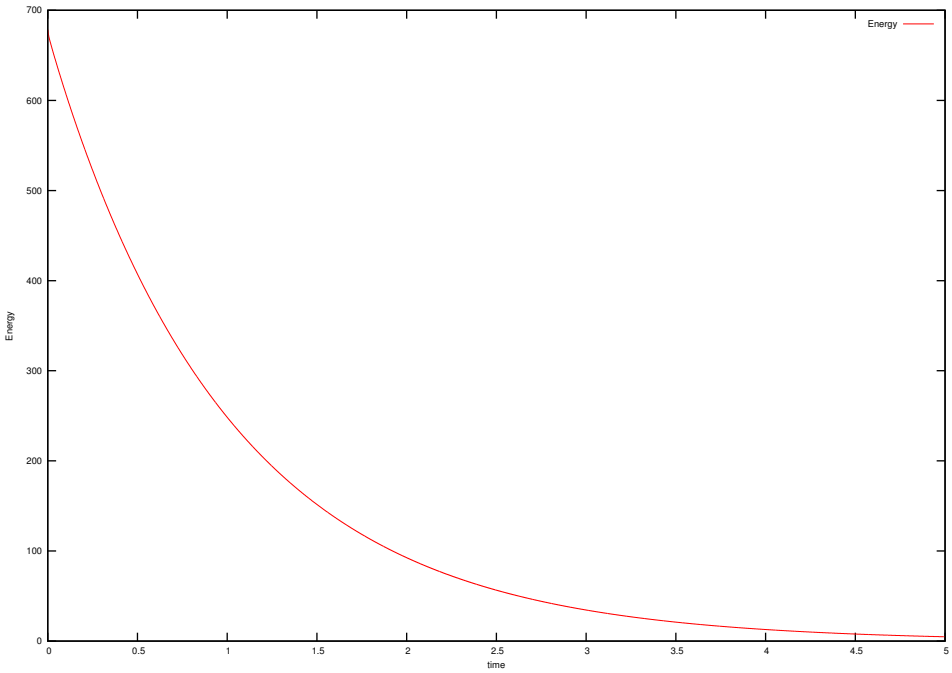

Figure 5: Energy evolution over time

The velocity profile in the z direction and as time pass is

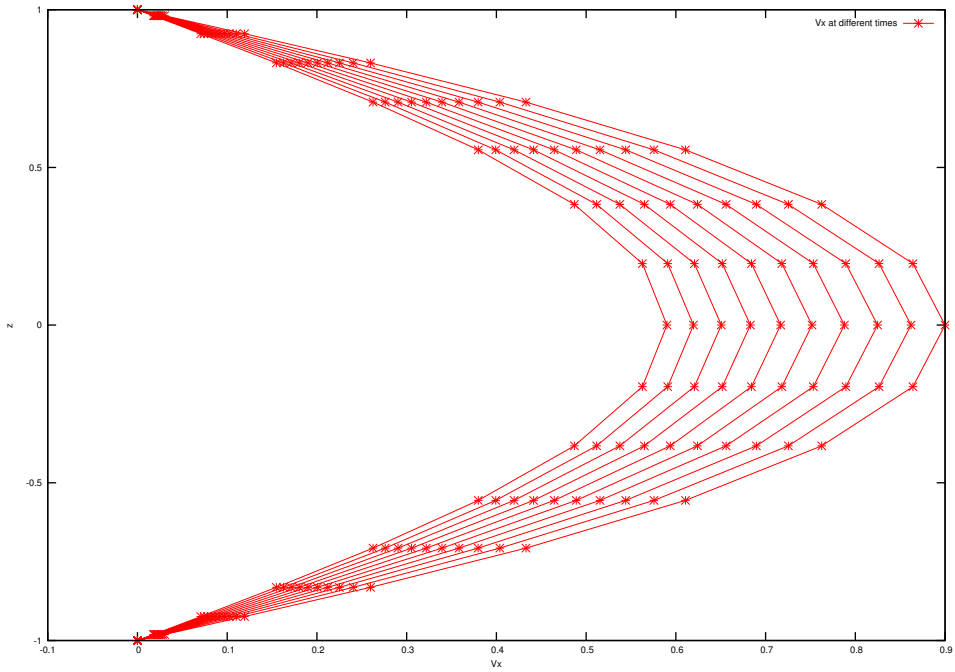

Figure 6: Velocity profile as at different times

Infinity norm of divergence in the field is

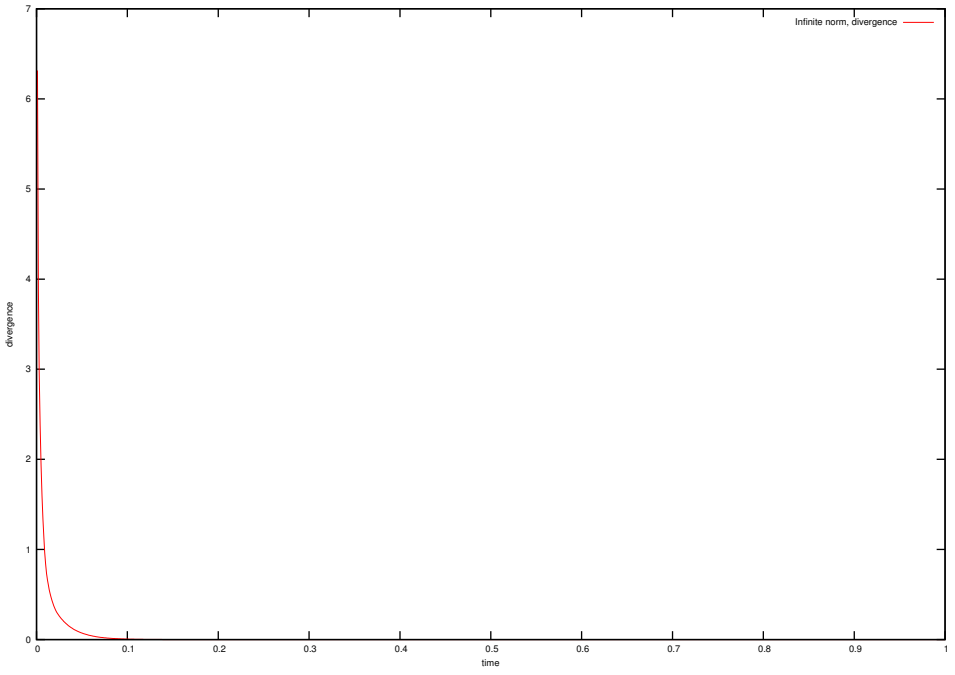

Figure 7: Infinity norm of divergence of velocity at different times

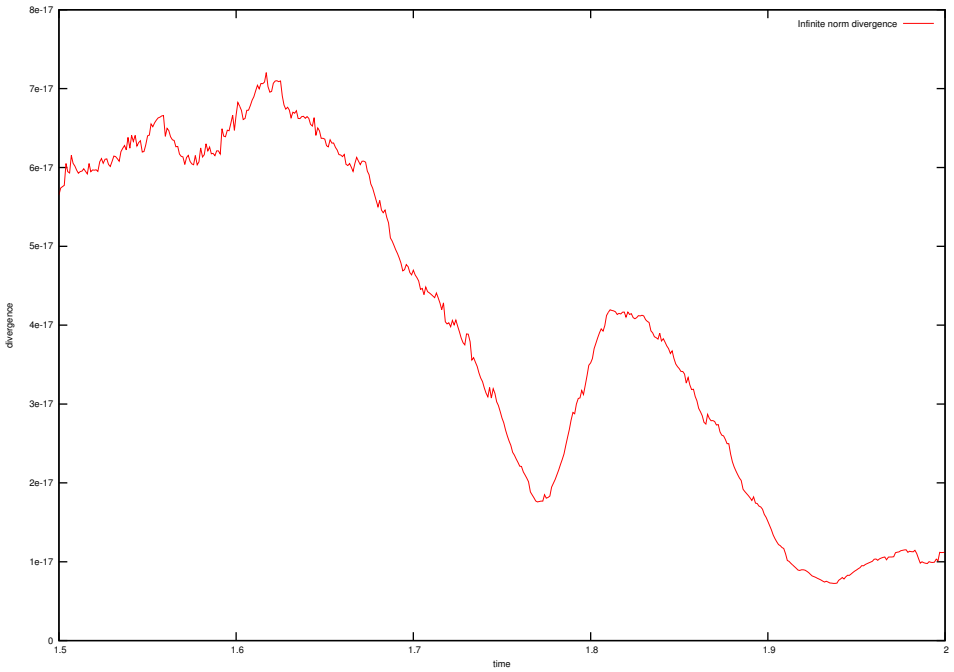

Figure 8: Infinity norm of divergence of velocity at different times - Zoomed in

and Vz at end points, should be always zero as shown in the following figure

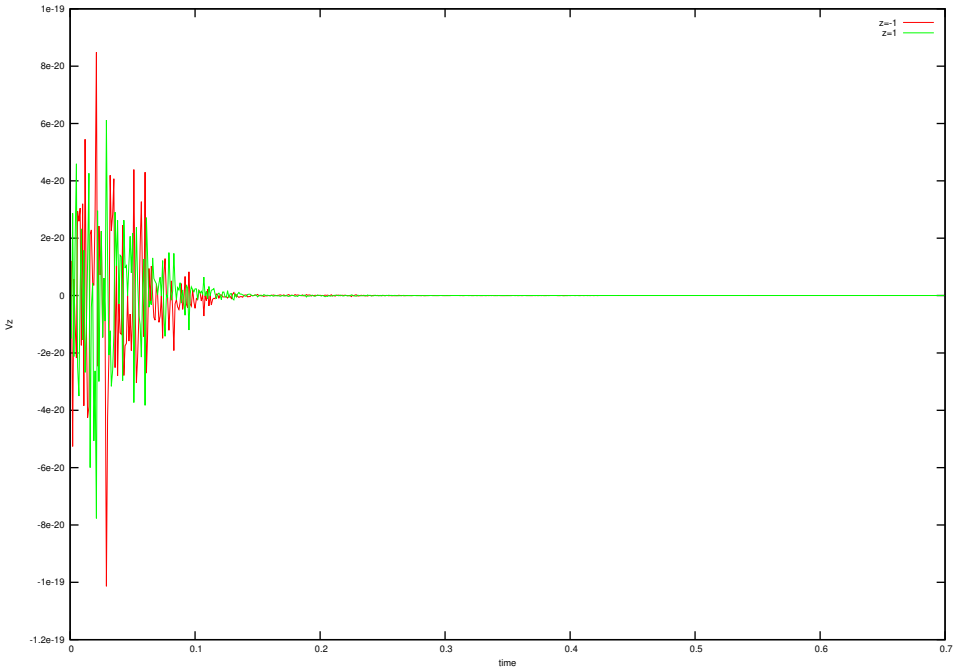

Figure 9: V_z at end points over time

2 Euler Equation

Again we did the same simulation (physical conditions), but with $\nu = 0$. Parabolic profile remains same, and Energy is cosntant along the time and whole flow is remains divergence free.

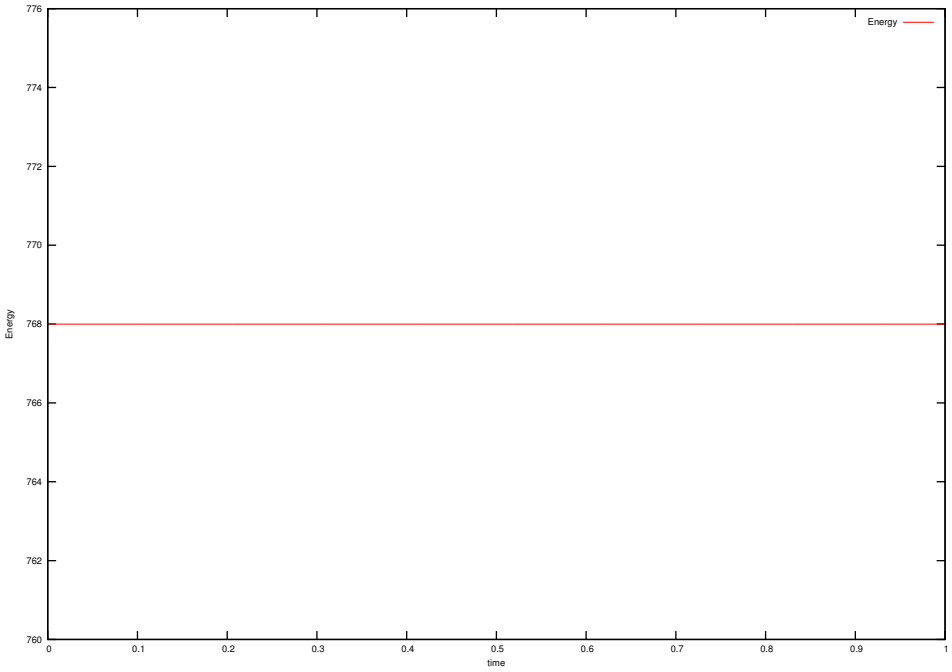

Figure 10: Energy evolution over time

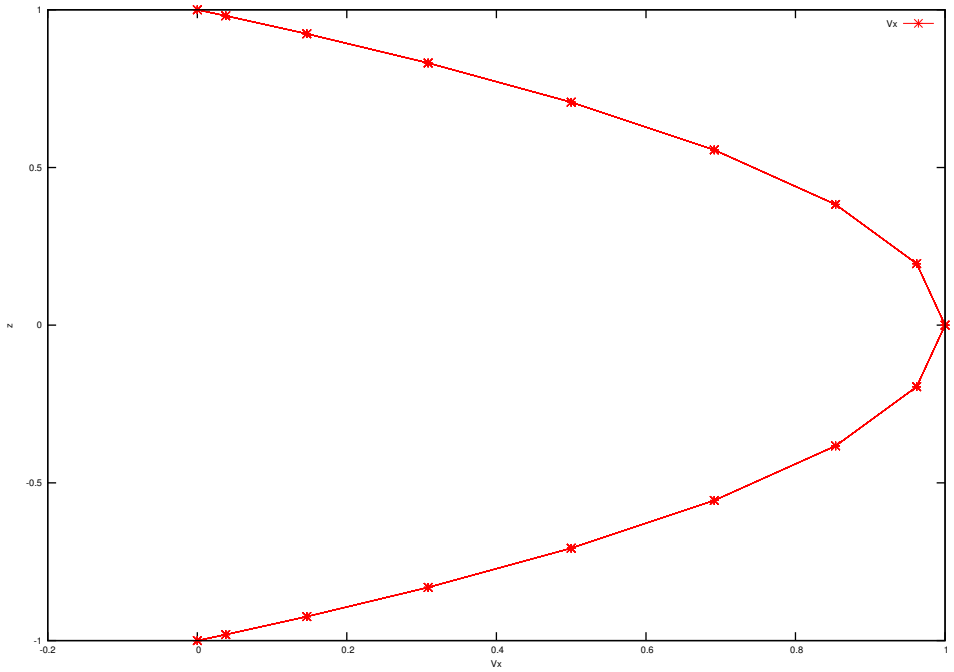

Figure 11: Velocity profile as at different times

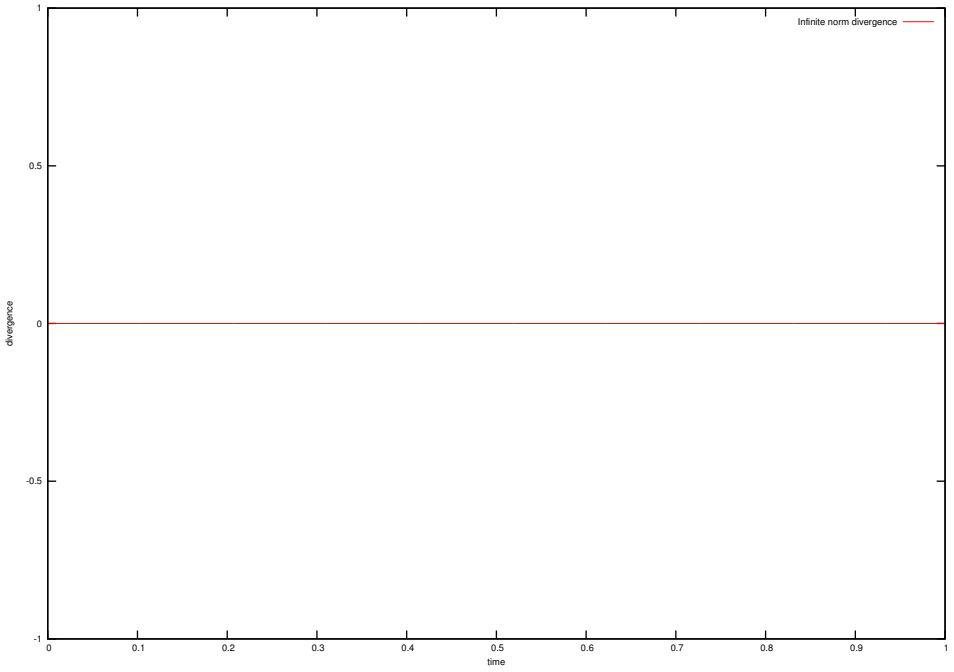

Figure 12: Infinity norm of divergence of velocity at different times