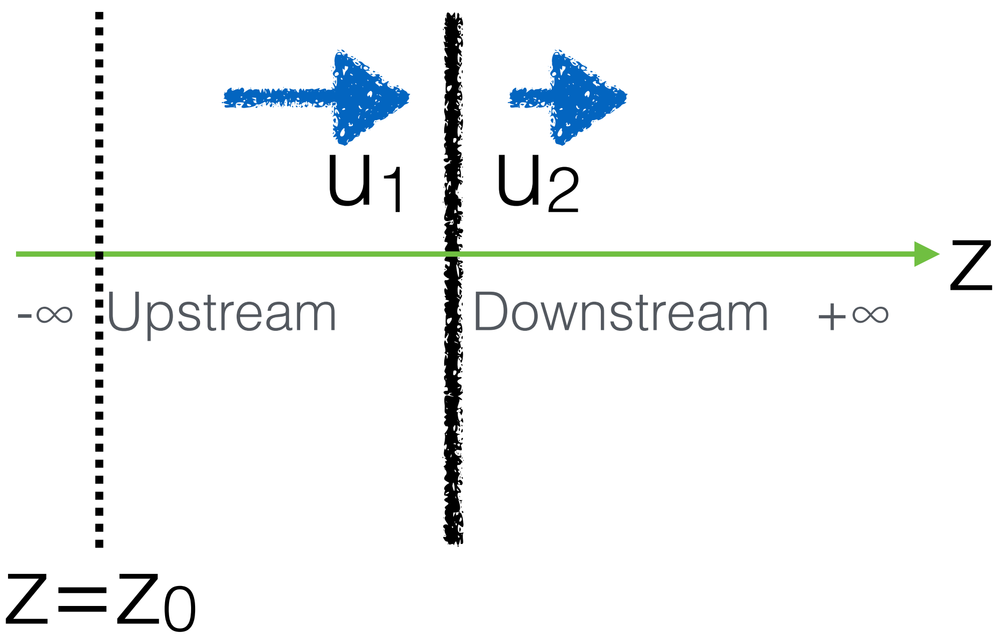
# Exercise n. 1

Consider an infinite plane shock wave at z=0 as in the figure




Particles are accelerated at the shock and are free to leave the system from a region at $z=z_0$. Calculate the spectrum of accelerated particles and the flux of particles across the surface at $z=z_0$ in the test particle approximation. Discuss the physical relevance of the solution for cosmic ray physics

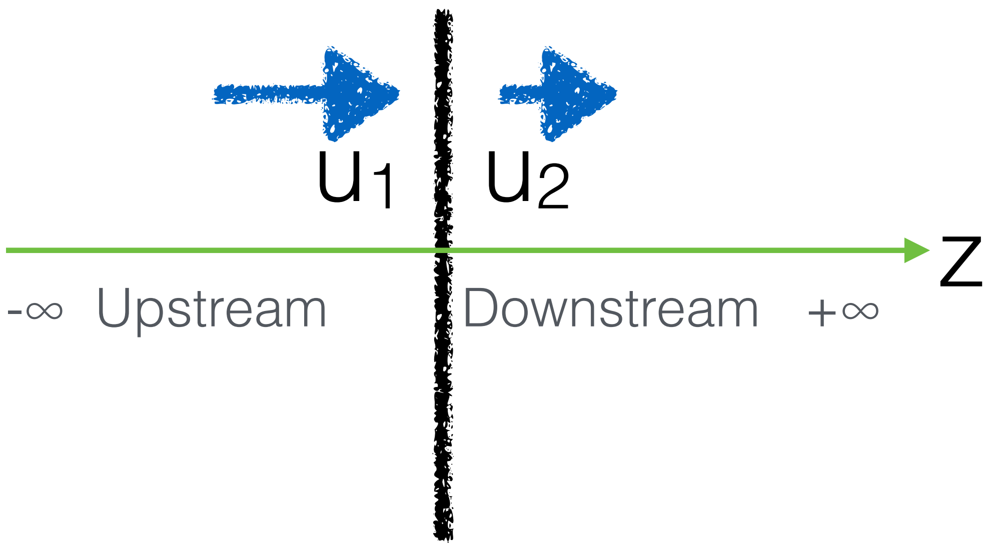
***Hint to the solution:*** solve the transport equation

$$\frac{\partial f}{\partial t} = \frac{\partial}{\partial x}\left[D\frac{\partial f}{\partial x}\right] - u\frac{\partial f}{\partial x} + \frac{1}{3}\frac{du}{dx}p\frac{\partial f}{\partial p} + Q(x,p,t)$$

separately at the shock and for z<0 (upstream) in the stationary situation, using the correct boundary condition at $z=z_0$ and assuming that the injection term is a delta function in both p and z (at z=0).

# Exercise n. 2

Consider an infinite plane shock wave at z=0 as in the figure




Assume that there is no fresh injection of particles at the shock but the plasma that enters the shock from upstream carries with it a population of non-thermal particles with spectrum $f_\infty(p) \sim p^{-a}$. Discuss what happens to these particles at the shock and how the result changes depending on whether "a" is smaller or larger than $3r/(r-1)$ where $r=u_1/u_2$ is the compression factor. Discuss the physical relevance of the solution for cosmic ray physics. What happens to the total energy of particles? and to the total number?

***Hint to the solution:*** solve the transport equation

$$\boxed{\frac{\partial f}{\partial t} = \frac{\partial}{\partial x}\left[D\frac{\partial f}{\partial x}\right] - u\frac{\partial f}{\partial x} + \frac{1}{3}\frac{du}{dx}p\frac{\partial f}{\partial p} + Q(x,p,t)}$$

in the stationary case with the boundary condition that $f(z=-\infty,p)=f_\infty(p)$, recalling that the injection term is assumed to vanish.