Outflow Driven Turbulence

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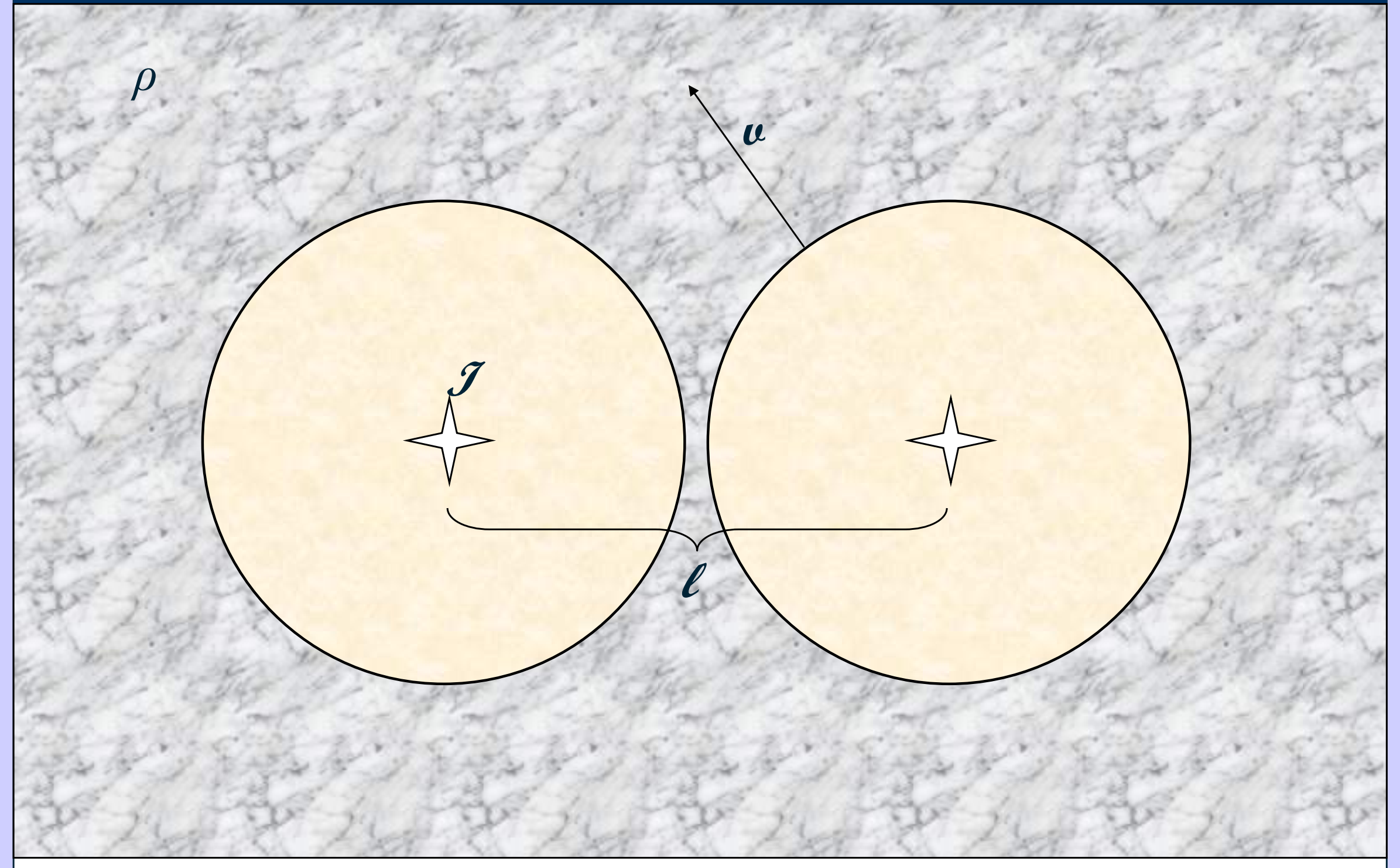
Outflow Properties



Given spherical outflows each carrying momentum I occuring at a rate S in an environment of density ρ, the outflows will begin to interact with one another after a time $t = \frac{\rho^{3/7}}{I^{3/7} S^{4/7}}$, at length scales $l = \frac{I^{1/7}}{\rho^{1/7} S^{1/7}}$, with velocities $v = \frac{I^{4/7} S^{3/7}}{\rho^{4/7}}$. Or if one chooses an interaction scale l, and an ambient density ρ, and an interaction velocity v, then we need outflows to occur at a rate $S = \frac{v}{l^4}$ with momentum $I = \rho l^3 v$.

Magnetic Fields

If we consider a weak uniform magnetic field and estimate the growth of the magnetic energy density we find:

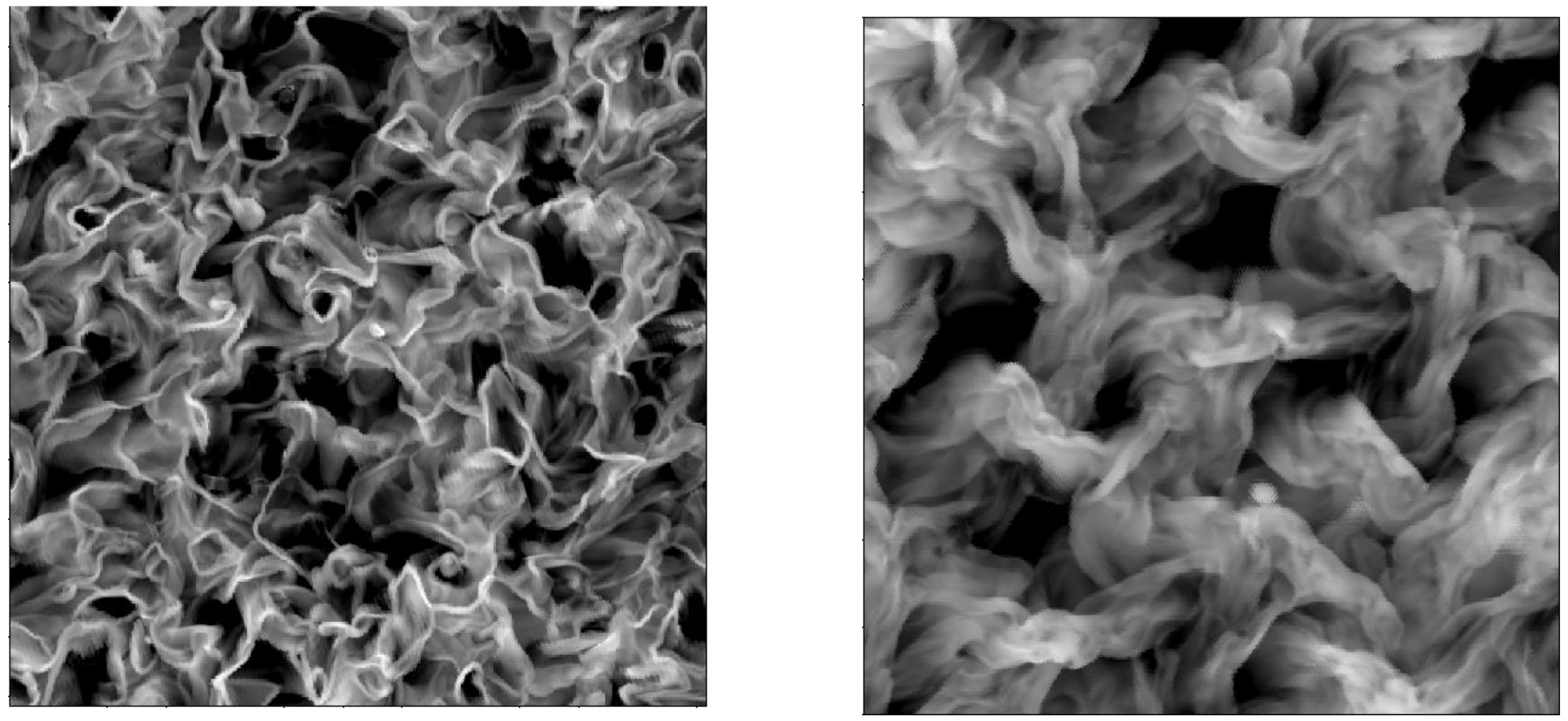
$$\frac{\partial \mathrm{B}^2}{\partial t} \approx B_0 \cdot \left(\frac{\partial B}{\partial t} \right) = B_0 \cdot \left[\nabla \times \left(v \times B_0 \right) \right] \approx \frac{{B_0}^2 v}{l} = \frac{B_0^2}{\tau}$$

Acknowledgements

Abstract

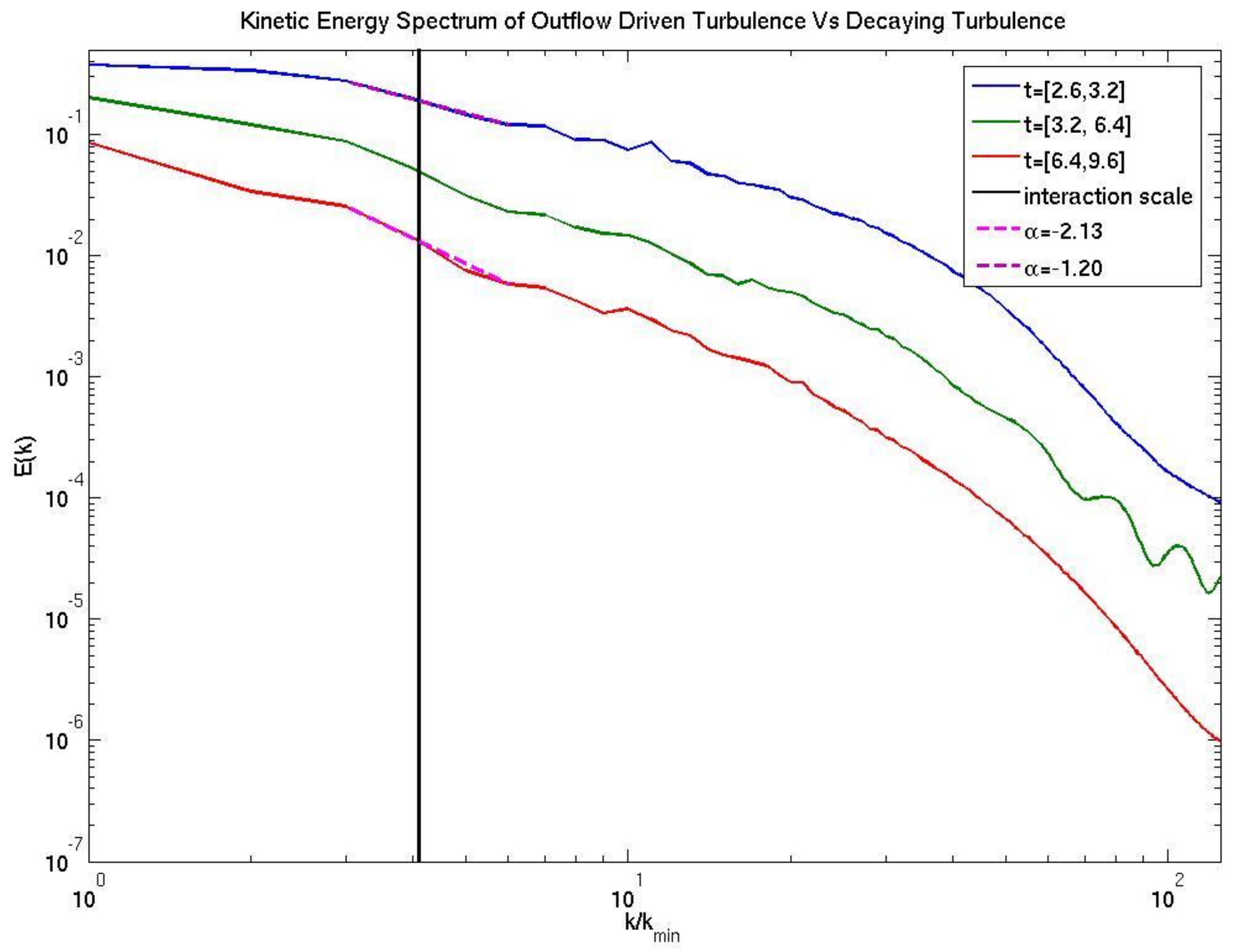
Protostellar outflows and their cavities are commonly observed within turbulent molecular cloud cores. To what extent these outflows are able to drive and sustain supersonic turbulence and the nature of there interaction with the turbulent environment remains poorly understood. Here we present the results of recent simulations of star forming cloud cores that demonstrate the ability of outflows to drive and sustain supersonic turbulence and characterize the nature of the driving and the resulting turbulence.

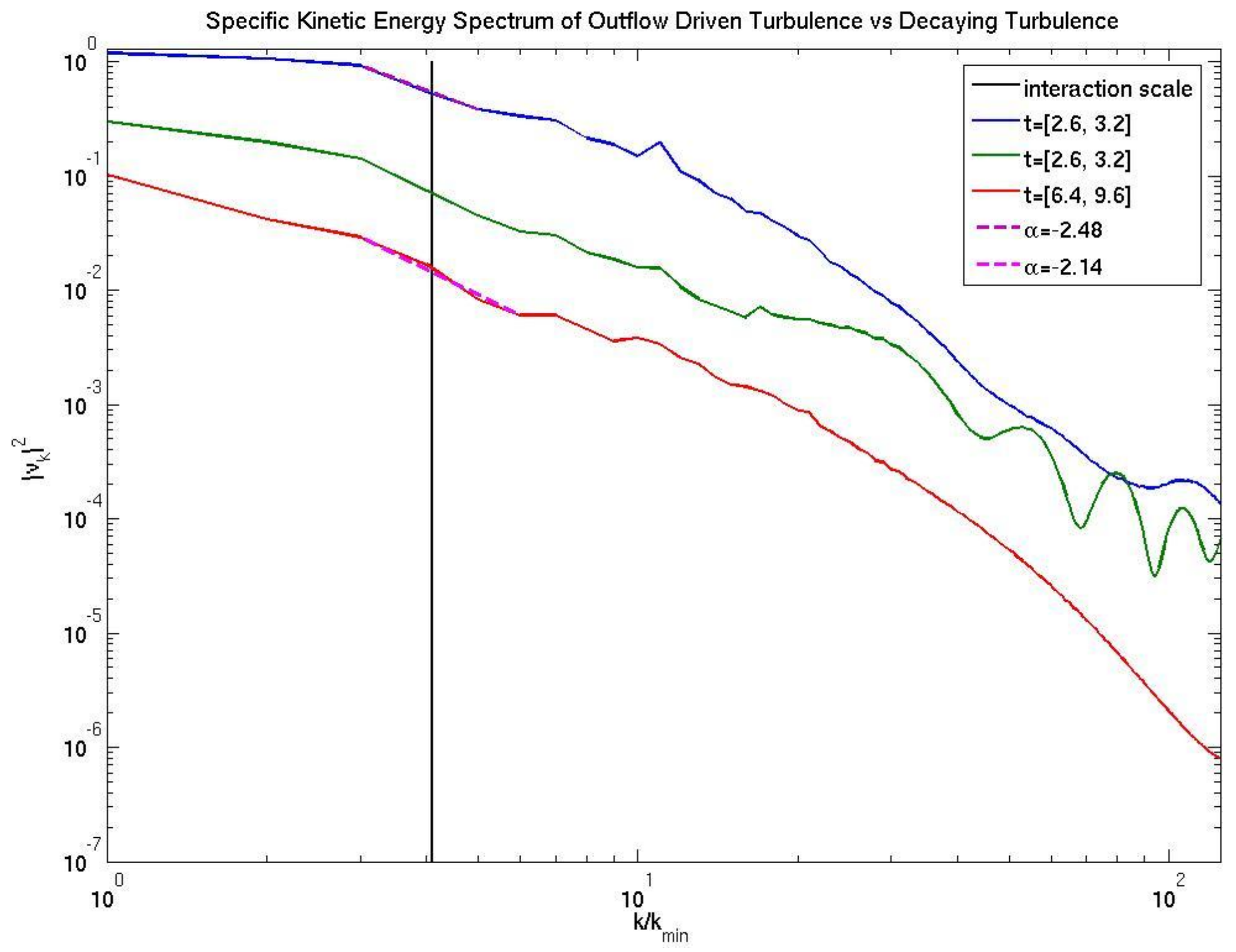
Numerical Simulations



Hydrodynamic simulations were performed on a periodic cube of length 1.5 pc for 1 Myr at a resolution of 256^3 using a polytropic equation of state (γ=1.0001) to approximate an isothermal gas at 10°K

Spectra

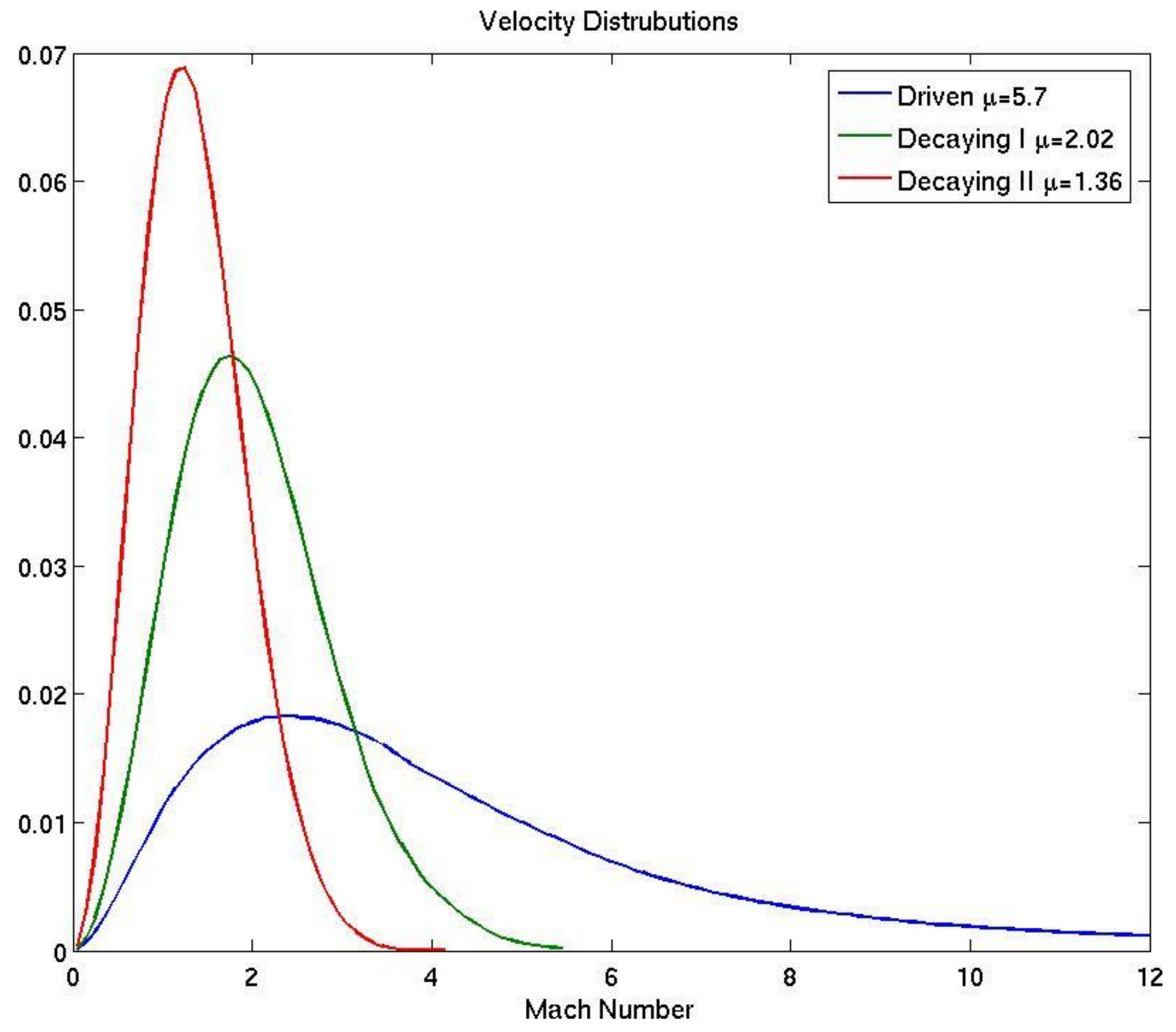

Kinetic Energy Spectrum of Outflow Driven Turbulence Vs Decaying Turbulence


Specific Kinetic Energy Spectrum of Outflow Driven Turbulence vs Decaying Turbulence

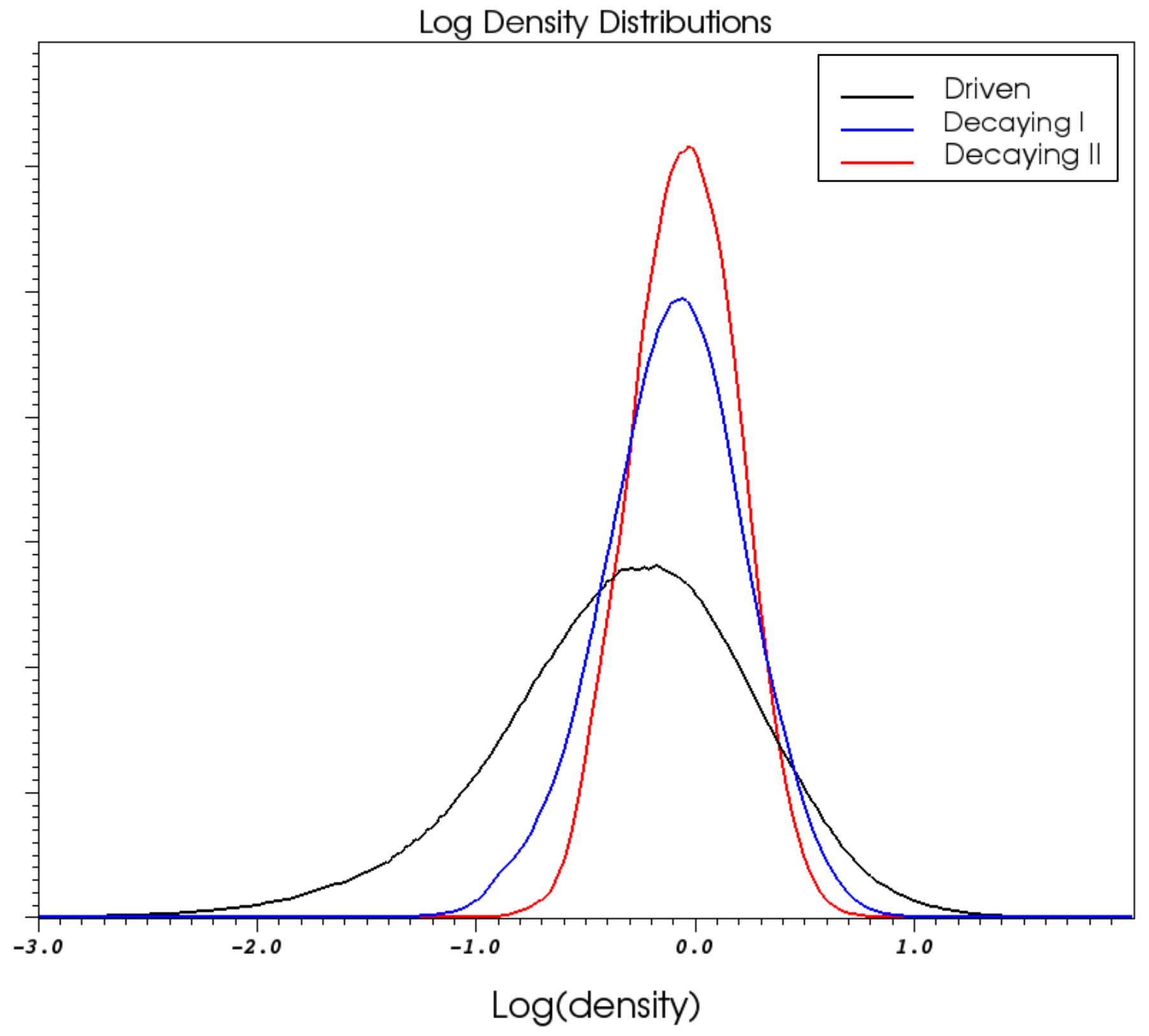
Simulations parameters

ρ	371 $M_\odot$ /pc^3
$\mathcal{I}$	17 $M_\odot$ /Myr
S	59 $pc^{-3}Myr^{-1}$
ℓ	.36 pc
t	.36 Myr
m	17 $M_\odot$
c_s	.2 km/s
$\rho_{outflow}$	92 $M_\odot$ /pc^3
$v_{outflow}$	240 km/s
$t_{outflow}$	.8 kyr
θ_{half}	5°
$r_{outflow}$	.03 pc

Velocity Distribution


Velocity Distrubutions

Density Distribution


Log Density Distributions