Multifluid magnetohydrodynamic turbulence in molecular clouds

T.P. Downes

School of Mathematical Sciences & National Centre for Plasma Science & Technology,
Dublin City University

Dublin Institute for Advanced Studies

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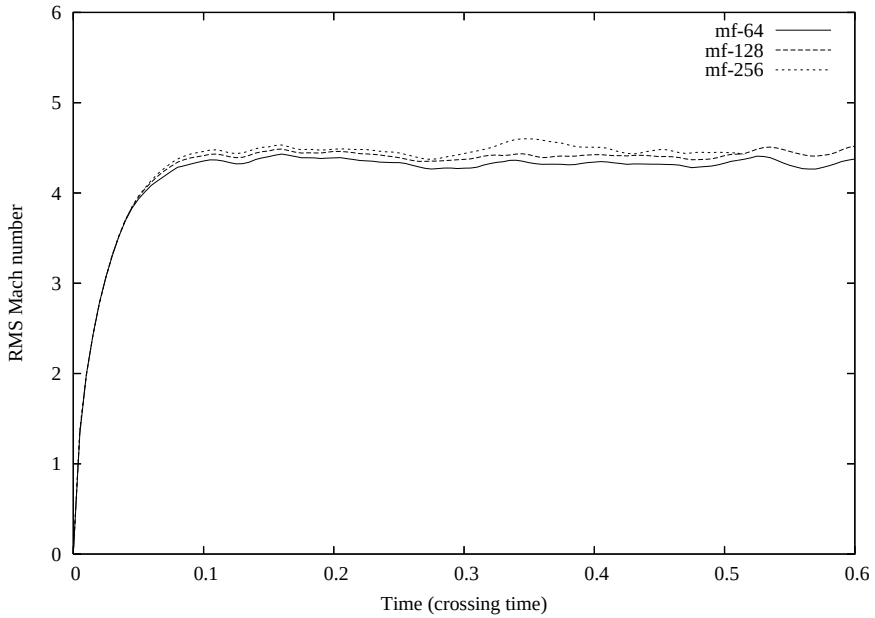
Collaborators

- Dr Stephen O'Sullivan (Dublin Institute of Technology)
- Dr Aoife Jones
- Mr Wayne O'Keeffe (grad student)

Numerical set-up

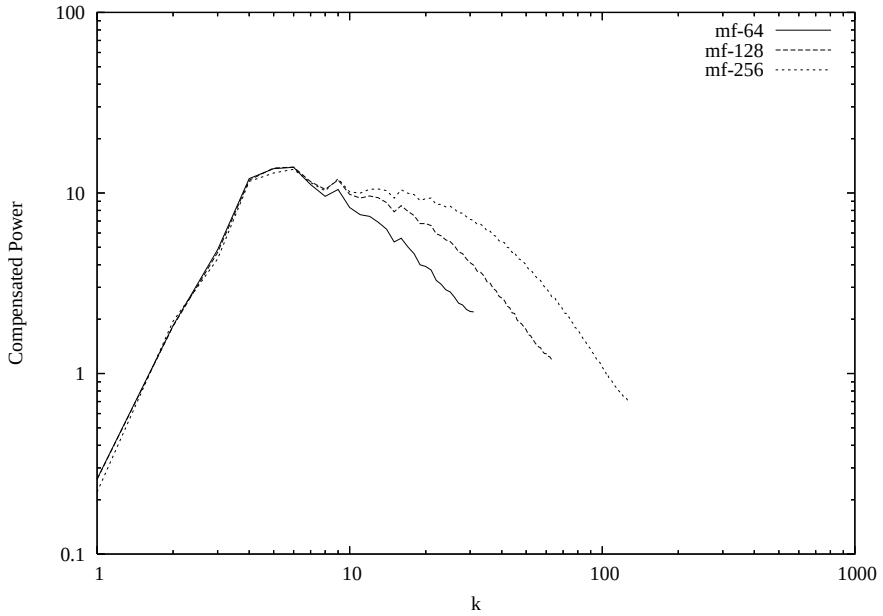
- Box of size 0.2 pc with periodic boundary conditions
- Four fluids (1 neutral, 3 charged - electrons, ions and “dust”)
- Density, temperature and magnetic field of $10^4\,\mathrm{cm}^{-3}$, 10 K and 20 μG, respectively
- Initially at rest
- Maximum resolution of 256^3.

Resolution study



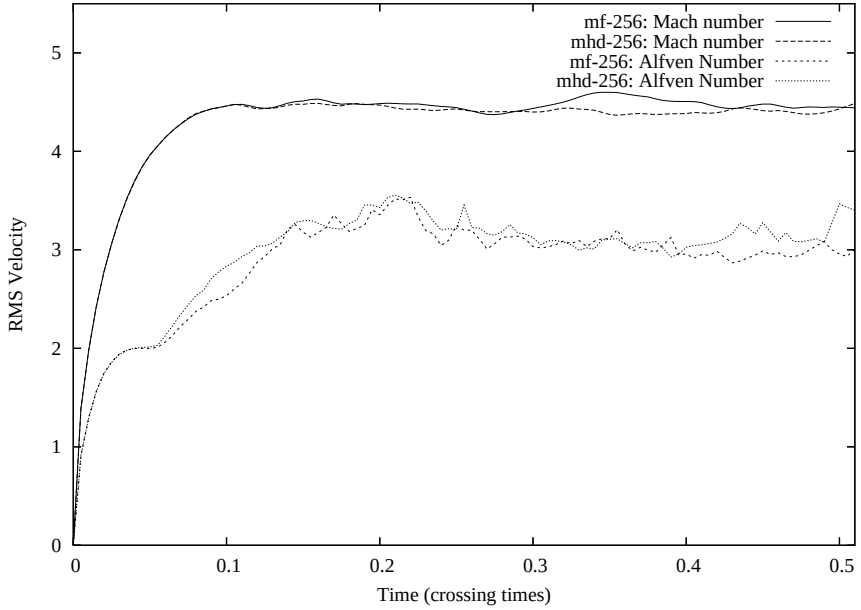
RMS Mach number as a function of time for differing resolutions

Resolution study



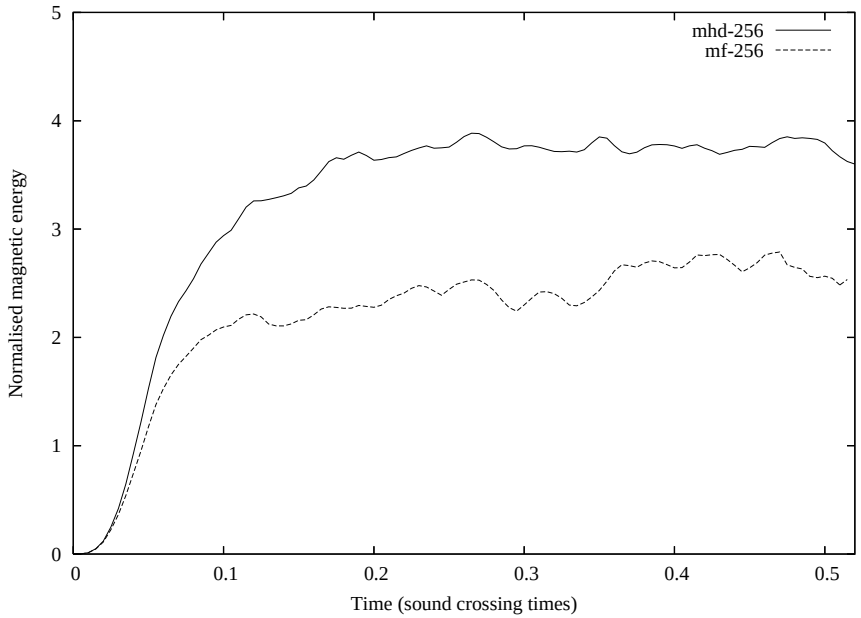
Compensated neutral velocity power spectrum for differing resolutions

Evolution of the turbulence



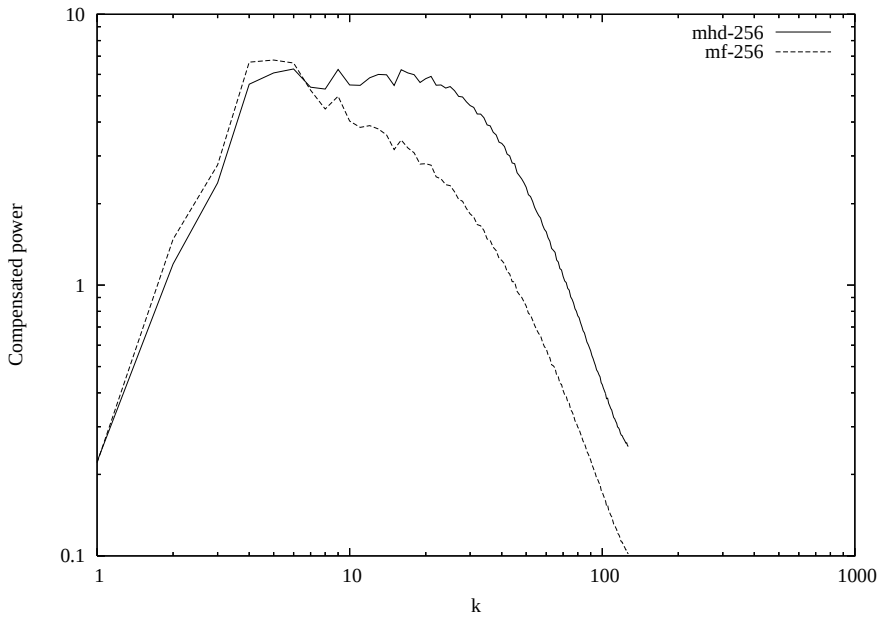
RMS Mach & Alvén numbers for multifluid and ideal MHD simulations (256^3)

Evolution of the turbulence



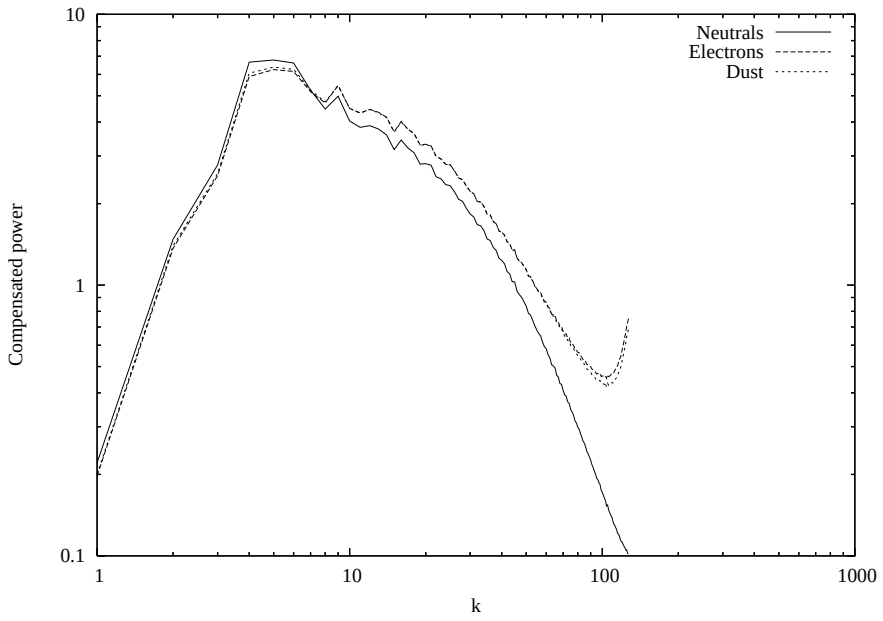
Perturbed magnetic energy for multifluid and ideal MHD simulations

Power spectra



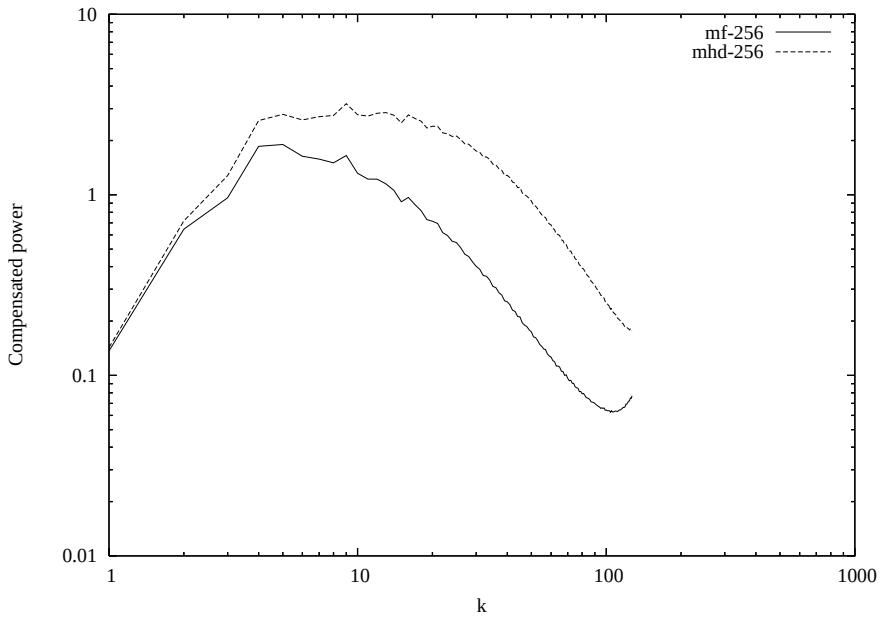
Compensated velocity power spectra for multifluid and ideal MHD simulations

Power spectra



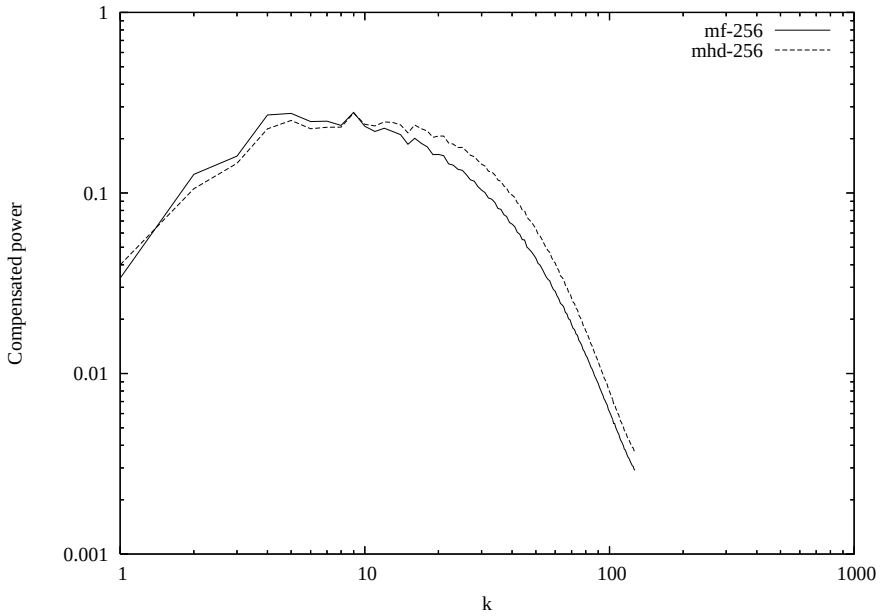
Compensated velocity power spectra for various fluids in the multifluid simulation

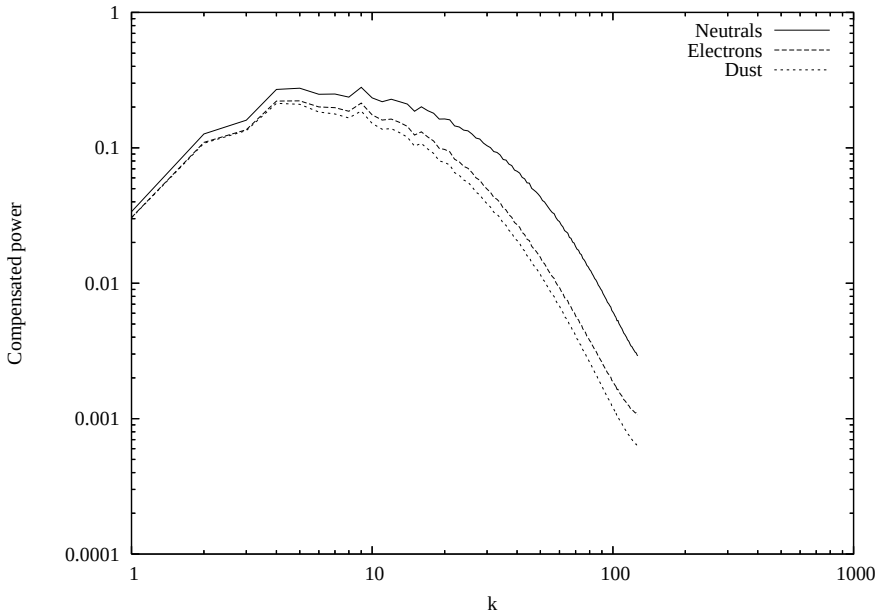
Power spectra



Compensated magnetic field amplitude power spectra for multifluid and ideal MHD simulations

Power spectra





Density power spectra for multifluid and ideal MHD simulations

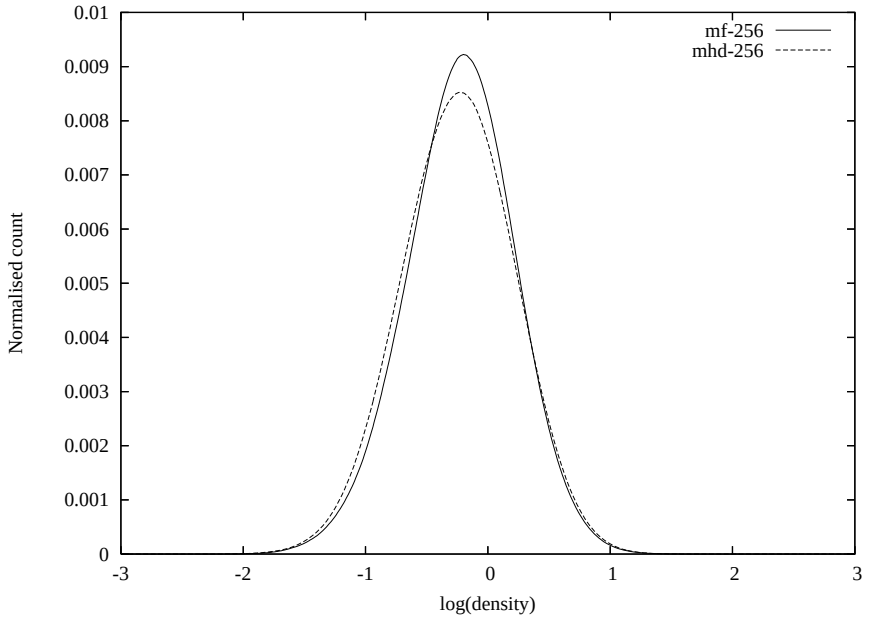
Power spectra

Simulation	M_s	M_A	Velocity power spectrum
mf-64	4.38	2.77	-2.54 ± 0.26
mf-128	4.47	3.01	-2.40 ± 0.23
mf-256	4.48	3.07	-2.40 ± 0.054
mhd-256	4.41	3.17	-1.81 ± 0.046

Power spectra

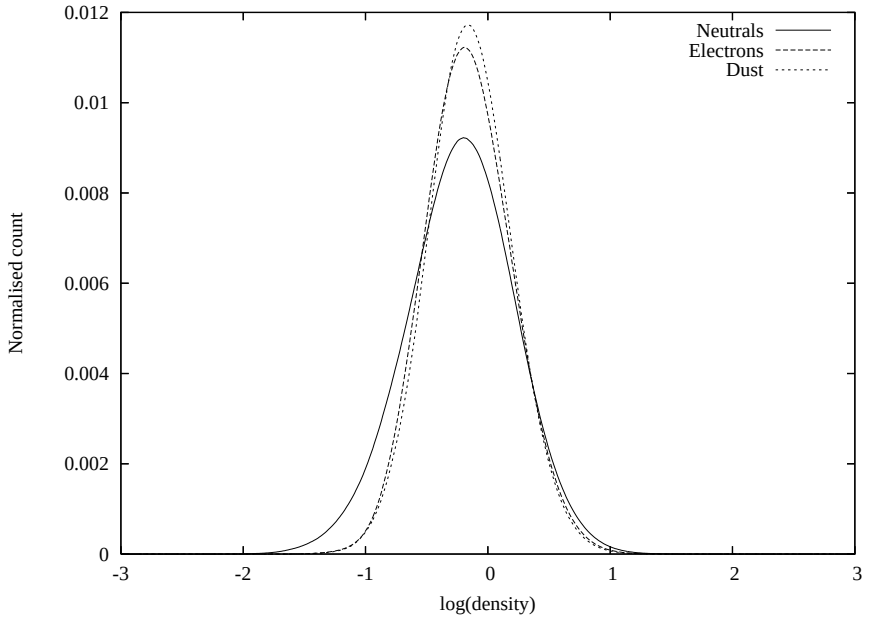
	mhd-256	mf-256			
		Neutrals	Electrons	Dust	Ions
Density	-0.60	-0.83	-0.99	-1.11	-0.99
Velocity	-1.81	-2.40	-2.17	-2.19	-2.17
B-field	-1.73		-2.26		

Density PDF



Time-averaged density PDFs for multifluid and ideal MHD simulations

Density PDF

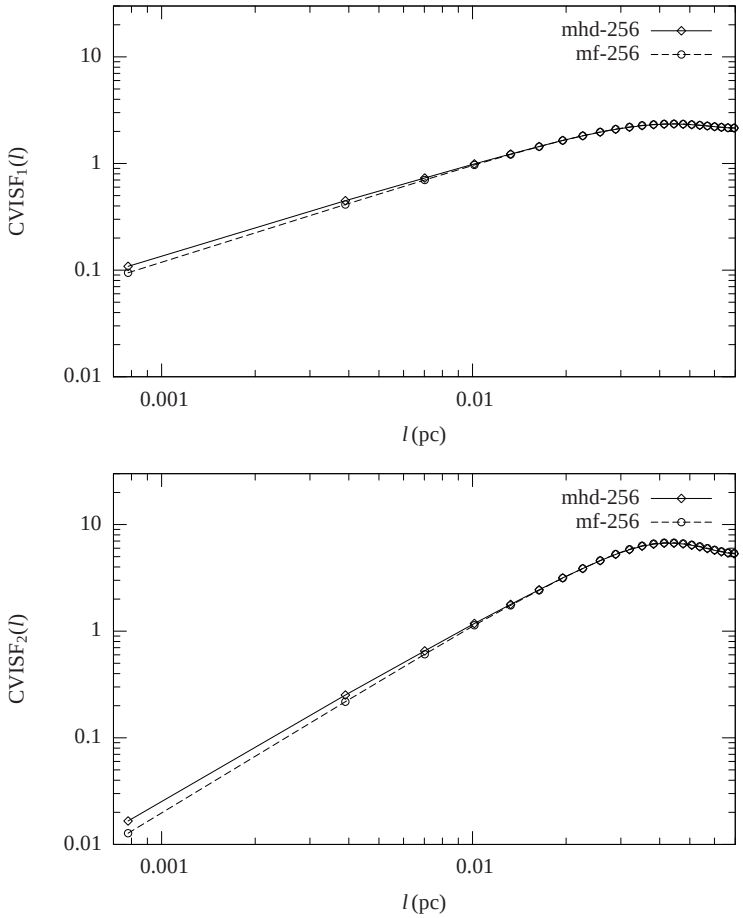


Time-averaged density PDFs for the 4 fluids in the multifluid simulation

Density PDF

	mhd-256	mf-256			
		Neutrals	Electrons	Dust	Ions
Standard deviation	0.46	0.44	0.36	0.34	0.36
Skewness	-0.050	-0.12	0.15	0.082	0.15
Kurtosis	-0.11	-0.071	-0.005	0.057	-0.005

Centroid velocity statistics



Plots of the first order (top panel) and second order (bottom panel) centroid velocity structure functions.

Conclusions

Multifluid effects:

- Reduce energy in turbulent magnetic field
- Soften the velocity and magnetic field power spectra
- Neutral density PDFs become more peaked
- Density power spectra significantly different for charged and neutral species
- Doesn't change the centroid velocity structure functions