Passive Scalars and Scalar Vectors in Isotropic Turbulence

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Dr. Frank Jacobitz
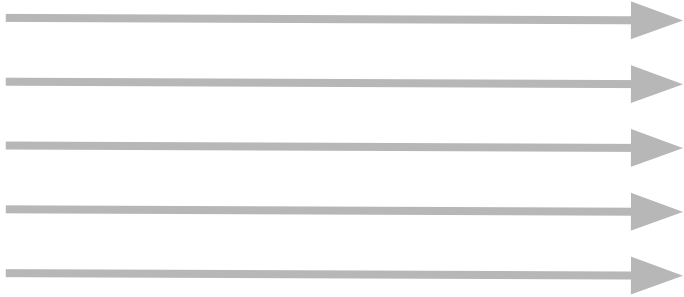
What is a fluid?

- A fluid is defined as a substance that yields to shearing forces.
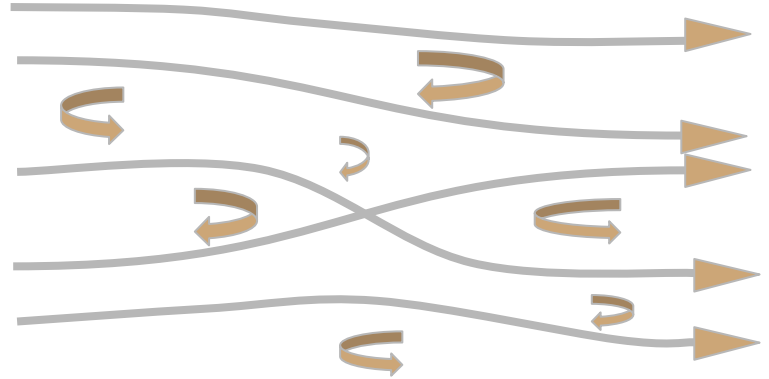   - A solid is not considered a fluid due its resistance of shear forces
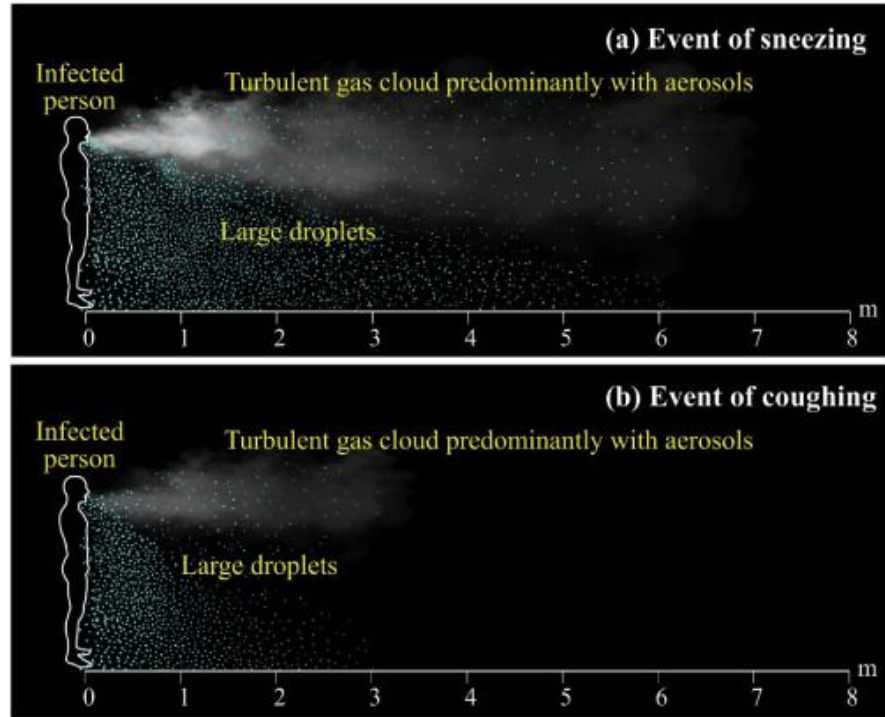

Reference 7

Flow of a Fluid

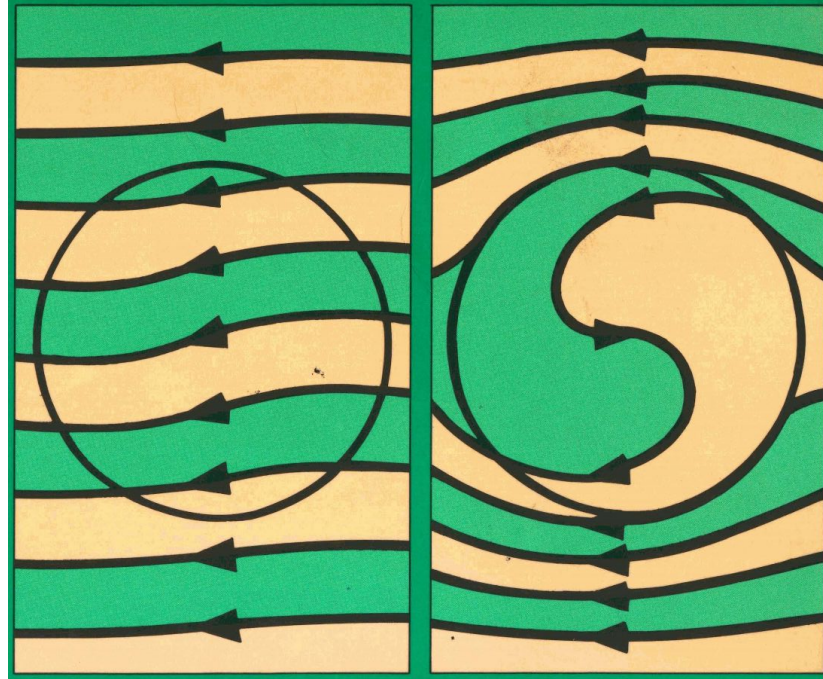**Laminar Flow**

Turbulent Flow

Why Study Turbulence?

Reference 1

Passive Scalars

Reference 2

Passive Vectors

Reference 5

$$\left(\frac{\partial}{\partial t} + u \bullet \nabla \right) w = \gamma_1 \nabla q + \gamma_2 \, w \bullet \nabla u + \alpha \nabla^2 w$$

1   2   3   4

$$\nabla \cdot \boldsymbol{w} = 0$$

Mass Conservation

What would happen if we added an imposed condition similar to mass conservation in a scalar quantity?

Visualizing Turbulence

Current Results

Isosurfaces of 000 ULACD.1

Isosurfaces of Scalar 000 SLACD.1

Isosurfaces of Scalar Vector 000 SLACD.1
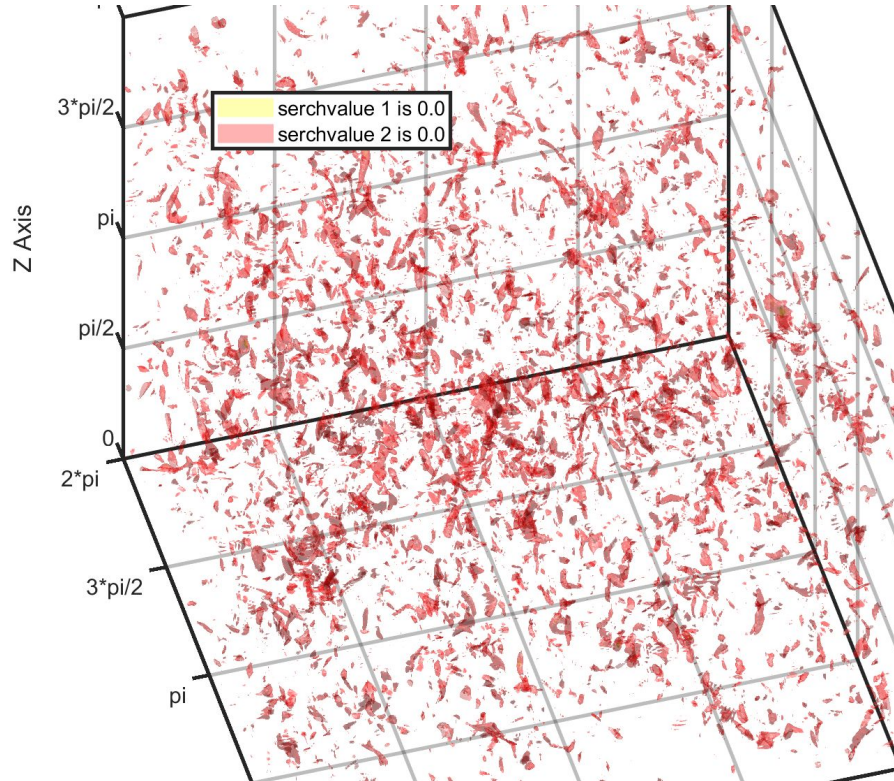
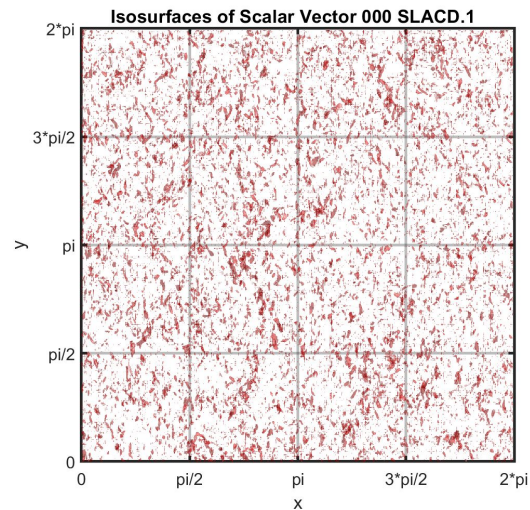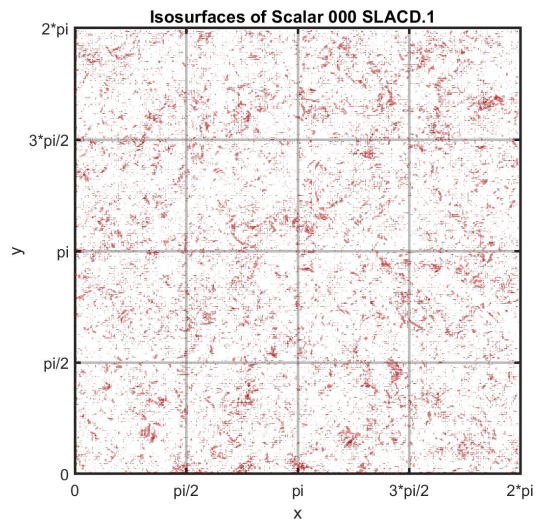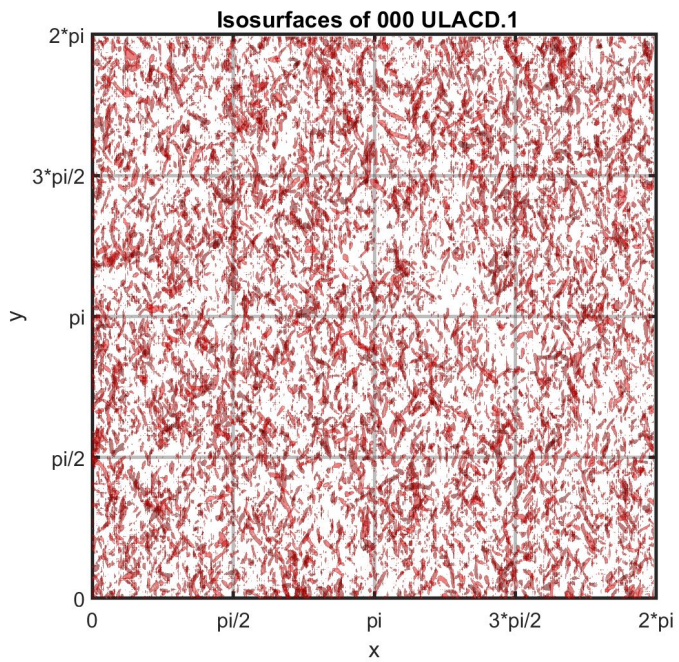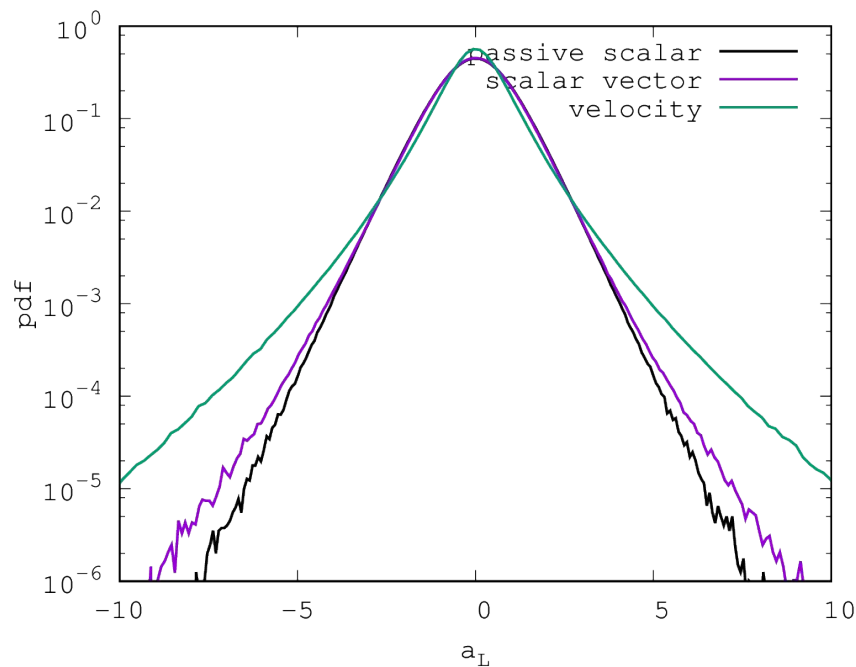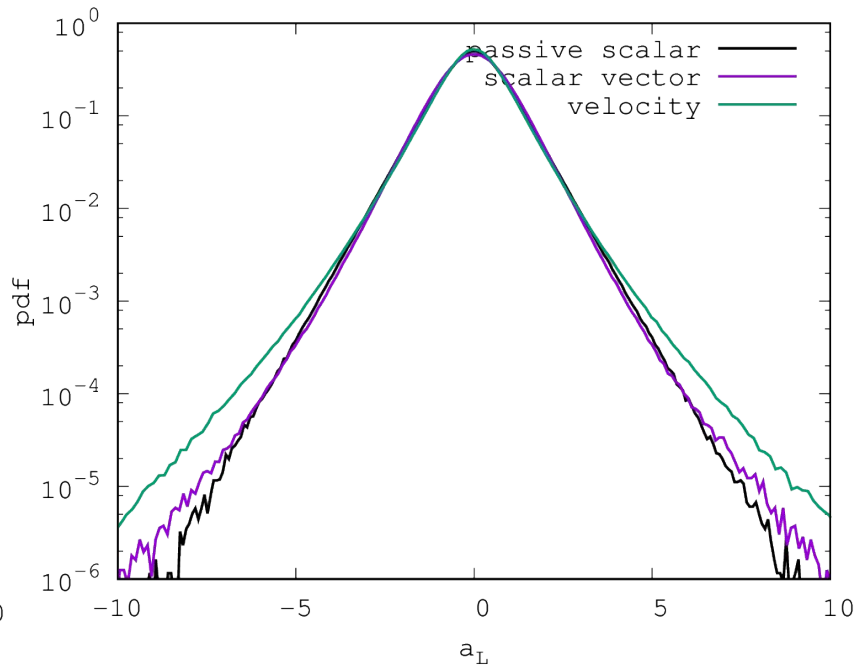# Probability Density Functions

time 0   time 3

			RMS	Flattness	Skewness
SCALAR 000	SLACD	1	1.422E-07	4.0276	-0.0027
		2	1.4172E-07	4.0056	0.000102
		3	1.4185E-07	4.0193	-0.0011
	ULACD	1	5.0922	8.5289	0.0055
		2	5.1345	8.8056	0.0012
		3	5.1313	8.7798	-0.0015
SCALAR 003	SLACD	1	1.2304E-08	4.8887	-5.4E-05
		2	1.2254E-08	5.1223	0.0027
		3	1.2075E-08	4.9474	0.0092
	ULACD	1	0.4626	6.4240	0.0017
		2	0.4620	6.8290	0.0072
		3	0.462	6.7707	-0.0042
SCALAR VECTOR 000	SLACD	1	2.1438E-07	4.3249	-0.0014
		2	2.126E-07	4.4153	0.000896
		3	2.1249E-07	4.4074	0.000165
	ULACD	1	5.0922	8.5285	0.0055
		2	5.1345	8.8056	0.0012
		3	5.1313	8.7798	-0.0015
SCALAR VECTOR 003	SLACD	1	1.7036E-08	4.727	-0.001
		2	1.7001E-08	4.8783	0.009
		3	1.6875E-08	4.7477	0.0051
	ULACD	1	0.4626	6.424	0.0017
		2	0.462	6.829	0.462
		3	0.462	6.7707	-0.0042

Key Questions Answered

- Why do the dynamics of a passive scalar differ from that of the velocity field, which determines its evolution?
- What is the impact of an additional constraint, mimicking mass conservation, have on the passive vector dynamics?
- Can a passive vector behave similarly to the velocity field when such a constraint is added?

Questions

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References

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2) http://www.dripbook.com/markmawson/photography-portfolio/aqueous-fluoreau/#0
3) Yang, Jingyuan, et al. "Statistical Properties of an Incompressible Passive Vector Convected by Isotropic Turbulence." Physical Review Fluids, vol. 4, no. 6, 2019, doi:10.1103/physrevfluids.4.064601.
4) Yoshida, Kyo, and Yukio Kaneda. "Anomalous Scaling of Anisotropy of Second-Order Moments in a Model of a Randomly Advected Solenoidal Vector Field." Physical Review E, vol. 63, no. 1, 2000, doi:10.1103/physreve.63.016308.
5) http://www.damtp.cam.ac.uk/user/hkm2/PDFs/Moffatt1978.pdf
6) https://www.sciencedirect.com/topics/engineering/fluid-mechanics#:~:text=Fundamentals%20of%20Fluid%20Mechanics&text=Fluid%20mechanics%20is%20the%20study%20of%20fluids%20at%20rest%20and,conservation%2C%20regulating%2C%20and%20constitutive.
7) https://www.youtube.com/watch?v=HurJ3b7n_8w