Today, we will:

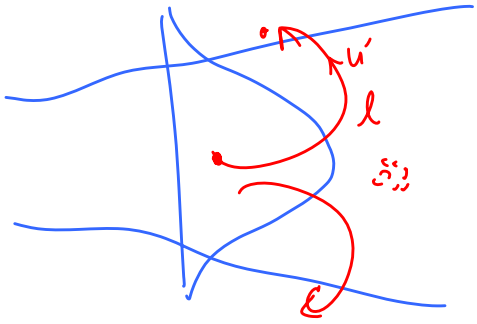
- Continue to discuss the eddy scales in turbulence and the energy cascade
- Watch the movie: **Turbulence** – approx. 30 minutes

2. Eddy scales in the Energy Cascade (continued)

a. Largest eddies

· SOME COMMENTS ABOUT THE LARGEST-SCALE EDDIES

1) The largest eddies do most of the transport of momentum



2) The largest eddies interact directly with the mean flow and have a time scale determined directly by the mean flow

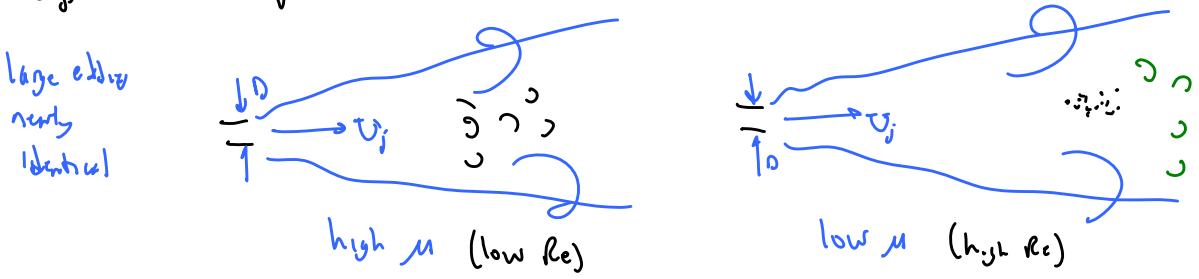
time scale = one "eddy turnover time" $\quad t_{time} \sim \frac{l}{u'}$

3.) The largest eddies can be very non-isotropic – even "coherent"

4) The largest eddies do not depend directly on viscosity

Large-scale turbulence is basically inviscid ☆

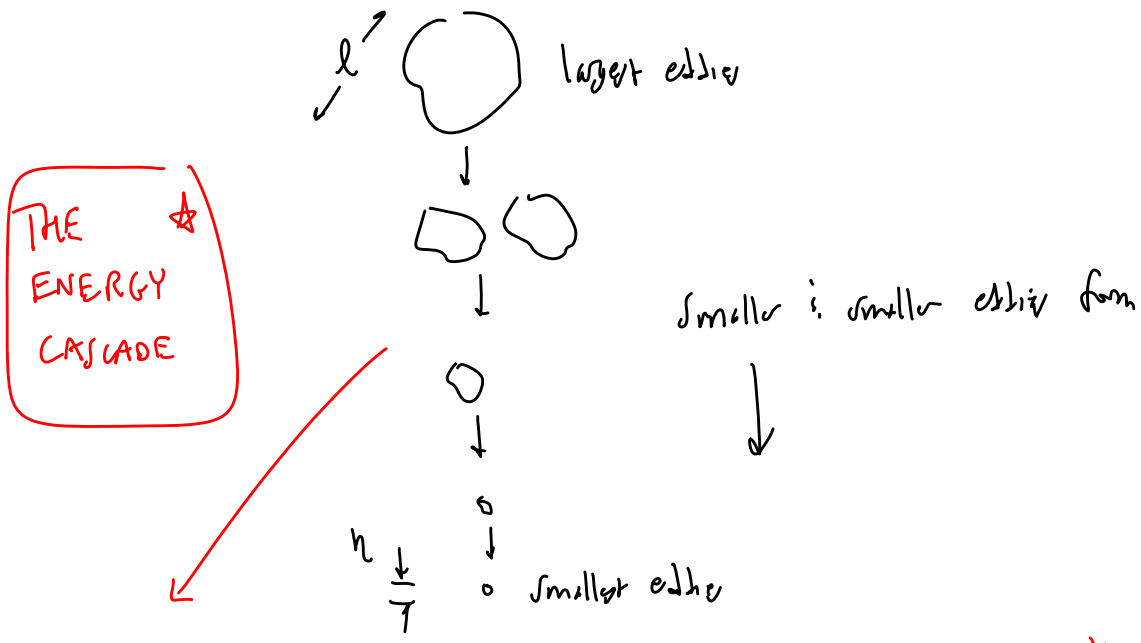
e.g. movie 2 jets



b. Intermediate-scale eddies

Sequence of events (really, these all happen simultaneously)

- large eddies are formed by mean shear
- large eddies are distorted, stretched, etc. by nonlinear interactions w/ mean flow & w/ other eddies (3-D)
- break up into smaller eddies



THE ENERGY CASCADE ☆

Kinetic energy is transferred from mean flow to the large eddies, and then to the smaller eddies ... etc. down to scale η

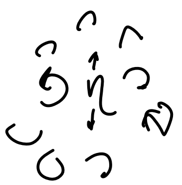
Comments about intermediate eddies

1) Still basically inviscid
2) Interm. eddies do not interact directly with the mean flow
   rather — they interact with scales larger & smaller than themselves
3) The smaller the eddies get, the more isotropic they get

C. Smallest eddies

1) ✩ **The smallest eddies are those where molecular diffusion (due to viscosity) smears out the velocity fluctuations**

Let η = length scale of the smallest eddies



→ Smallest eddies dissipate all their k.e. into heat (through viscosity)

2) **The smallest eddies are determined by viscosity**

- The time scale of the smallest eddies << time scale of the large eddies
- " " " " " " " << " " " " mean flow

Summary Statement:

Largest eddies are determined by the mean flow
" " " independent of viscosity ✩

But,

Smallest eddies are determined by viscosity
" " " independent of the mean flow

Small-scale turbulent motion is statistically independent of the large-scale turbulence or the mean flow ✩