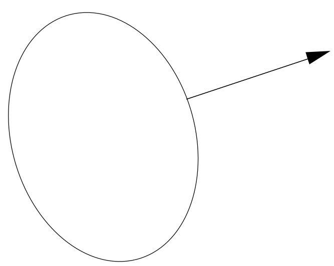
FLOW INDUCED MICROSTRUCTURE IN VISCOELASTIC FLUIDS

The normal stress on a body due to viscoelasticity in slow steady flow of a viscoelastic fluid is always *compressive*; it can be called a viscoelastic "pressure".



$$\boldsymbol{T_{nn}} = \frac{-\boldsymbol{\Psi_1(0)}}{\boldsymbol{4}} \overset{\circ}{\gamma}^{\boldsymbol{2}}$$

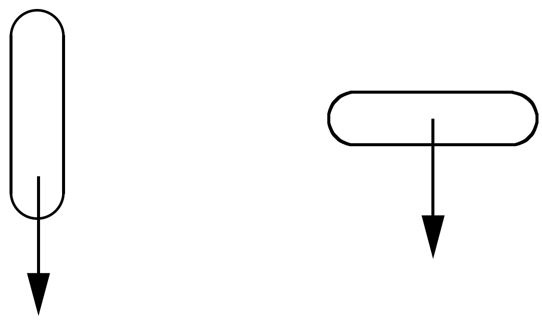
where

> $\Psi_1(0) > 0$ is the coefficient of the first normal stress difference,
> $\overset{\circ}{\gamma}$ is the shear rate at the wall

Bodies are *pushed* by normal stresses proportional to γ^2.

CHANGE OF TYPE

- When the body falls fast enough, inertia will dominate. A long body falling in a viscoelastic fluid will change its orientation by 90.°



$U < U_c$ $\qquad$ $U > U_c$

- "Fast enough" means faster than diffusion

$$U > \frac{\nu}{d} \qquad (\text{Re} > 1)$$

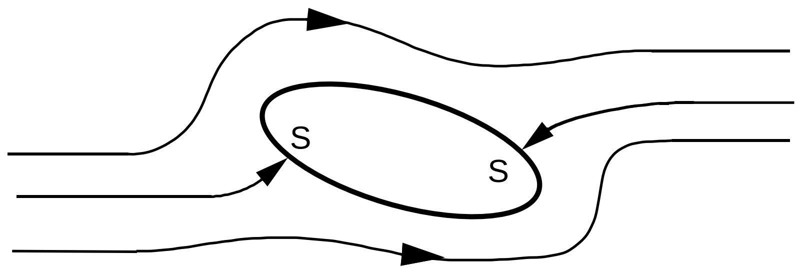
and faster than shear waves

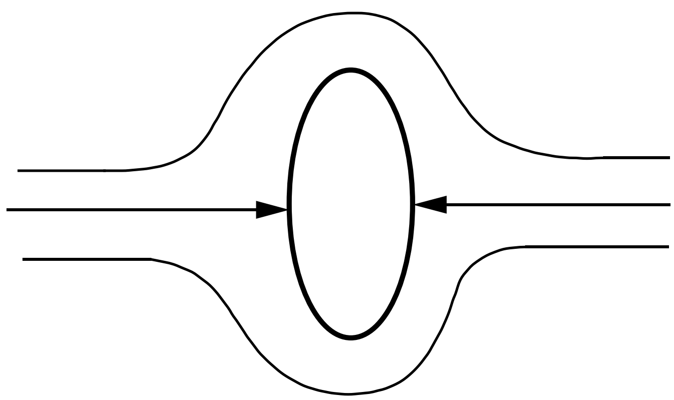
$$U > c \qquad \left(c = \sqrt{\frac{\nu}{\lambda}} \right) \qquad (\text{M} > 1)$$

In this case the body feels forces from potential flow in front of the body.

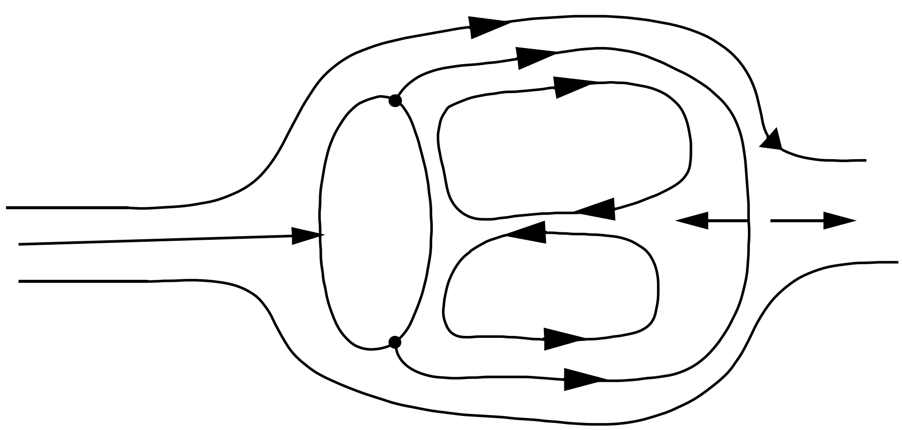
MICROSTRUCTURE IN NEWTONIAN FLUIDS

- High pressure at stagnation points turn long bodies into the stream





Ideal fluid,
no
separation



Real fluid
separation

In turbulent flow the long body shakes around due to vortex shedding, but we still get the long side perpendicular to the stream, on the average

FLOW INDUCED MICROSCTRUCTURE

- Fluidized suspensions have an **anisotropic structure** determined by **microstructure**
- Microsructure arises from
  - **WAKES**
  - **TURNING COUPLES ON LONG BODIES**
- The anisotropic structure of a suspension of spheres is determined by the stable orientation of a long body.
- Microstructure of Newtonian and viscoelastic liquid are maximally different

COMPETITION BETWEEN INERTIA & VISCOELASTICITY

- The shear rate is large where the velocity is large.
- The pressure of inertia is largest near stagnation points and smallest where the velocity is large.
- The viscoelastic pressure is large where the inertial pressure is small. The viscoelastic pressure is small where the inertial pressure is large. This is the reason why the microstructure in Newtonian and viscoelastic fluids are maximally different.