Institute for Research in
ELECTRONICS
AND
APPLIED PHYSICS

Daniel P. Lathrop's
Nonlinear Dynamics 雷丹
laboratory

Lorentz forces and power dissipation in turbulent flows

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Training and Research Experiences in Nonlinear Dynamics
TREND 2003

Our Goal:

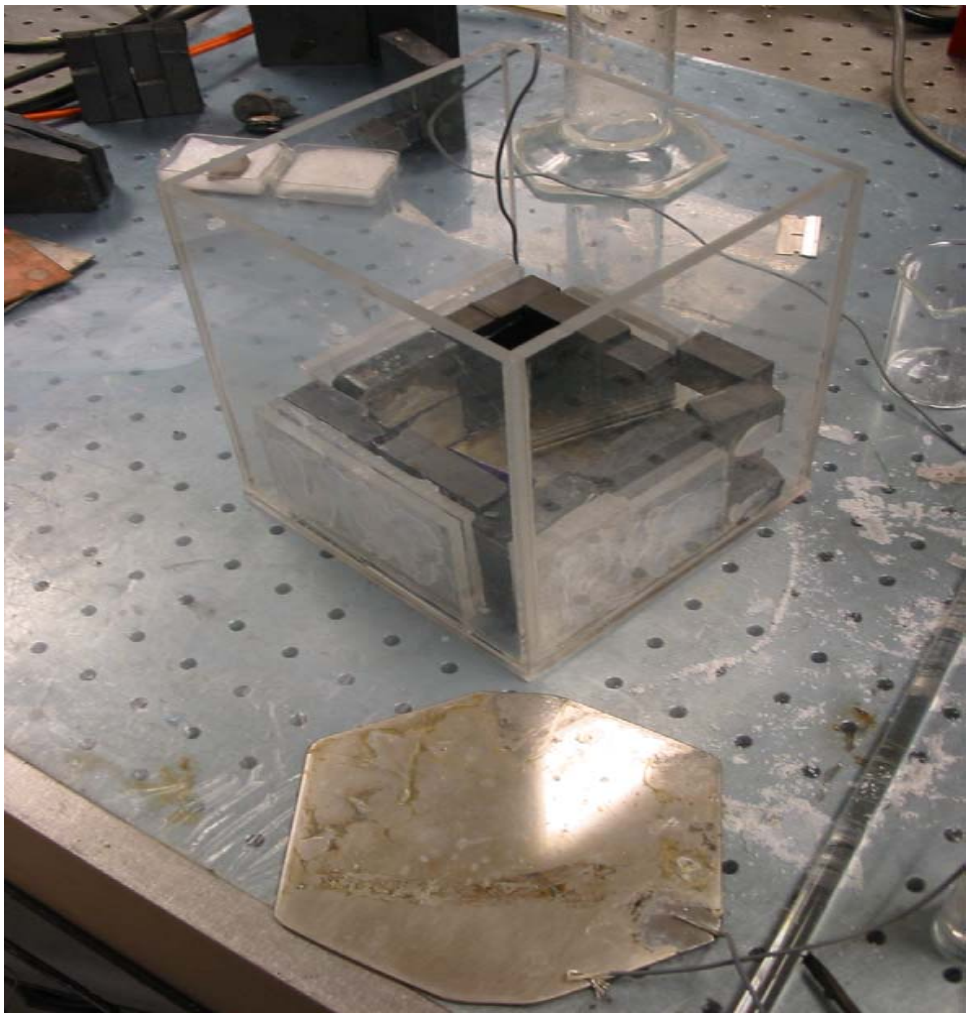
examination of local instantaneous power

$$P = \vec{u} \cdot \vec{F} \,,$$

where

$\vec{u}$ = local velocity of fluid element

$\vec{F}$ = local force on fluid element



$\vec{F}$ (The Tank):

Tank designed to produce turbulence via Lorentz force,

$$\vec{F}_L = \vec{J} \times \vec{B},$$

where

$\vec{J}$ = current density

$\vec{B}$ = magnetic field

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$\vec{u}$ (Particle Image Velocimetry):

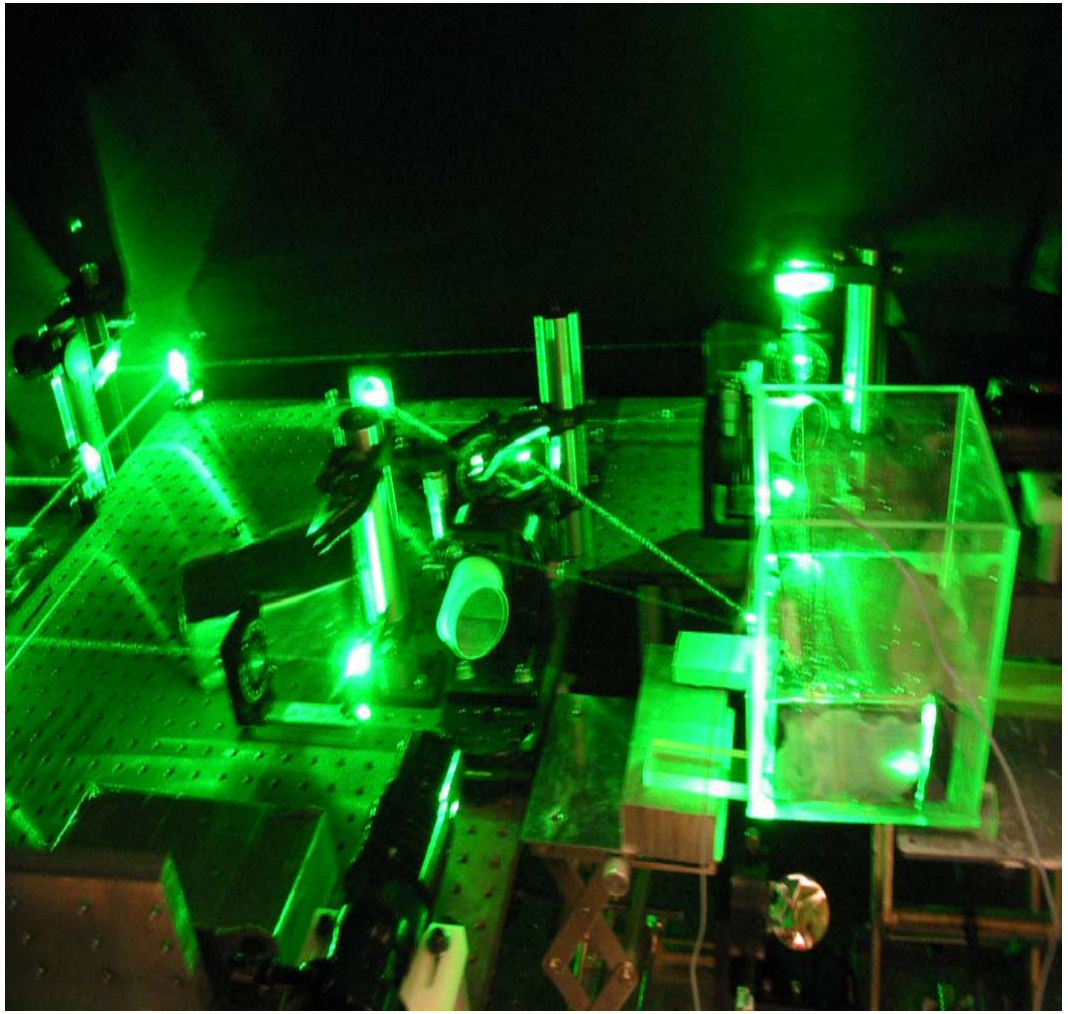
3-D reconstruction of flow in small cubic volume such that

$$\vec{v} \approx \vec{b} + M \cdot \vec{x} ,$$

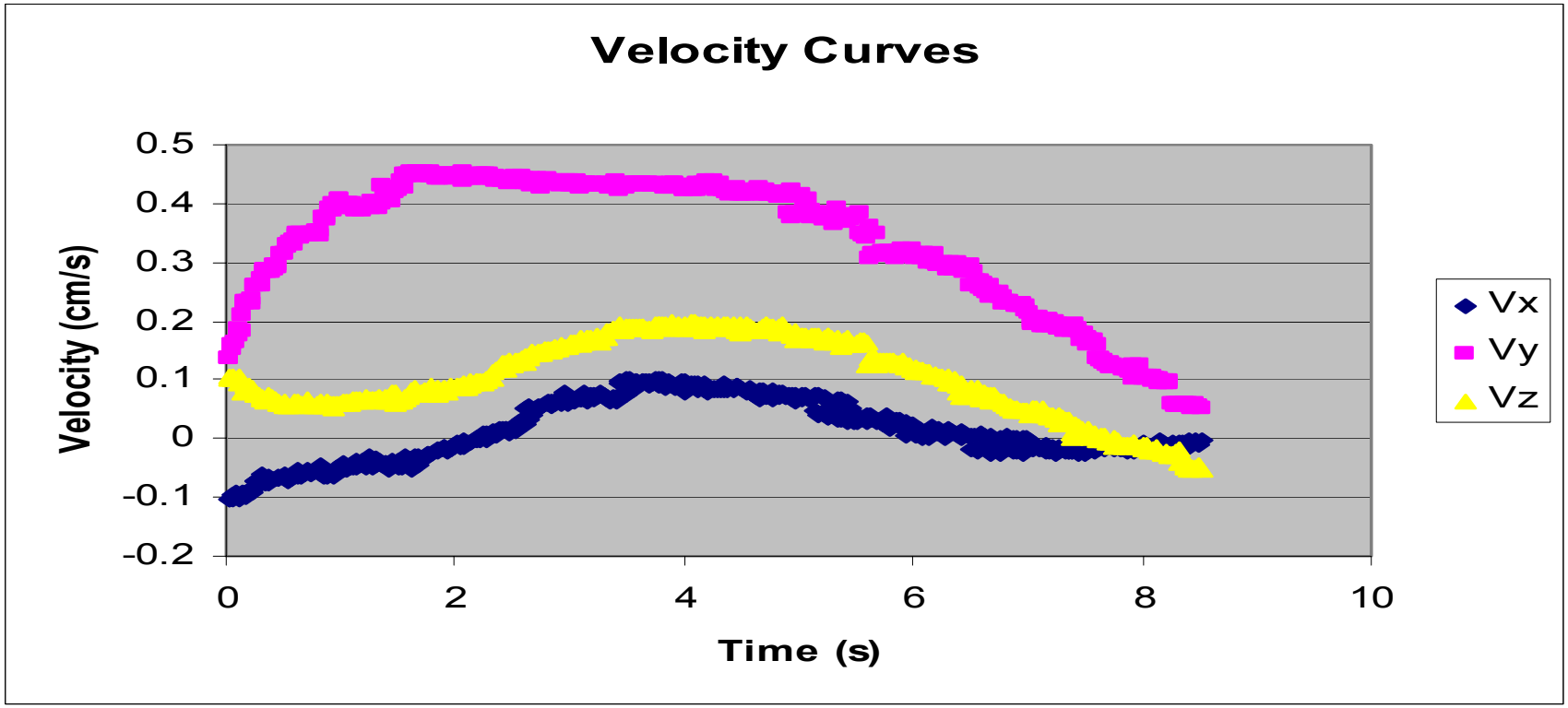
where

$$M = \partial v_i / \partial x_j$$

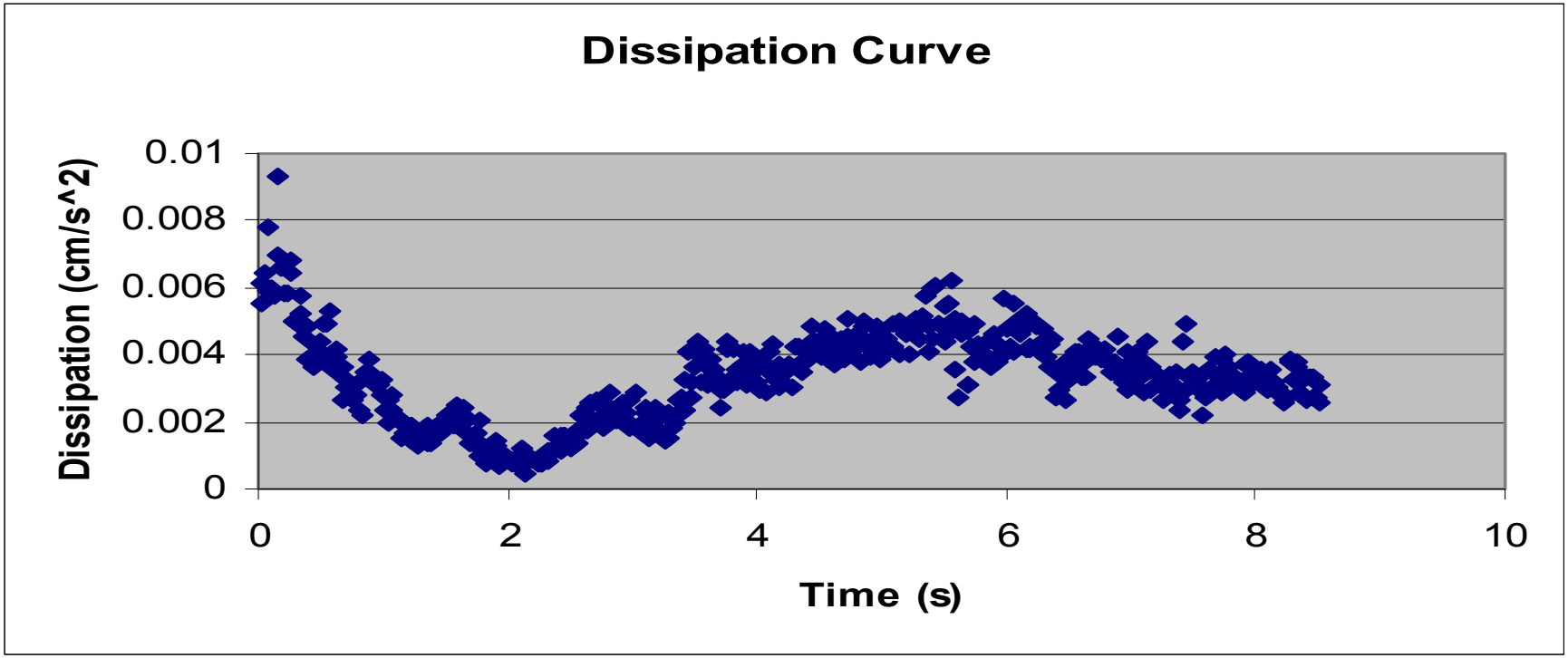
is matrix of gradients, and 2-D velocity vectors used to estimate $\vec{b}$, M



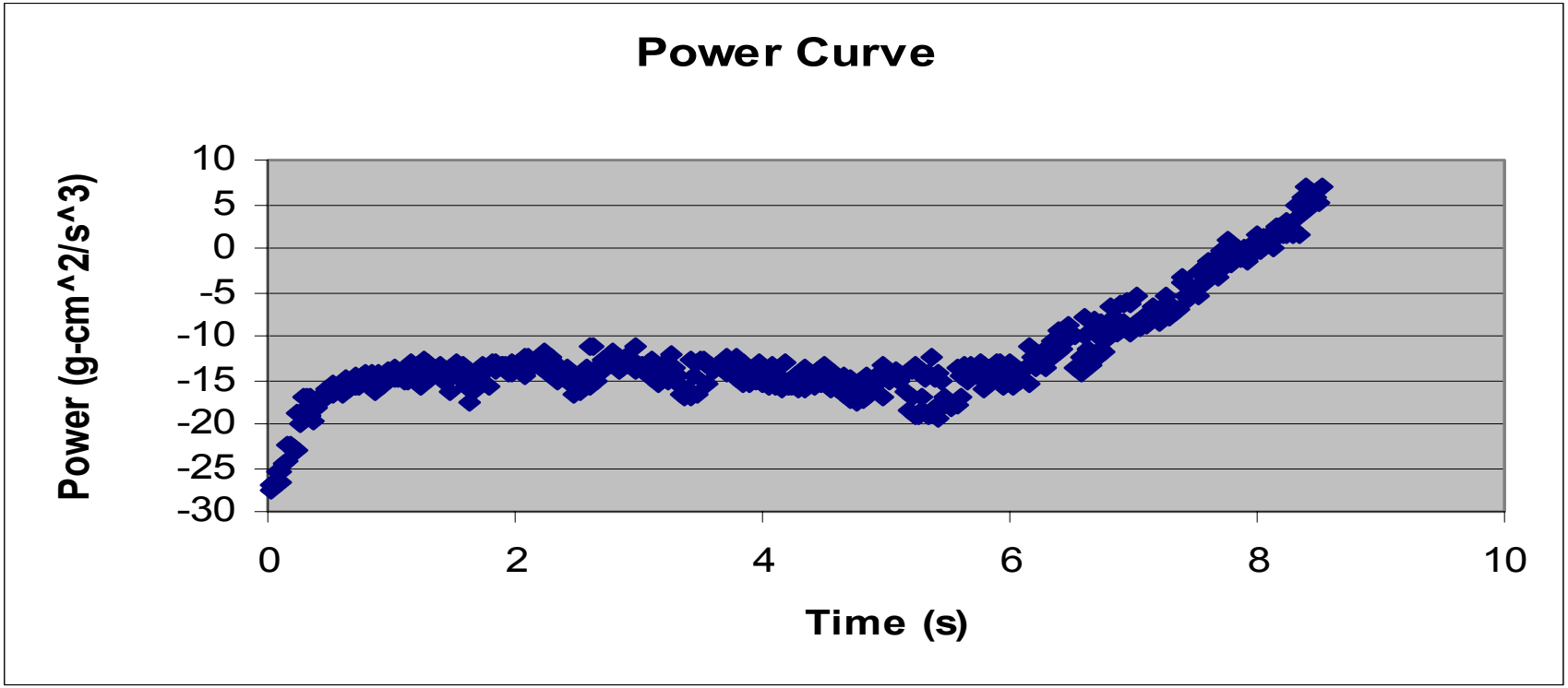
P (Results):


Velocity Curves
Velocity (cm/s)
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
0
2
4
6
8
10
Time (s)
Vx
Vy
Vz

P (Results):


Dissipation Curve
Dissipation (cm/s^2)
0.01
0.008
0.006
0.004
0.002
0
0
2
4
6
8
10
Time (s)

P (Results):



Future Work:

- complex laminar vs. turbulent flow?
- refinement of electrode design (longer experimental lifespan, greater uniformity in $\vec{J}$)
- fluid medium other than NaCl ?
- electromagnets (uniform $\vec{B}$, investigation of boundary nature of turbulence)