Simulation and Modeling of Turbulence Subjected to Plane Strain

Blair Perot
Chris Zusi

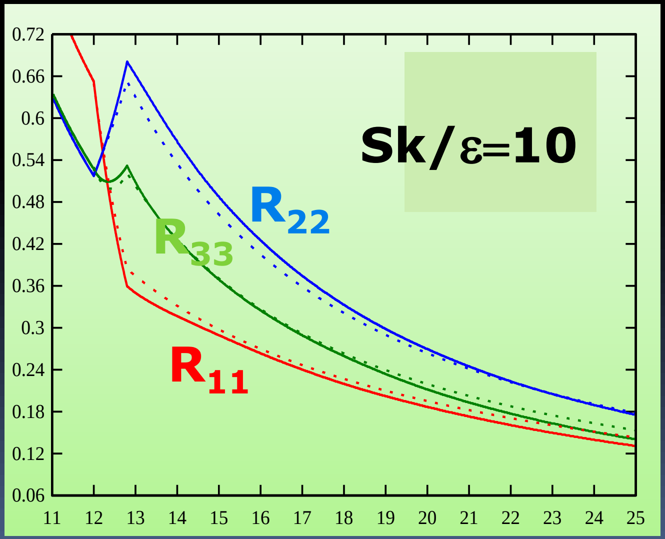
Theoretical and Computational Fluid Dynamics Laboratory

Motivation

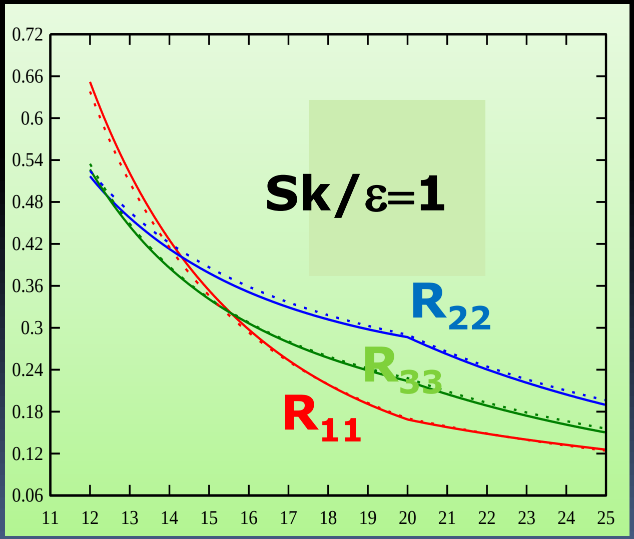
- Explore the energy cascade for non-isotropic turbulence

- Revisit the Return-to-isotropy modeling problem

Reynolds Stresses



time



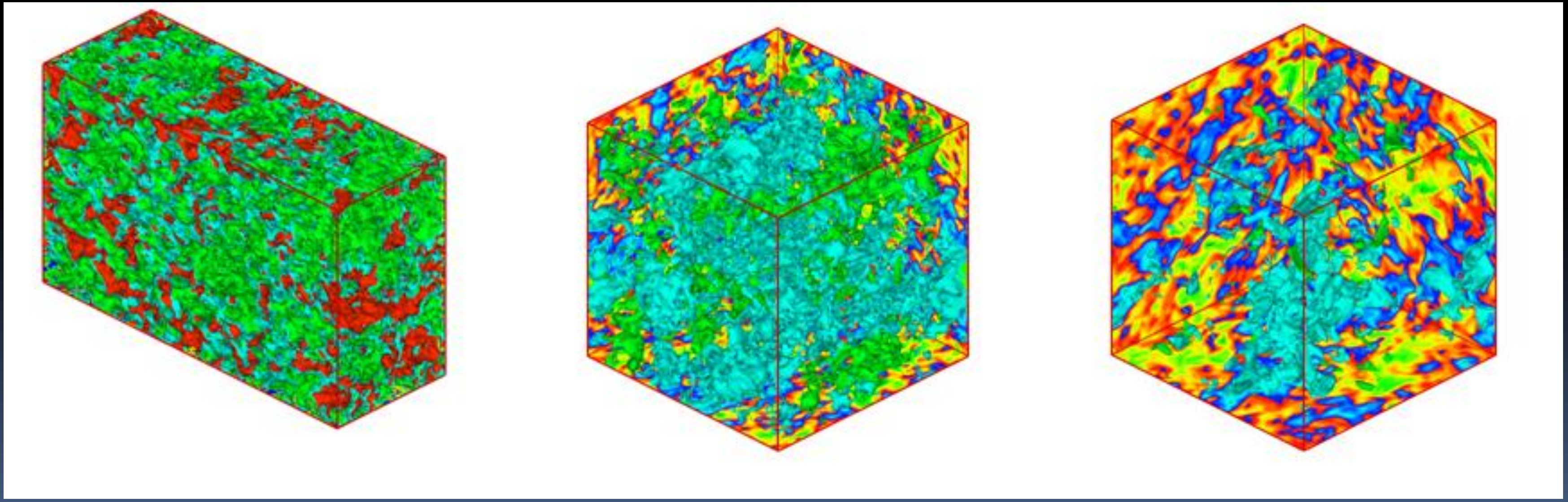
time

Approach

Generate real turbulence (with 512^3 DNS).

Strain it. (Many strain rates, Re, etc)

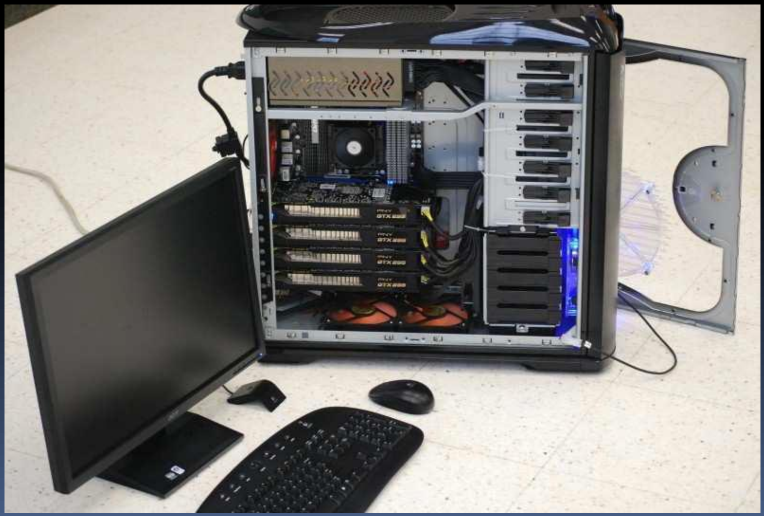
Observe the resulting anisotropic decay.



Simulation Details

- 2^{nd}-order Staggered Mesh
- Exact Fractional Step
- Low storage, 3-step Runge-Kutta
- Moving mesh
- 64 GPUs

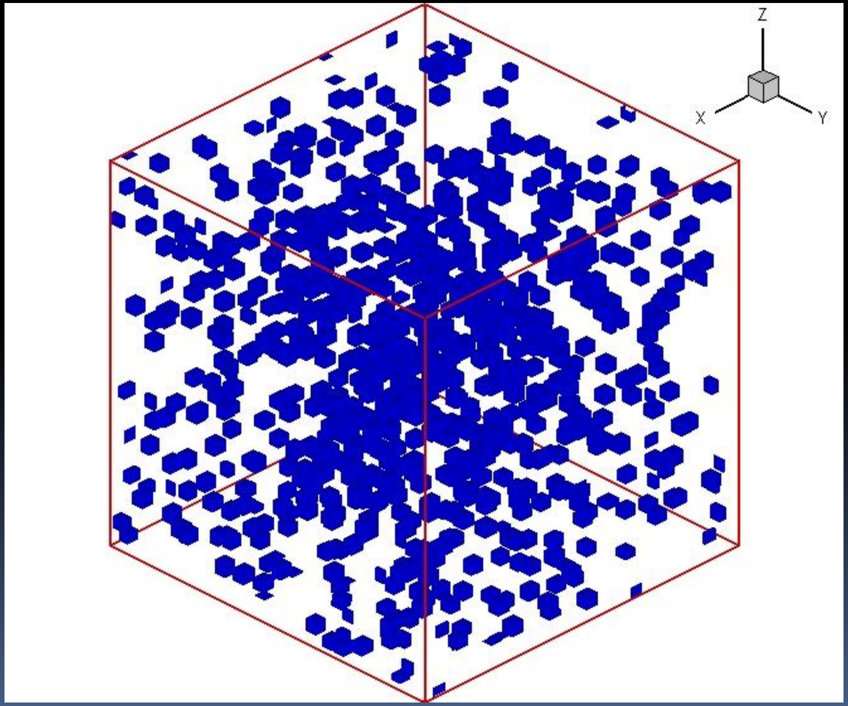
~ 5×10^{-7} s
/grid point
/ timestep.



Initial Conditions

Initially zero velocity and pressure
No large scale forcing
No initial spectra

Acceleration of fluid past 768 small solid boxes.
(1/35 of domain size)



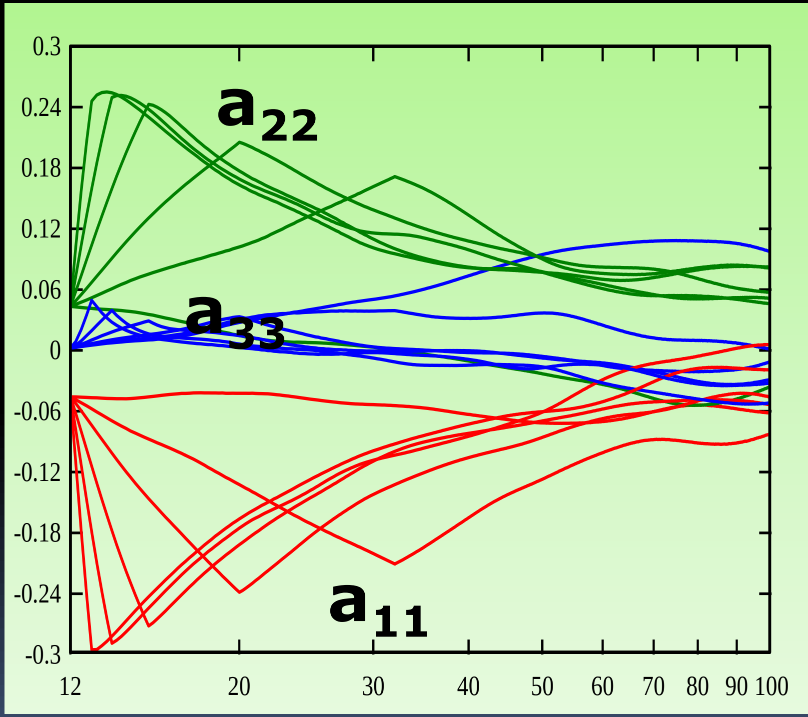
J. B. Perot, *Determination of the Decay Exponent in Mechanically Stirred Isotropic Turbulence*, Advances in Physics, **1**, 2011.

Shear Rate

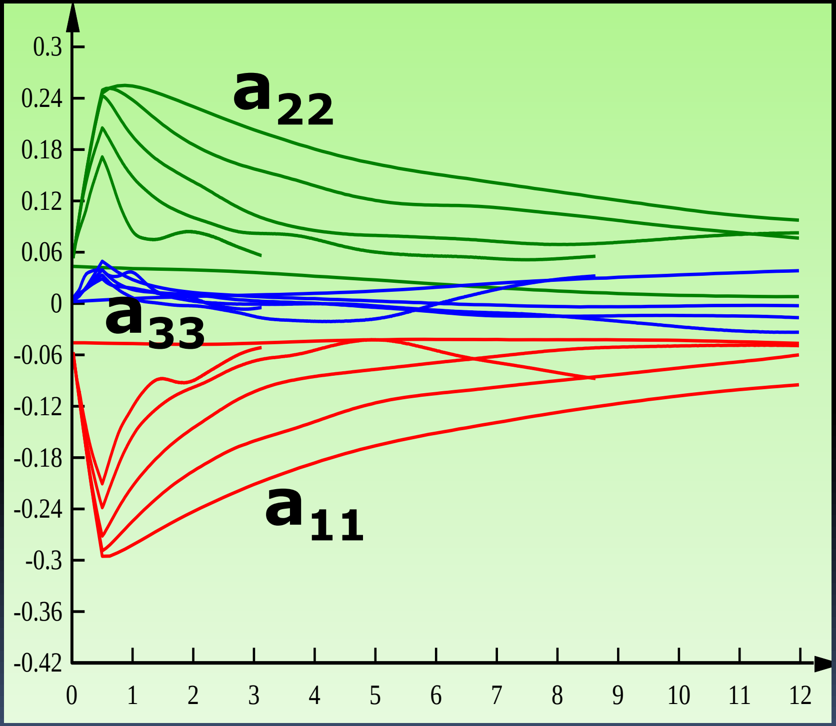
ST = 0.5

Sk/ε = 10, 5, 2.5, 1, 0.4

$$a_{ij} = \frac{R_{ij}}{k} - \frac{2}{3}\delta_{ij}$$

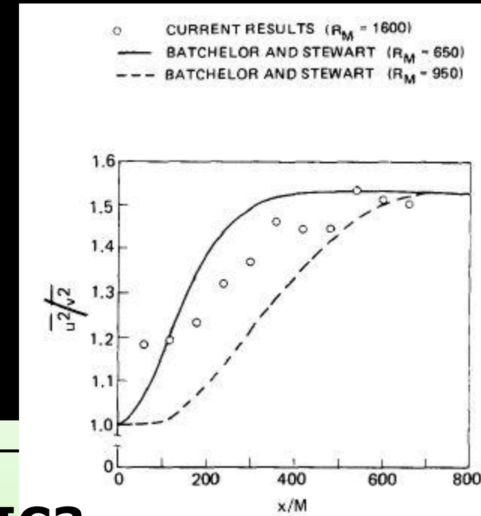


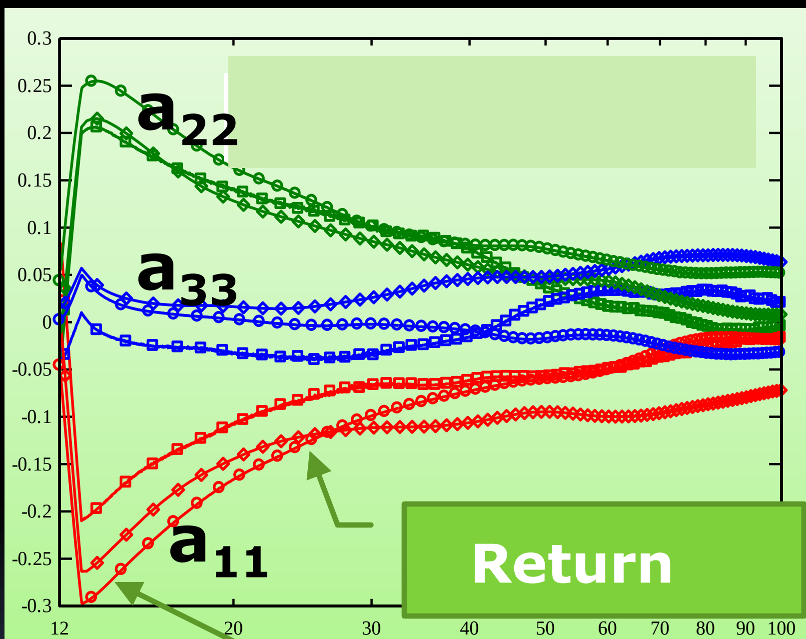
time



S*time

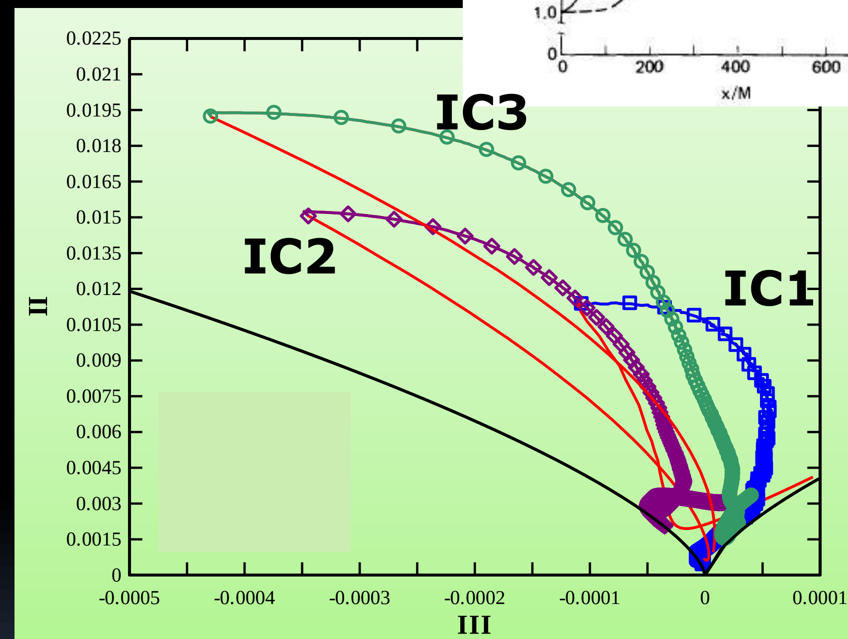
Statistical Variation





time

Recovery



$$II = a_{ij}a_{ji}$$

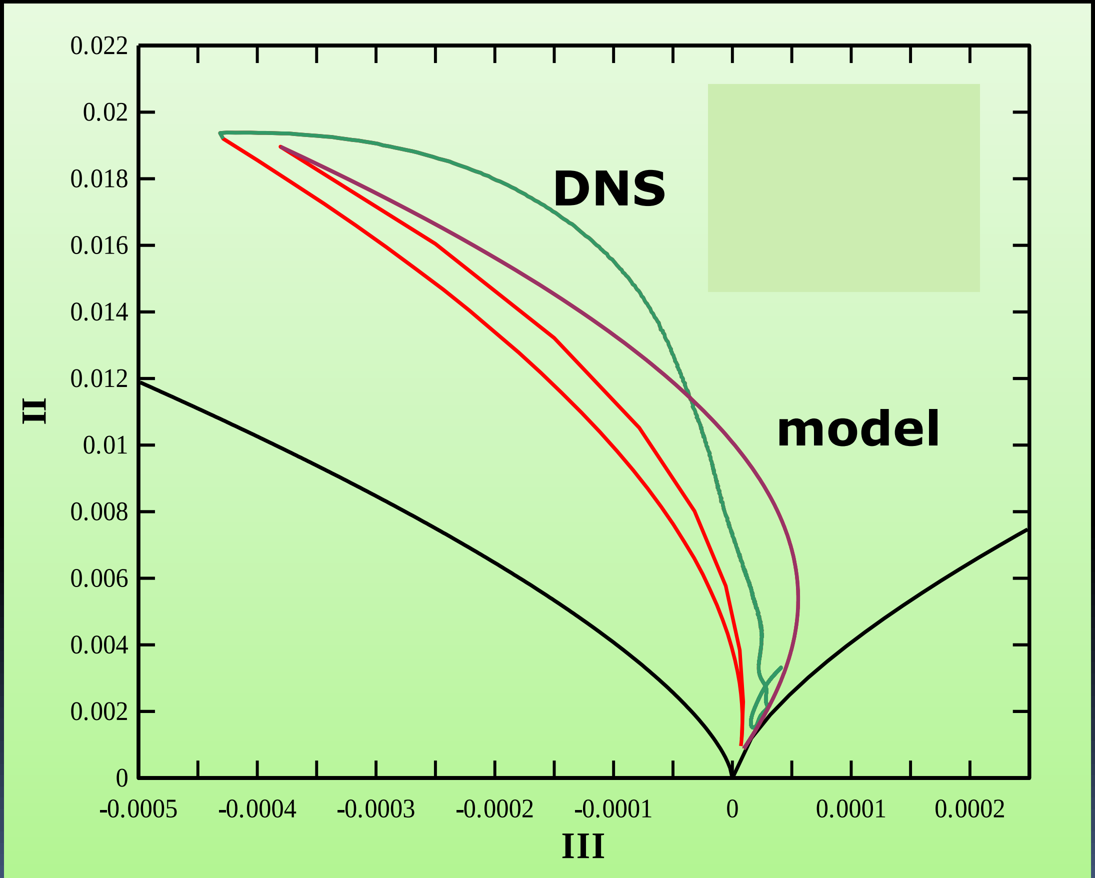
$$III = a_{ij}a_{jk}a_{ki}$$

Modeling

Oriented Eddy Collision (OEC) model

A method to model 2-point velocity correlation evolution

Eddy structure also returns to isotropy



Conclusions

- Long time – no return (Corrsin)
- RST models are fundamentally unable to predict anisotropic turbulent decay.
- It is possible to model recovery and return with a very simple model (for the 2-point correlations).

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