JWPSR Research Program
Applying Wiener Machinery to Turbulence

We study turbulent flow using the Wiener Machinery – Integral Polynomial Functionals based on the Wiener process. All random velocities and pressures can be exactly defined by these functionals. Since the functionals have deterministic kernels, the equations of motion become deterministic Partial Differential Equations (pde's) in real functions of real variables. In other words, the randomness of turbulence is transformed out of the equations!

The resulting sequence of non-linear pde's closely parallel the Navier-Stokes equations with four dependent quantities (3 velocities and pressure) as functions of four parameters (3 space and time). But, great complexity arises from the infinite sequence of equations in the functional kernels. Nevertheless, if these equations can be solved – approximately or numerically if necessary – then all physical quantities can be calculated directly and analytically without simulation or measurement.

The Wiener Machinery offers many advantages for studying turbulence theoretically. Most important, it is a complete representation of random quantities in a Hilbert Space with all the attendant properties of convergence, etc. Moreover, the smooth properties of physical quantities translate directly to the functional kernels. Similar statements are true for symmetry properties and wall conditions.

However, the Wiener Machinery is limited to flow situations that are stationary in time and/or homogeneous in space. This includes decaying flows (like Isotropic Turbulence) and channel flows (like Plane Poiseuille flow), but excludes many bounded flows (like a vigorously stirred cup of coffee).

We have applied the Wiener Machinery to several cases of decaying and channel flows with gratifying results. The solution process is straightforward in theory but very complicated in detail. We need strong computer aids including Maple and MathType.

We use Wiener's Homogenous Polynomial Functionals to analyze Homogeneous Isotropic Turbulence in the final stages of decay. We obtain all the standard results for lowest order decay laws. We also show that there are many other decay laws possible, including the celebrated Kolmogorov $\boldsymbol{\kappa}^{-5/3}$ law. There are also higher order pressure terms and alternator terms in the correlation array.

We use Wiener's Orthogonal Polynomial Functionals to analyze Plane Poiseuille Flow with Reynolds numbers of $1000<R_{HD}<10{,}000{,}000$ with excellent correlation to experiment for velocities and drag (friction factor).

We will now extend these studies to other strongly convergent functionals, other transform techniques, and better computational techniques. We will also extend to other flows including Plane Couette flow, Circular Pipe flow, Axisymmetric Decaying flow (wire gauze in a wind tunnel), and the Magneto Fluid Dynamic (MFD) cases of each of these flows.

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