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Development of the Fractal Dimension of Material Elements in Homogeneous Isotropic Turbulence Using Kinematic Simulation

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The evolution of the fractal dimension of material elements as a function of time in homogeneous isotropic turbulence is investigated using Kinematic Simulation. The fractal dimension of a 3D line is found to obey:

$$D = 1 + 0.088 (Re_{KS})^{\frac{1}{2}}\, t \frac{u'}{L}$$

where Re_{KS} is the KS equivalent Reynolds number. A comparison between ours and Villermaux's results leads to a relation between experimental and KS Reynolds numbers:

$$Re_{KS} = 30.25 \left(\frac{L}{\eta}\right)^{\frac{4}{3}}$$

We also study the evolution an initially horizontal square. Its dimension is found to increase with time as follows:

$$D = 2 + \frac{0.088}{2} (Re_{KS})^{\frac{1}{2}}\, t \frac{u'}{L}$$

Finally we use KS to track particles released from a cube and measure the fractal dimension of this set of particles as a function of time for different Reynolds numbers. The fractal dimension of the cube is found to decrease regularly towards 2. The cube's fractal dimension is found to be independent of the Reynolds number but function of the cube's initial size (S):

$$\frac{S(D-3)}{tu'} = 0.3 \left(\frac{tu'}{L}\right)^{-\frac{2}{3}}$$

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