

# Intermittency, intermittency, intermittency!

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It is well known that those who are concerned with the sale of property say that the three factors determining the value of a house are: location, location, location. In fact I believe that there is a television programme with that as a title. This trope has passed into the general consciousness; so much so, that a recent prime minister declared his principal objectives in government to be: education, education, education. (Incidentally, I wonder how that worked out?)

My use of the title here is not to suggest that I think that intermittency is the dominant feature of the turbulent velocity field, or indeed of any particular importance, so much as to draw attention to the fact that there are three types of turbulent intermittency. Of course in complicated situations such as in turbomachinery, an anemometer signal can be interrupted by the passage of a rotor, say. That would be a form of intermittency. However, by intermittency, what I have in mind is something intrinsic to the turbulent field and not caused by some external behaviour. I believe that is what most people would mean by it.

For convenience, we may list these different types, as follows:

1. **Free surface intermittency.** This form of intermittency occurs in flows like wakes and unconfined jets. It arises from the irregular nature of the boundary of the flow. An anemometer positioned at the edge of the flow will sometimes register a turbulent signal and sometimes not. There is also a dynamical problem posed by the interaction between the flow of the wake or jet and the ambient fluid, but that is not something that we will pursue here.

2. **The bursting process in pipe flow.** This was discovered in the 1960s, when it was found that a short-sample-time autocorrelation could show a near-sinusoidal variation with time, corresponding to a sequence of events in which turbulent energy was generated locally in both space and time. Measurement of the bursting period was helpful in understanding the mechanism of drag reduction by polymer additives.

3. **Internal intermittency.** This is the apparent inability of the eddy motions of turbulence to fill space, even in isotropic turbulence. Originally it was referred to as the *dissipation intermittency* and then later on as the *fine-structure intermittency*. In recent years it has been established that by means of high-Reynolds number simulations that this inability to fill space is in fact present at all length scales. Thus the growing modern practice is to describe it as *internal* which distinguishes it from the two types of intermittency above.

An account of all three types may be found in Section 3.2 of the book [1], although at that time I used the term *fine-structure intermittency*, in line with other writers at that time. I should also point out that I would no longer give the same prominence to the instantaneous dissipation. I am now clear that the failure to distinguish between this and its mean value; combined with the failure to recognise that the significant quantity in determining the inertial-range spectrum/structure-function is the inertial transfer rate, underpins much of the confusion over the  $k^{-5/3}$  (or  $r^{2/3}$ ) result for the inertial range. I have written quite a lot about this matter in recent years and expect to write a great deal more.

[1] W. D. McComb. The Physics of Fluid Turbulence. Oxford University Press, 1990.