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HIT: Do three-letter acronyms always win out?

In 1997, I visited Delft Technical University and while I was there gave a course of lectures on turbulence theory. During these lectures, I mentioned that nowadays people seemed to refer to homogeneous, isotropic turbulence; whereas, when I started out, it was commonplace to simply say isotropic turbulence. The homogeneity was assumed, as a necessary condition for the isotropy. After the morning session, when we were making our way back for lunch, the postgrads who were attending, said to me `Three-letter acronyms always win out!'. Naturally, I pooh-poohed this, but many years on, I have to confess that I use the three-word name of the subject (it was the title of my 2014 book) and the acronym as well. Sometimes it is just a matter of euphony. But does it do any harm? Well, that's an interesting question, but for the moment let us make a short digression.

In recent years I have been thinking a little about cosmology (well it makes a change from turbulence) and have learned about the *cosmological principle,* which states that the universe is both homogeneous and isotropic. Homogeneous means that its properties are independent of position and isotropic means that its properties are independent of orientation. In everyday life, one might think of a piece of metal or plastic being homogeneous and isotropic, in contrast to wood which has a grain. So naturally when I step out into my back garden in the evening, I can observe this for myself … or rather, I

can’t. Actually the night sky looks anything but homogeneous, let alone isotropic. Are the cosmologists deluded?

The answer lies in the fact that the cosmological principle applies to *averaged* properties. Apparently it is necessary to take averages over huge volumes of space, each of which contains vast numbers of galaxies, for the concepts of homogeneity and isotropic to apply. Evidently, to paraphrase J. B. S. Haldane (and following in the footsteps of Werner Heisenberg) the universe is not only bigger than we think, it is bigger than we *can* think. So, if I want to behave like an idiot, I should just go about proclaiming: `The cosmologists are mad. You only have to look up at the night sky to see that their claims about the uniformity of the universe are completely unjustified.’ In doing so, I would be ignoring the details of what the cosmologists actually said, and surely no one would be so silly as to do that before launching into speech? Well, in turbulence that is exactly what many people do.

In turbulence, for many years we have had flow visualisations based on direct numerical simulation of the equations of fluid motion. These undoubtedly show a spotty distribution of various characteristics of interest, especially the dissipation rate, and this is generally taken as supporting the idea that turbulence intermittency has implications for statistical theories. Indeed, there are those who go further and see results like this as invalidating assumptions of homogeneity and isotropy. What they leave out of the reckoning is; first, *that homogeneity and isotropy are properties of average quantities, in turbulence as in cosmology*. Secondly, the flow visualisations are snapshots or single realisations. If you average over them, the spottiness disappears, as indeed it has to, in order to conform to homogeneity and isotropy, and the field becomes uniform and without structure.

If we go to the fountain head for this subject, in Batchelor’s classic monograph on page 3 we may read: `*The possibility of*

this further assumption of isotropy exists only when the turbulence is already homogeneous, for certain directions would be preferred by a lack of homogeneity'. Batchelor also points out that homogeneity and isotropy are average properties of the random variable, and in fact they are defined formally in terms of the probability distribution functional (the pdf, or equivalently its moments).

So this is where I answer my own question. It does matter. It is needed for clear thinking and the best possible understanding that we are careful about the fact that homogeneity is a necessary condition for isotropy. In the process we have to be careful about definitions. In that way one can perhaps avoid the egregious errors which occur in a recent paper, where it is argued that intermittency at the small scales is incompatible with homogeneity and so invalidates the energy-balance equation derived rigorously by averaging the equations of motion. Actually, intermittency is present at all scales and is part of the exact solution of the equations of motion. It is not in any way incompatible with the pdf, which must take a form appropriate to the intermittent (single-realization characteristic) and homogeneous (ensemble-averaged characteristic) nature of the random field. We shall return to a more specific way to this publication in later posts.

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