A Non-Perturbative Approach to Ionospheric Turbulence

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Batchelor and Townsend (1949) were probably the first ones to report that small scales of high-Reynolds number Navier-Stokes turbulence were intermittent. We now strongly believe that intermittency might be the cause behind the existence of non-Gaussian tails in the Probability Distribution Functions (PDFs). The conventional approaches have primarily used perturbation schemes to tackle turbulence problems. The conventional models have failed to catch the essence of intermittency. Indeed, many phenomena, in various fields of physics and in plasma physics in particular, manifest themselves through tails in the PDFs. The challenge is to develop mathematical models that enable the extraction of PDFs from nonlinear partial differential equations. One such model is the "Instanton" model first developed in Quantum Mechanics and Quantum Field Theory (t'Hooft).

In this talk we will start by a brief review of conventional approaches to turbulence, and move on to show that the “instanton” formalism can be successfully used to shed some light on some of the outstanding problems of ionospheric turbulence as it occurs in the auroral E and F regions. We will focus on Farley-Buneman turbulence in the auroral E region, and on the Gradient-Drift turbulence in the auroral F region. We first find exact stationary solutions to the partial differential equations describing one or the other problem of turbulence of interest. This in turn enables us to construct time-dependent solutions using the powerful instanton formalism. We then proceed to determine some statistical properties, which show that the non-Gaussian characteristics of the observed fluctuations can be explained by the intermittent formation of nonlinear coherent structures.

(Note: File corrected by Conference Officials)