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**Francois N. Frenkiel Award Talk: Shock Structure in Shock-Turbulence Interactions**[1]

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In many natural and engineering flows, turbulence often interacts with shock waves. Significant efforts have been devoted to understand the effects of the shock on the turbulence in the canonical configuration of turbulence convected through a stationary shock, at a convective Mach number $M$. Most studies, however, treated the shock as a discontinuity leading to dependencies only on $M$. However, numerical and experimental evidence shows systematic dependences on Reynolds ($R_\lambda$) and turbulent Mach numbers ($M_t$), the other two non-dimensional parameters in the problem. Even more limited is the understanding of the effect of turbulence on the shock, especially when the shock cannot be assumed to be a discontinuity. This is the main focus of this work. We use general principles of similarity scaling show that consistency with known physical limiting behavior requires incomplete similarity solutions where the governing non-dimensional parameters ($R_\lambda$, $M$ and $M_t$) can be combined to reduce the number of similarity parameters that describes the phenomenon. An important parameter is found to be $K = M_t/R_\lambda^{1/2}(M-1)$ which is proportional to the ratio of laminar shock thickness to the Kolmogorov length scale. The shock thickness under turbulent conditions, on the other hand, is essentially a random variable. Under a quasi-equilibrium assumption, shown to be valid when $K^2 \ll 1$, analytical results are obtained for statistics of the turbulent shock thickness, velocity gradient, and dilatation at the shock. It is shown that these quantities exhibit universal behavior in the parameter $K$ with corrections in $M_t/(M-1)$, for velocity fields with arbitrary statistics. Excellent agreement is observed with available data from direct numerical simulations. We further use the results to understand amplification factors of the streamwise velocity component as well as to determine whether the interaction is in the so-called wrinkled or broken regime.

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