A Tale of Two non-Maxwellians

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An early contribution of the DSMC method was its use in studying the internal structure of shocks. [1] Even a simple shock consisting of a monatomic gas such as argon exhibits translational nonequilibrium between the temperature along the direction of propagation and the normal directions, particularly in the shock overshoot region. This difference is a well known kinetic effect which cannot be captured in the solution of the Navier-Stokes equations across a shock. However, what has not previously been considered is that the internal structure of 1-D shocks causes self-induced fluctuations in the shock [2,3], and these serve to increase the complexity of laminar shock-boundary layer effects unsteady at even lower Reynolds numbers than were previously considered. [4] The talk will discuss the importance of bimodality in shocks and their spectral response, as shown in Fig. 1. Interestingly enough, bimodality occurs in the completely unrelated phenomena of electron solitary waves in plasmas that we have captured in another particle, kinetic technique known as particle-in-cell. Fully kinetic PIC simulations of electron two-stream instabilities, and how they are different from Maxwellian electron distributions, will also be briefly discussed.

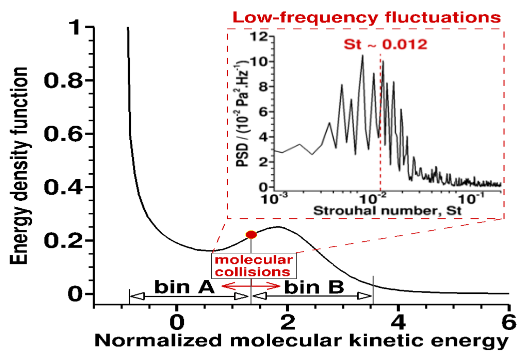

Figure 1. Self-excited fluctuations inside a 1-D shock structure.

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[2] S.S. Sawant, D. A. Levin, V. Theofilis, Analytic Prediction of Low Frequency Fluctuations Inside a One-dimensional Shock, Theoretical and Computational Fluid Dynamics, 36, 25-40 (2021).
[3] S. S. Sawant, D. A. Levin, V. Theofilis, A kinetic approach to studying low-frequency molecular fluctuations in a one-dimensional shock, Physics of Fluids 33, 104106 (2021)
[4] S. S. Sawant, V. Theofilis, D. Levin, On the Synchronization of Three-Dimensional Shock Layer and Laminar Separation Bubble Instabilities in Hypersonic Flow over a Double Wedge, J. Fluid Mechanics, 941, A7, (2022)