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REVISITING RAREFIED GAS EXPERIMENTS WITH RECENT SIMULATION TOOLS

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The Direct Simulation Monte Carlo (DSMC) method was proposed by Graeme Bird back in the 1970's [1]. It models the molecular collisions within a rarefied gas and samples the flow at specific times to obtain the macroscopic properties of the flow. In order to validate the method several experiments have been conducted at the Department of Aeronautics of the Imperial College of London [2], at the beginning of the 1980's. Those experiments have been specifically designed to evaluate the very first collision models used in the DSMC method. In order to investigate the models in their limits, the used body shapes were chosen very carefully to minimize experimental errors. The flow conditions were selected in such a way that the involved Nitrogen has its rotational DoF (Degree of Freedom) activated. All the experiments were conducted in the Imperial College Hypersonic Nitrogen Wind Tunnel, which operates at Mach number range of 20-24. After several years those carefully designed experiments have been overlooked in favor of more recent ones. In this work we simulate the flows experienced during the aforementioned experiments with the current state of the art molecular models, whereas we compare their results with those obtained with the outdated and obsolete models used at that time. Very interesting results arise as we can see how the molecular models evolved during time and investigate the similarities as well as the differences of the past and modern models. Moreover, we can clearly evidence the number of particles required by the old and modern models in order to produce adequate results. All simulations are conducted using SPARTA, a state-of-the-art parallel DSMC solver [3].

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