Maxwell-Boltzmann Distribution

In an early attempt to understand the behaviour of gases, Daniel Bernoulli (1700-1782) assumed that a gas was made up of a myriad of tiny masses all travelling at the same speed. From this he derived a number of relationships that had been discovered experimentally in the previous century by Robert Boyle (1627-91) and others. For example:

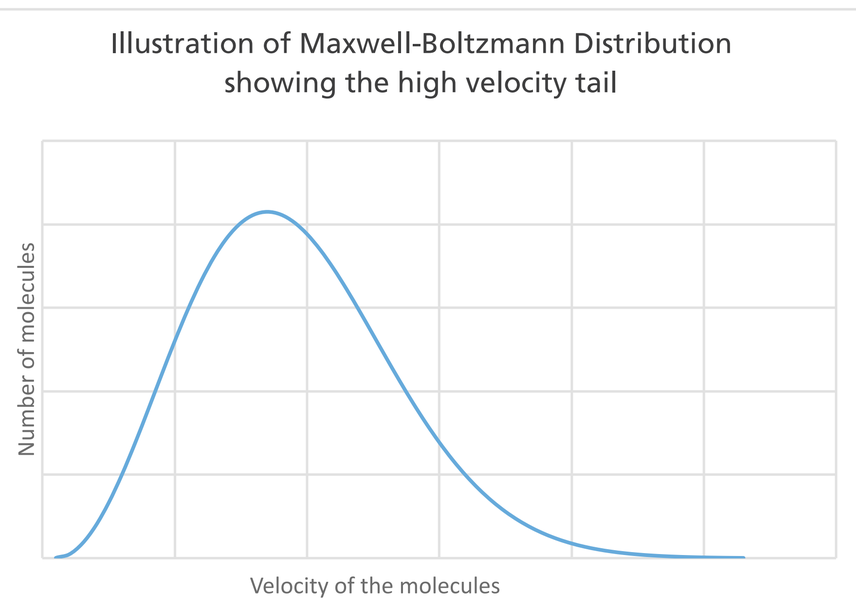
$$Pressure \cdot Volume = constant$$

In 1860, while at Aberdeen, Maxwell pioneered the introduction of statistics into the dynamical theory of gases. He realised that all the molecules of a gas would not be travelling at the same speed because of their mutual collisions. What he looked for was a mathematical function that described the statistical distribution of the speeds of the molecules. Maxwell produced this distribution in three elegant lines, making the reasonable assumption that the molecular speeds in the *x*, *y* and *z* directions are all independent.

The density function for the number of molecules with velocity between v and $v+dv$, now known as the Maxwell-Boltzmann distribution, is:

$$N \frac{4}{\alpha^3 \sqrt{\pi}} v^2 e^{-\frac{v^2}{\alpha^2}} dv$$

where N is the number of molecules in the gas and α is a constant that depends on the mass of a molecule and the average temperature of the gas. The graph illustrates the distribution and in particular that there are a few molecules that have a very high velocity (the right hand tail of the distribution).



At the same time Maxwell predicted a range of other properties of gases, e.g. that the viscosity of a gas was independent of its pressure, and performed the experiment which showed that this prediction was correct. This experiment stimulated further practical work in this important branch of physics.

Maxwell's contributions in 1860 initiated the field of statistical physics and stimulated Boltzmann to develop his own further scientific contributions. Nowadays, approaches from statistical physics underlie our understanding of areas as diverse as superconductivity and astrophysics.

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