LONG RANGE BEHAVIOR OF VAN DER WAALS FORCES

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The van der Waals forces occuring between neutral atoms and molecules, play an important role in physics, chemistry and biology. These forces are of a quantum nature and it has long been conjectured and experimentally verified that they exhibit a universal behavior at large separations: they are attractive and decay as the inverse sixth power of the pairwise distance between the atoms or molecules. We shall present a proof of the van der Waals law for systems of neutral atoms under some conditions, the most important being that ionization energies of atoms are larger than electron affinities of atoms. This condition is well justified experimentally and we verify it for systems of hydrogen atoms. With an informal definition of the interaction energy $W(y), y = (y_1, ..., y_M)$ between M atoms as the difference between the ground state energy of the atoms with their nuclei fixed at the positions $y_1, ..., y_M$, and the sum of the ground state energies of the non-interacting atoms, we show that for $|y_i - y_j|,\ i, j \in \{1, ..., M\}, i \neq j$, large enough,

$$W(y) = -\sum_{i<j}^{1,M} \frac{\sigma_{ij}}{|y_i - y_j|^6} + \mathcal{O}\left(\sum_{i<j}^{1,M} \frac{1}{|y_i - y_j|^7}\right)$$

where σ_{ij} are positive constants depending on the nature of the atoms i and j.