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The Macroscopic Mechanical Equilibrium Condition Governing and Supporting Equilibrium States: the Physical Origin of the Equation of State

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The Equation of State (EOS) has a pretty long history. The physics behind it should be explored. The main purpose of the EOS is to yield the volume of a given material system under given external temperature and mechanical condition. Since the predicted volume is fixed, the EOS is for the system in a macroscopic equilibrium state. In such a situation, the Macroscopic Mechanical Equilibrium Condition (MMEC) applies. Imagine that the system is cut into a great number of small, yet macroscopic pieces. The macroscopic equilibrium state and the MMEC hold, implying that the macroscopic internal stress at every macroscopic point of the system balances the external stress applied onto the system, and determine the equilibrium positions of all the inside microscopic particles. As a result, the MMEC determines the volume of the system as well. Since both the MMEC and the EOS determine the volume of the system but can not conflict, they should be equivalent to each other mathematically, or the MMEC is, in fact, the physical origin/foundation of the EOS. Furthermore, as they determine the geometry of the system, the MMEC/EOS can describe all thermodynamic quasi-equilibrium processes caused by the change of the external temperature and/or mechanical environment. If they cannot be satisfied, the system cannot be in an equilibrium state.

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