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Towards relations between compaction and compressibility of hard sphere mixtures

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The study of the influence of local properties of multi-particle conglomerations on their macroscopic properties is one among of the traditionally relevant problems of statistical physics. Parameterization of local properties can be carried out in various ways, for example, in terms of ordering parameter tensors, Euler invariants, Voronoi tessellations and others. While the macroscopic properties discussed above are the usual ones in statistical physics and thermodynamics, like compressibility, heat capacity, thermal conductivity, and others. In this paper, we study the influence of the compaction factor (packing) on the property of compressibility using the example of a model conglomeration of solid spheres, starting with a mono-disperse system and further, for multi-component mixtures. Using the known equations of state of the Carnahan-Starling type and their generalizations to the case of poly-disperse mixtures, the inverse problem of the influence of the proper parameters of the system (mixture) on the degree of compaction (packing) is considered. Non-monotonicity in the behavior of the packing parameter and the possibility of achieving its maximum value using a consistent selection of relations of the sizes of components and their molar fractions are shown. Application of the above-described approach to two different physical systems - a binary liquid mixture and a two-component granular system - showed quite good agreement between theory and experiment (especially in the case of a granular system). The proposed approach can be generalized without fundamental difficulties to the case of multi-particle conglomerations with an arbitrary number of components.

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