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David Adler Lectureship Award: n-point Correlation Functions in Heterogeneous Materials.

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The determination of the bulk transport, electromagnetic, mechanical, and optical properties of heterogeneous materials has a long and venerable history, attracting the attention of some of the luminaries of science, including Maxwell, Lord Rayleigh, and Einstein. The bulk properties can be shown to depend rigorously upon infinite sets of various n-point correlation functions. Many different types of correlation functions arise, depending on the physics of the problem. A unified approach to characterize the microstructure and bulk properties of a large class of disordered materials is developed [S. Torquato, *Random Heterogeneous Materials: Microstructure and Macroscopic Properties* (Springer-Verlag, New York, 2002)]. This is accomplished via a *canonical* n-point function H_n from which one can derive exact analytical expressions for any microstructural function of interest. This microstructural information can then be used to estimate accurately the bulk properties of the material. Unlike homogeneous materials, seemingly different bulk properties (e.g., transport and mechanical properties) of a heterogeneous material can be linked to one another because of the common microstructure that they share. Such cross-property relations can be used to estimate one property given a measurement of another. A recently identified *decorrelation principle*, roughly speaking, refers to the phenomenon that unconstrained correlations that exist in low-dimensional disordered materials vanish as the space dimension becomes large. Among other results, this implies that in sufficiently high dimensions the densest spheres packings may be disordered (rather than ordered) [S. Torquato and F. H. Stillinger, "New Conjectural Lower Bounds on the Optimal Density of Sphere Packings," *Experimental Mathematics*, **15**, 307 (2006)].