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Characterization of Porous Media by Local Porosities, Minkowski- and Non-Minkowski Functionals

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The presentation will review local porosity theory [1]. Recent results and new developments will be discussed.

At present local porosity theory seems to be a unique quantitative methodology for the geometric characterization of porous media in two respects. It includes explicitly and quantitatively the length scale of resolution of the pore space image, and it incorporates Non-Minkowski functionals into the characterization. Moreover it can be used directly for effective medium calculations of physical and material parameters.

The geometric observables in local porosity theory are closely related to Hadwigers theorem from stochastic geometry. The functional theorem of Hadwiger [2, p.39] emphasizes the importance of four set-theoretic functionals, the so called quermassintegrals or Minkowski functionals, for the geometric characterization porous media. While implementing the idea of local Minkowski functionals local porosity theory has at the same time emphasized strongly the need for geometric observables, that are not linear combinations of Minkowski functionals and hence are not covered by the assumptions of Hadwigers theorem.

Advances in computer and imaging technology have made threedimensional microtomographic images more readily available. Tomographic images allow to measure all geometric observables, and to solve the underlying physical equations of motion numerically, at least in princple. Practical implementations however still remain difficult.

The availability of threedimensional microstructures allows also to test approximate theories and geometric models by comparing them quantitatively. Distinguishing model microstructures quantitatively is very important for reliable predictions of physical and material properties. Little attention is usually paid to match the geometric characteristics of a model geometry to those of the experimental sample, as witnessed by the undiminished popularity of capillary tube models. Usually the matching of geometric observables is limited to porosity alone. Recently the idea of stochastic reconstruction models has found renewed interest. In stochastic reconstruction models one tries to match not only the porosity but also other geometric quantities such as specific internal surface, correlation functions, or linear and spherical contact distributions. As the number of matched quantities increases one expects that also the model approximates better the given sample. The presentation will test this expectation by quantitative comparison of stochastic resp. physical reconstruction models and the experimental microstructure obtained from computer tomography.

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