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Modeling and statistics of random tessellations with applications to the study of microstructure of polycrystallic materials

We present a parametric statistical methodology for analysing a Laguerre tessellation data set viewed as a realization of a marked point process of generators. We study the dependence of the marks and the point process in detail. Further, we suggest two general models. The first one is based on marked Gibbs point processes and leads to a broad class of Gibbs-Laguerre tessellations. Under mild assumptions we prove the existence of the infinite-volume Gibbs measure. Then the choice of energy function for applications is discussed in detail. The second model is hierarchical, where in the first step the point pattern is modelled and in the second step the marks are modelled conditionally on points, using exponential family models based on geometrical characteristics of the tessellation. Statistical tools for the parameter estimation, model selection and fitting are suggested and implemented. We apply our methodology for a 3D Laguerre tessellation data set representing the microstructure of a polycrystalline metallic material, where simulations under a fitted model may substitute expensive laboratory experiment.