Transition properties in dynamical and statistical features of shrinkage-induced crack patterns

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We investigate dynamical and statistical properties of shrinkage-induced crack patterns, which are observed such as on the surfaces of cooling lava and drying soil. Since the surface crack patterns evolve slowly in accordance with shrinkage, the statistical properties of the patterns, for example, fragment size distributions are also time-dependent. Understanding such time-dependency of the statistical properties is an important task to estimate the environment history the materials experienced from the current patterns. In this study, we investigated experimentally and theoretically time-dependent properties of fragment size distributions on surface crack patterns of a thin layer of drying dense colloidal suspension. As a result, we found that the time series of fragment size distributions converged with a single master curve by scaling the fragment sizes with its average, i.e., the statistics had a dynamical scaling law. Although this has been already predicted in numerical simulations by previous studies, the confirmation in real experiments is the first time. To understand the scaling law, we constructed a statistical model of the fragmentation process and succeeded in reproducing the scaling law. In addition, a detailed analysis of the model predicts that there is a transition in the classes of functional forms of the fragment size distributions. To verify the existence of this transition, we applied a Bayesian model selection analysis to the time series of the fragment size data and confirmed the existence of the transition. This result says that investigating the functional form of the fragment size distribution in the current patterns provides the information of shrinkage history the material experienced.

Keywords: Surface crack patterns, Shrinkage-induced cracks, Statistical properties

