Fragmentation of fractal random structures

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Breakup phenomena are ubiquitous in nature and technology. They span a vast range of time and length scales, including polymer degradation as well as collision induced fragmentation of asteroids. In geology, fragmentation results in the distribution of grain sizes observed in soils; fluids break up into droplets and fluid structures such as eddies undergo fragmentation. On the subatomic scale, excited atomic nuclei break up into fragments. Practical applications, such as mineral processing, ask for optimizations according to technological requirements and efficiency considerations. More generally, a wide range of structures from transport systems to social connections are described by complex networks, whose degree of resilience against fragmentation is a recent subject of intense scrutiny.

We analyze the fragmentation behavior of random clusters on the lattice under a process where bonds between neighboring sites are successively broken. Modeling such structures by configurations of a generalized Potts or random-cluster model allows us to discuss a wide range of systems with fractal properties including trees as well as dense clusters. We present exact results for the densities of fragmenting edges and the distribution of fragment sizes for critical clusters in two dimensions. Dynamical fragmentation with a size cutoff leads to broad distributions of fragment sizes. The resulting power laws are shown to encode characteristic fingerprints of the fragmented objects.

References

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