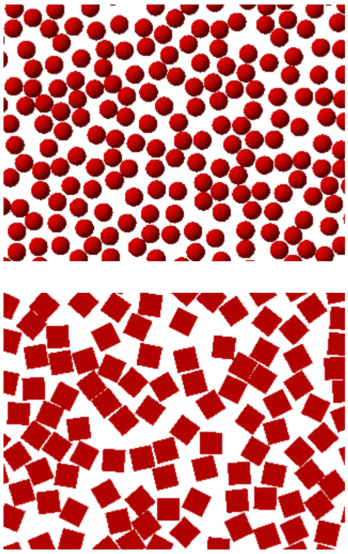
Random packings - from fundamentals to applications

Imagine a plane, on which we randomly place a number of identical shapes. These shapes are placed one after the other. They cannot intersect, and once placed they cannot change their positions. The packing becomes saturated when there is no large enough space to place another shape (see Fig.1).

One of the most important parameters of saturated random packing (SRP) is a packing fraction equal to the average ratio of covered area. Packing fractions are different for different shapes. For disks it is approx. 54%. In general it can change from 0% (for infinitely elongated shapes) to almost 60% for ellipses of long-to-short axis ratio of 1.85. Packing fraction depends also on properties of a space (e.g. dimension, porosity and curvature) where shapes are placed.



Rys. 1. Example saturated random packings built of disks and squares on a plane.

The aim of this project is to study dependence of packing fraction on shapes as well as on properties of space, where these shapes are placed.

The packing problems are probably one of the most ancient scientific problems and they are still of great practical importance for all industries involved in processing of granular matter. For example, a systematic study of the maximum packing of spheres in three-dimensional space began in the early seventeenth century during The European colonial period and related problems with maritime transport of ammunition, particularly cannonballs. Interestingly, this problem was finally solved a year before. Random packing appears in the field of soft matter and biology. Saturated random packing is a popular model for adsorption layers (formed by deposition of molecules on the previously prepared substrate). One of quite surprising applications of packing is telecommunication, where transferred information corresponds to a point in a multidimensional space. Interference (noise) causes the point to blur into a multi-dimensional shape. Thus, effective and efficient transmission of information can be reduced to the maximal packing of these shapes without overlapping in the hyperspace defined by the properties of the transmitting medium.

SRP became a popular model of adsorption layers. However, besides quite intensive investigations there are no analytical answers for a number of basic questions, for example, what is such packing fraction for disks on a plane. Known results are from experiments or numerical simulations. Thus, expected project results will not only answer fundamental scientific questions needed to understand granular and soft matter properties but also will provide effective methods for modelling adsorption layers, which may be used in nanotechnology or material sciences. This also will help in designing materials of given properties.