

Lungs, a glass of sugar, the bottom of the sea – does anything connect these objects? They are different from each other, both in the function and the material they are made of. It turns out that there is a common feature. Porosity is a property that links them, a property of networks of interconnected voids: channels, fractures, and pores. These void spaces can let fluids (liquid or gas) pass through the porous material. Porous materials are ubiquitous in nature, e.g. the artery system, soil, rocks, sponge, sand beds, etc. (M. Schlösser, *What sponges, beards and the lung have in common*, Max Planck Institute for Marine Microbiology, 2009). Moreover, they are also important in modern materials, cars, computers, etc., where they are used in countless technological processes...

The transport of fluids in porous media is important for both science and industry. The first example is the mining industry, where methods are developed for the effective extraction of fuel trapped in the channels of rocks. The most important parameter characterizing porous materials is permeability, describing the ability of the system to transport fluid with the applied external force. It depends on many structural factors of the medium, including porosity and pore surface. To account for the influence of the irregularity of the fluid flow paths through a porous medium, tortuosity was introduced. It contains information on the curvature of the motion path of the transported liquid molecules. This curvature is a consequence of the existence of obstacles and the formation of channels in porous media.

One of the basic challenges in the physics of porous media is the mutual influence of microscopic (tens of millimeters) and macroscopic (centimeters, meters) scales. The porous structures under consideration are usually real (i.e. from Micro Computer Tomography) or created by computer algorithms. For example, abstract objects strikingly similar to porous media in shape and complexity are fractals - self-similar figures are the objects that fascinate (not only) scientists for years. Interestingly, studying synthetically created porous media can give much insight into real-life samples, such as lungs, an object with an extremely developed surface concerning volume (a similar feature to fractals).

In this project, we will examine the tortuosity and hydrodynamic properties of complex systems (i.e. Sierpinski fractal, randomized media, and real granular samples). For the first time, a comprehensive analysis of this type of media will be performed in terms of hydrodynamic tortuosity in a wide range of physical flow speeds. We will perform simulations of objects of varying complexity. We will use our previous experience in modeling porous media of random structure and look for the impact of physical flow conditions on the results. In the project, we will also attempt to modify the classical equations so that they account for inertial effects.

The main motivation for the project is to study the inertial effects of flow through a complex medium with low porosity. This will extend our basic knowledge of fluid dynamics in such systems that is of utmost importance for science, technology, and life. The other significant effect of the project will be the development of new, meshless methods for simulating flows in complex media. This opens up the possibility for society to use them, as we plan to make source code and project results openly available. The resulting framework and methods can also be used in other fields related to fluid flow, including (but not limited to) biophysics and medical applications of flows in the arterial system.