DESCRIPTION FOR THE GENERAL PUBLIC

Nature is probably the main source of inspiration for scientists. Deep understanding of patterns observed in surrounding environment can lead to better designs of products and constructions. The reason for this is the fact that evolution is typically producing the optimized response to external conditions. Chicken bone, having optimized external shape and internal architecture with respect to minimum weight and maximum strength, is one of the examples. Shape adaptation is also visible in case of trees. Depending on the wind loading, the optimal shape of tree's cross-section might be provided by adaptive growth that fairly distributes the load (axiom of uniform stress) - there are no zones with locally excessive stresses nor regions not fully loaded.

The evolution of shape can be observed in multiple natural systems. One of them is meandering river, which has attracted the world's greatest thinkers [1]. Morphodynamics of this type of systems is governed by the interaction between erodible walls and sediment-carrying fluid. River bed can be mobilized by a shear stress exerted onto the bed by water flow. When the flow carries large quantity of sediment then abrasion can enhance this effect. The magnitude of shear stress is governed by local water velocity.

River shape is slowly evolving in time together with the flow and bottom topography. Curvature of the river shape is altering the flow in such a way that there are regions characterized by higher velocity, where the sediment is flushed away resulting in locally larger depth. In the regions, where the flow is slower the depth is smaller. This process renders typically smoothly varying bathymetry such as the one in the Fig. 1.

In this research project we focus on the propagation of surface water waves in such system. From the viewpoint of surface waves, meandering river can be considered as a waveguide with spatially varying refractive index that depends on local water depth. By varying water depth one can alter the propagation of waves. Meanders of the waveguide can be considered as waveguide defects that enhance scattering of waves compared to a straight waveguide. Through proper design of bottom topography one can render these defects invisible to the incident waves - waves can be perfectly transmitted despite the defects. Remarkably, bathymetry rendered by fluvial processes in meandering river is very similar to a specially designed bed that hides/cloaks defects of a meandering waveguide. The main objective of this research project is to answer the question whether natural changes occurring in bottom topography of meandering rivers can enhance transmitted energy flux with respect to surface water waves, and how this enhancement compares with human-designed bathymetry, or in other words, can human be more efficient? Can we learn from nature? To answer this question we will compare propagation of surface water waves in different waveguide geometries with bathymetries that were specially designed to hide the defects and bathymetries generated "naturally" by the flow. The project includes performing experiments and numerical simulations.

References

[1] A. Einstein. Die ursache der mäanderbildung der flußläufe und des sogenannten baerschen gesetzes. *Naturwissenschaften*, 14(11):223–224, 1926.

Figure 1: Meandering river Breivikseidet in Torms (Northern Norway): (left) river photo, (right) measured bathymetry of the river. Blue color corresponds to deeper regions, whereas yellow to shallower zones. Source (Nils Rüther & Markus Först): https://nilsatwork.wordpress.com/research-projects/