A Myriad Shades of Green

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Abstract

We discuss the possible application of techniques inspired by the theories of G-convergence and homogenization to understand mixtures of colors and how they appear as observed by the human eye. The ideas are illustrated by pictures describing the equivalent of a convergence process for different kinds of mixtures of colors.

The mathematical theory of homogenization and G-convergence (see [1]) deals with the convergence of balances

$$A^h u^h = f$$

between a source *f*, material properties A^h and a response u^h. When *h* passes to infinity we may reach a limit state described by a similar equation

$$Bu = f$$

where *B* is the effective property of the limit material. This could deal with elasticity or heat conduction in heterogeneous media or flow in porous media so why not colors? Here *f* could be the light illuminating an object, A^h distributions of colors, *B* the "effective color" in the limit and u^h and *u* the way the objects are judged by the human eye, see Figure 1.

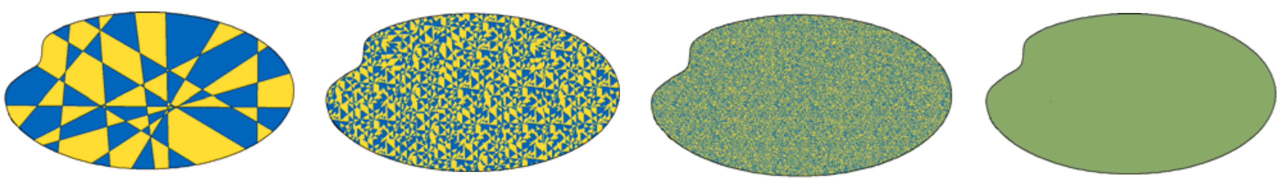

Figure 1: *A sequence of mixtures of colors.*

For periodically arranged materials there are methods to find *B* and hence to compute *u* for any given *f*. Different distributions of materials in the representative unit will result in different limit materials when the size of the repetitive units containing this mixture of materials shrinks to zero and their number hence goes to infinity. The stabilization during this process can be described by the result *u* for the limit equation and a corrector u_1^h as

$$u^h = u + u_1^h$$

Translation to colors *u* is again the limit color as it is observed by the human eye and u_1^h the disturbance of this impression by the heterogeneous pattern of colors that is still possible to view, see Figure 2.
The patterns below have about the same proportions between blue, yellow and white, but the colors are arranged in different ways. We can see that both cases approach a homogeneous green color but is maybe this process faster and passes through other nuances for one of the arrangements than for the other?

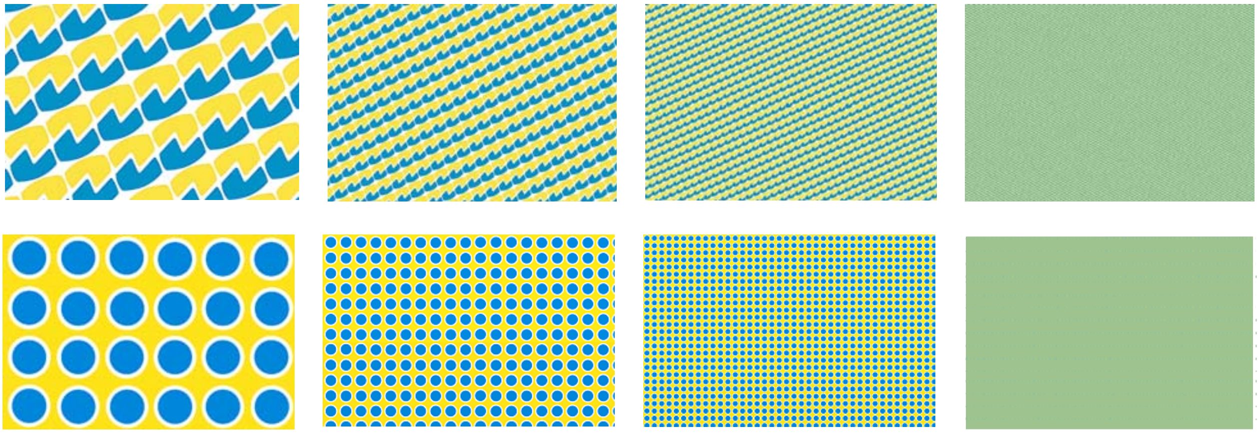

Figure 2: *Two sequences* of *periodically arranged colors.*

We raise the question whether techniques similar to mathematical homogenization can be applied to understand what mixtures of colors in different patterns look like when they appear in front of the human eye. This means that we would like find out if it is possible to find a relationship between this impression and the microstructure of the arrangement of colors that can be subject to computations based on equations formulated on one representative unit in a similar manner as in periodic homogenization. If this is successful the next challenge would be to study the corresponding issues for non-periodic structures.

References

[1] D. Cioranescu and P. Donato, An introduction to homogenization, Oxford Lecture Series in Mathematics and its Applications, 17. The Clarendon Press, Oxford University Press, New York, 1999.