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Complex Spatial Networks and Programmed Shape Selection: Topology and Geometry in Biology

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Carl Modes did a PhD in Physics and Astronomy at the University Pennsylvania, Philadelphia. In 2008 he started as a Postdoctoral Research Associate in the Theory of Condensed Matter Group at the University of Cambridge. In 2011 he moved back to the United States as a Postdoctoral Associate. He was working at the Center for Studies in Physics and Biology (The Rockfeller University) until 2017. Since 2017 Carl Modes is a group leader at MPI-CBG.

Career advice:

• Be aware of the Impostor Syndrome: Fight it, struggle with it, but don't hesitate to talk about it with your peers; its an incredibly common issue among scientists.
• Be brave: No job is too good to apply to if you believe you could fit there
• Cast as wide a net as possible: Remember that the whole job hunt is a numbers game. But if you can't imagine being happy at a place, for whatever reason, then don't bother with them.
• Think critically about the advice you receive: Survivorship bias is very real and even people that mean well can fall prey to it.

Abstract:

Nature finds the means to leverage complex geometric and topologic effects in many ways that are we only now beginning to understand. For example, in the case of topology, natural transport webs are frequently dominated by dense sets of nested cycles; the architecture of these networks – the topology and edge weights – determines how efficiently the networks perform their function. We present a new characterization of these physical networks that rests on an abstraction of a physical tiling in the case of a two dimensional network to an effective tiling of an abstract surface in space that the network may be thought to sit in. This new algorithmic approach can be used for automated phenotypic characterization of any weighted network whose structure is dominated by cycles, such as, for example, mammalian vasculature in the organs, the root networks of clonal colonies like quaking aspen, and the force networks in jammed granular matter. On the geometric side of the ledger, it has recently been more and more appreciated that developing biological systems employ complicated 2D stress fields during early onset of morphogenesis from flat or quasi-flat epithelial sheets to a rich zoo of fully three dimensional objects. We discuss a speculative approach based on methods from the physics of exotic shape-shifting materials to reduce the complexity of the interacting "parts" of the stress distribution to model these developmental morphomechanics in a parameter space of drastically reduced dimensionality.

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