Maria Ruiz

Modeling and predicting the overlap of B-cell receptor repertoires in healthy and SARS-CoV-2 infected individuals

Adaptive immunity's success relies on the extraordinary diversity of protein receptors on immune cell membranes. Despite this diversity, the existence of public receptors shared by many individuals gives hope for developing population wide vaccines and therapeutics. Yet many of these public receptors are shared by chance. We present a statistical approach, defined in terms of a probabilistic V(D)J recombination model enhanced by a selection factor, that describes repertoire diversity and predicts with high accuracy the spectrum of repertoire overlap in healthy individuals. The model underestimates sharing between repertoires of individuals infected with SARS-CoV-2, suggesting strong antigen-driven convergent selection. We exploit this discrepancy to identify COVID-associated receptors, which we validate against datasets of receptors with known viral specificity. We study their properties in terms of sequence features and network organization, and use them to design an accurate diagnosis tool for predicting SARS-CoV-2 status from repertoire data.

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Manuel Diaz

Non-equilibrium theory of resistive switching in strongly correlated materials

Insulator-to-metal transitions in strongly correlated materials are among the most abrupt first-orders phase transitions in Nature, where small temperature variations can cause dramatic drops of several ordes of magnitude in the resistivity. They can also be driven by a strong electric field or current, in which case they are commonly refered to as resistive switchings. The underlying mechanisms of these non-equilibrium phase transitions are currently under debate. Both in the experimental and theoretical communities, arguments are made in favor of a thermal process on one hand, and a purely non-equilibrium electronic mechanism on the other hand. We study this phenomenon in the context of a simple microscopic model for Vanadium dioxide (VO_2), the dimer-Hubbard model. Driven by an external electric field, we solve for the steady states of the model using non-equilibrium dynamical mean-field theory (DMFT), and map out its phase diagram. We show that, by relying on the concept of an effective temperature, it is possible to bring together both sides of the debate over the origin of resistive switching.