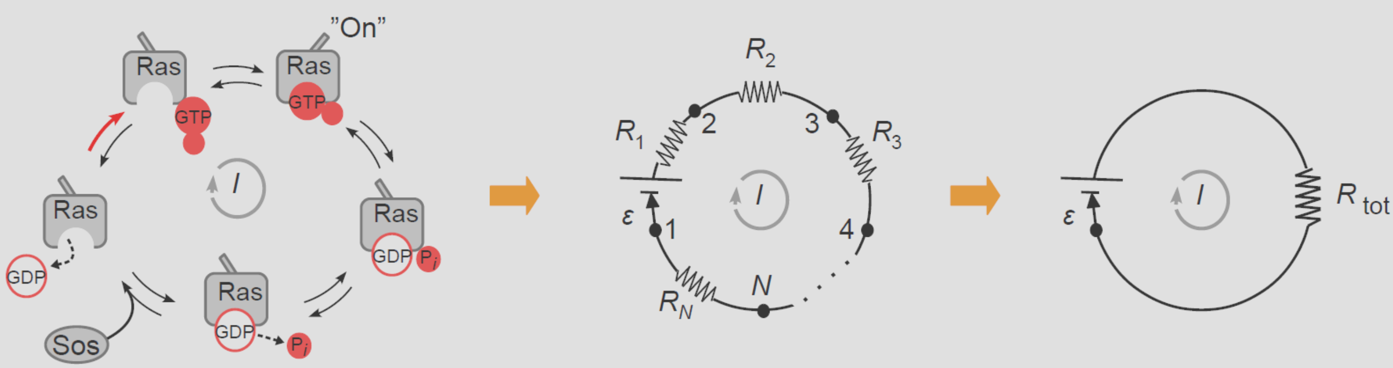
UNIVERSITY OF MIAMI

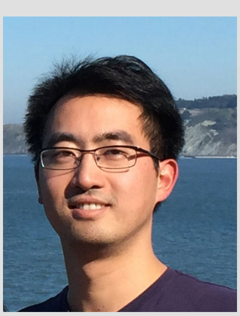
PHYSICS COLLOQUIUM
Wednesday, October 21, 4 pm

https://miami.zoom.us/j/97130869624?pwd=eTgvSzJJTFdDSy9Fb2ZYRVpxUFJTZz09

Circuit theory for molecular biology

For systems at thermodynamic equilibrium, the well-known Boltzmann distribution predicts system behavior without needing to account for the combinatorial interactions. However, most biochemical processes are not at equilibrium because they are driven by sources of energy and matter. Finding universal principles governing nonequilibrium behavior is an open problem. I will present a general probability flow equation governing Markov systems that is a direct generalization of the Boltzmann distribution. This simple equation is mathematically equivalent to the voltage equation describing charge flow in an electronic circuit with batteries and resistors; powerful simplifications and theorems from circuit theory can be brought to bear on nonequilibrium steady states. The equation leads to surprisingly simple closed-form solutions for nonequilibrium behavior, with known near-equilibrium results emerging as special cases. Far from equilibrium, these solutions set tight behavioral limits that hold regardless of system details. This approach also demonstrates that important properties characteristic of living systems, such as catalytic regulation and high thermodynamic efficiency, are only possible far from equilibrium. Experimental data show that living systems often operate at the upper limits allowed by the theory.





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