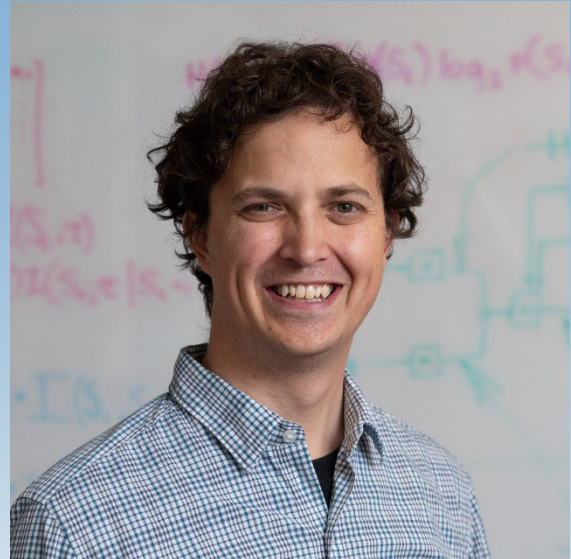


College | Physical Sciences

UCLA Physics & Astronomy Colloquium

Thursday, November 5th, 2026 at 4 p.m.
Physics & Astronomy Building (PAB) 1-434

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Supra-resonant dynamics and self-excited oscillations in insect and robot flight

Since Anderson's "More is different" and Schrödinger's "What is life?", physics has appreciated that the rules governing living systems may be irreducible to elemental components and hence emergent. Their composition matters. Locomotion arises from interacting physiological systems (neural, mechanical, muscular) all mediated through feedback from the environment. What sets living systems apart from simple active matter is that evolution has tinkered with this composition to produce behaviors that afford function. One of the most successful evolutionary examples of movement is the vast diversity of insect flight. Energetic costs to fly at small body sizes are high, dynamic stability is difficult to ensure, and yet thousands of insect species take wing, often with quite different wingbeat frequencies, mass, and morphology. In this talk, I will use the agile flight of insects to show how an organismal physics approach can give insights into this emergent functionality. I will show how nearly all insects operate as resonant "spring-wing" systems to power flight. This reduces the inertial power costs to accelerate their wings on each stroke. But contrary to the prevailing idea that many insects must operate at their resonant frequency, we find that they are in fact supra-resonant, flapping at frequencies often well above what would seem ideal. This arises from constraints on how muscle functions, but can also be functionally useful because rapid modulation and control of resonating wings would be quite difficult. We will then explore how insects have evolved two different strategies for powering this resonant flight system using muscles that either provide periodic oscillatory forcing or use a stretch-responsive activation to set up self-excited limit cycles. While these two strategies seem dichotomous both in their evolution and their physics, we find that they can be unified in a single dynamic systems framework that shows how major evolutionary transitions reflect transitions in emergent dynamics. We embody this framework in robotic models and test the parameter space for flapping flight. We find that these two dynamic regimes are separated by a classic entrainment boundary but also bridged by a region of parameter space enabling smooth transitions between the two flight modes. Our biophysical models help explain the repeated transitions and diversification of insect flight strategies.

Hosted by Seth Putterman