Canadian Association of Physicists
Association canadienne des physiciens et physiciennes

Contribution ID: **2788** Type: **Oral Competition (Graduate Student) / Compétition orale (Étudiant(e) du 2e ou 3e cycle)**

Non-equilibrium response of a strongly coupled rotary motor

Tuesday 4 June 2019 12:00 (15 minutes)

Living systems at the molecular scale are complex (composed of many constituents with strong and heterogeneous interactions), far from equilibrium, and subject to strong fluctuations. Energy conversion in such contexts would seem to be challenging, yet nature has evolved numerous molecular machines that efficiently, precisely, and rapidly transduce free energy between non-equilibrium reservoirs. Here we discuss design principles for effective free energy transduction in a simple model of FoF1 ATP synthase, a rotary motor that is crucial for virtually all living things. In particular, we discuss the interplay between non-equilibrium driving forces, natural equilibrium fluctuations, and interactions between the strongly coupled sub-systems that comprise the full machine.

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Session Classification: T2-1 Soft Matter AM-2 (DCMMP) | Matière molle AM-2 (DPMCM)

Track Classification: Symposia Day - Soft Matter Canada 2019