Contribution ID: **16**

Type: **Poster**

Sufficient and necessary conditions of entropy driven framework for hot unfolding of RNA thermometers

Tuesday, 22 September 2026 15:45 (5 minutes)

The exchange of matter and energy between an open system and its surroundings triggers thermally activated spontaneous processes that drive entropy toward a maximum. Consequently, thermal equilibration is fundamentally entropy-driven, establishing a final equilibrium state whose population increases with temperature. In certain cases, this behavior manifests as an entropy-driven thermal extra-sensitivity. A prime biological example is found in specific bacterial mRNAs known as RNA thermometers, which exhibit an extraordinarily sharp, temperature-dependent regulation of their translation initiation rate. This regulatory capacity stems from conformational unfolding near their ribosome-binding sites. However, a rigorous thermodynamic derivation of the master equation governing this entropy-driven unfolding has remained elusive. This report establishes the sufficient and necessary conditions of an entropy-driven framework to model the hot unfolding of RNA thermometers withing a two-configuration approximation. By restricting the system to transitions between two primary states (folded and unfolded) a consistent equation for the thermodynamic probability of the entropy-driven unfolding process is derived. The probability of the unfolded state is determined and its temperature dependence is mapped. This formulation reveals that the fundamental necessary condition for an entropy-driven unfolding process is that the entropy of the initial folded state exceeds the entropy of the initial unfolded one, both calibrated at an initial temperature. With rising the temperature, this condition breaks making the unfolding process to be steeply temperature-dependent in a power-like form such that the temperature exponent becomes equal the excess heat capacity at constant pressure, scaled in units of the gas constant. Furthermore, it is demonstrated that a high heat capacity increment is driven by an increased number of degrees of freedom and a growing degeneracy of the unfolded state. The sufficient condition is constituted by explaining the thermal extra-sensitivity of the biomolecules in the framework of entropy-driven scenario, in which the change of enthalpy is considered as minor process, whereas that of entropy change is regarded prevalent and increasing with temperature. Finally, the derived approach shows excellent agreement with existing experimental data of melting curves on mRNA unfolding transitions, thus providing a robust thermodynamic background for RNA thermometry.

The authors acknowledge the support by the NAS of Ukraine through the project No.01261U001252.

Primary author: Dr TESLENKO, Victor (Bogolyubov Institute for Theoretical Physics, NAS of Ukraine)

Co-author: Dr KAPITANCHUK, Oleksiy (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine)

Presenter: Dr KAPITANCHUK, Oleksiy (Bogolyubov Institute for Theoretical Physics, National Academy of Sciences of Ukraine)

Session Classification: Poster Session

Track Classification: STATISTICAL PHYSICS AND SOFT MATTER