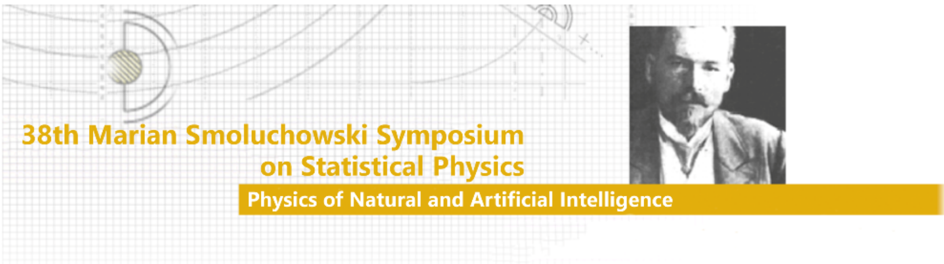

Contribution ID: **12**

Type: **Regular Talk**

Understanding the thermodynamic limits of finite-time computation in small systems

Monday, 15 September 2025 13:00 (20 minutes)

It is a general experience that computation in a computer produces heat. A part of this heat appears because of the erasure of memory, which is an essential step for irreversible logic operations in regular computational processes. The laws of thermodynamics fix a limit for the heat evolution associated with this erasure step and eventually for the computation[1, 2]. In small systems with fluctuations, the limit is set on the average value of the quantity. It is a common observation that the higher the speed of computation, the greater the amount of heat evolved. For practical situations, it is desirable to keep this heat as low as possible. However, to achieve the lower limit of the evolved heat, one needs to perform computation infinitely slowly, and that would not be a useful function. Consequently, a very important field of research has emerged very recently, which focuses upon the optimization of heat evolution for finite-time computation. This significant and practical problem has been targeted to be solved with different approaches; however, no definite solution has been found yet. We address this crucial issue to figure out what possible factors would be important to look at, which can minimize the heat evolution for a finite-time computation. We derive an analytical expression for the work done for the finite-time erasure protocol[3]. We primarily concentrate on exploring the environmental factors and shape modifications of the potential, mimicking the memory states. These are supposed to play significant roles in the understanding of the optimization of the heat involvement in the erasure process.

[1]Dillenschneider et al., Phys. Rev. Lett. 102, 210601 (2009).
[2]Berut et al., Nature 483, 187 (2012).
[3]Giorgini et al., Phys. Rev. Research 5, 023084 (2023).

Primary author: Dr DAS, Moupriya (Indian Institute of Technology Mandi)

Presenter: Dr DAS, Moupriya (Indian Institute of Technology Mandi)

Session Classification: Session 4: Network Science in Neurobiology and Collective Dynamics