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## ***Atom–Surface Interactions: Forces and Energetics***

23 Luglio 2025, aula E, DiFC, Via Archirafi 36 ore 11:00

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Systems out of thermodynamic equilibrium are common in nature and attract growing attention due to their relevance to physics and nanotechnology. Dynamical van der Waals/Casimir forces between atoms, molecules, and surfaces are a particular class of non-equilibrium phenomena. These quantum forces cause contactless friction between objects moving relative to each other. However, the detailed quantitative description of non-equilibrium systems is challenging, and common approaches assume small corrections to equilibrium characteristics. The validity of these procedures and approximations is limited, affecting the reliability of results.

This talk shows how thermodynamic considerations, such as the energy flow in and out of a moving atom under a nonequilibrium steady state, expose shortcomings in some quantum friction approaches. This thermodynamic approach highlights the importance of fluctuation-dissipation relations and long-time correlations between subsystems, introducing a consistency condition for models of nonequilibrium dynamics of open quantum systems.