[Talk 11] Mutually exclusive fluctuations in flows of dense granular materials

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Granular materials are highly unpredictable, they spontaneously start to flow and unexpectedly cease the flow indicative of the key role played by the instantaneous fluctuations in the rheology of dense granular flows—which is the main subject of our study. We establish a thermodynamic approach to study fluctuations that instantaneously violate the second law of thermodynamics in flows of dense granular materials. Most remarkably, we discover that these fluctuations have different origins in the fluid and the yield-stress states. In order to capture the instantaneous nature of fluctuations, we establish a time-independent fluctuation theorem which gives rise to an effective temperature which is found to be equal to the granular temperature in the fluid regime and larger than that in the yield stress regime. Our findings can provide detailed insights into the larger class of ubiquitous nonequilibrium systems which are much less known.