Dense pedestrian crowds at bottlenecks: How do the pedestrians' behaviours kick in ?

Alexandre NICOLAS[a*]

a. LPTMS, CNRS et Univ. Paris-Sud, Univ. Paris-Saclay, F-91405 Orsay, France
* alexandre.nicolas@polytechnique.edu

Public facilities (railway stations, stadiums, etc.) should be designed so as to allow optimal pedestrian flows and quick evacuation in the event of an emergency. While these issues have traditionally been left to empirical approaches, agent-based models have emerged in the last two decades to describe pedestrian dynamcis. One of the most widely used among these models, the social force model, considers pedestrians as self-propelled particles subjected to attractive and repulsive « social » interactions, thus making them amenable to a physical approach.

In this talk, I will first wonder if there exists a *fundamental* difference between the dynamics of a pedestrian and that of dry active particles. Leaving aside the complexity of pedestrian motion, we will see that the reaction time may play a key role in such a distinction.

Then, we will study the impact of the *behaviours* (which are specific to pedestrians) on the dynamics of a dense crowd in a particular situation : a bottleneck flow through a narrow door. To this end, we performed controlled experiments in which heterogeneous behaviours were prescribed to the participants [1]. It turns out that the main flow properties were controlled, not by the detail of the behaviours, but by the pedestrian density in front of the door, at least as long as crowd pressure was low. Paying closer attention to the microscopic flow dynamics, we noticed the existence of robust statistical patterns, such as the alternation between short and long time intervals between successive escapes. These statistical features can be rationalised by generic minimal models [2] and thus appear not to be specific to pedestrians.

[1] Nicolas, A., Bouzat, S., & Kuperman, M. N. (2017). Pedestrian flows through a narrow doorway: Effect of individual behaviours on the global flow and microscopic dynamics. *Transportation Research Part B: Methodological*, *99*, 30-43.
[2] Nicolas, A., & Touloupas, I. (2018). Origin of the correlations between exit times in pedestrian flows through a bottleneck. *Journal of Statistical Mechanics: Theory and Experiment*, *2018*(1), 013402.

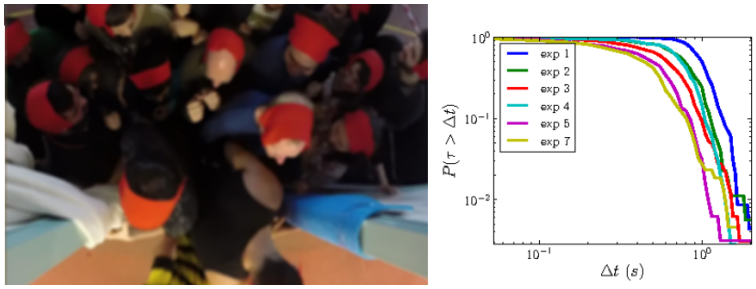

Figure 1 : (*Left*) Snapshot of an evacuation experiment through a narrow door. (*Right*) Survival functions of the time intervals Δt between successive pedestrian escapes for different behavioural prescriptions (to be described in the talk).