

Les mobilités humaines À distance *à travers le prisme de la physique*



$$P(r) \sim \frac{1}{r^v}$$

$$P(r_g) \sim (r_g + r_g^0)^{-\beta} \exp(-\frac{r_g}{\kappa})$$

$$\partial_t v + c_0 \partial_x v - D \partial_{xx}^2 v = 0$$

$$m \ddot{r} = F_{phys} + F_{soc}$$



Thématiques :

- ★ Dynamique piétonne
- ★ Structure des villes
- ★ Dynamique urbaine
- ★ Statistiques des flux de voyageurs & déplacements
- ★ Modélisation des mobilités

Orateurs invités :

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Appel à contributions : soumettez vos résumés
sur <https://jmc17.sciencesconf.org>
avant le 15 mai 2021 !

Les questions de mobilité et de transport sont des enjeux majeurs dans des sociétés toujours plus urbanisées, où la demande de mobilité s'accroît et les usages se transforment. L'afflux de données depuis les années 2000 a ouvert la voie à de nouvelles approches quantitatives et révélé des similitudes avec les propriétés de systèmes physiques plus classiques. Et ce, à toutes les échelles. Ce mini-colloque a pour but de faire tomber les barrières entre des problèmes de mobilité à des échelles différentes.

Active flow of pedestrian crowds: from large-scale measurements to variational modeling

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Pedestrians walk and choose their direction based on individual objectives and instantaneous traffic: this yields high variability in crowd dynamics, from diluted to dense regimes. Despite the unpredictability of single individuals, ensemble-level universal physical features emerge. These encompass frequent fluctuations and rare events within «solo» dynamics, mutual interactions, as well as routing choices. Reaching a quantitative understanding of these features is a major scientific challenge retaining great societal impact (e.g., in the design of civil infrastructures or crowd management measures), and sharing deep connections with the statistical physics of active matter.

To move towards a quantitative physics-based understanding of crowd dynamics, over the previous years, we established large-scale observational experiments held in real-life settings (stations, festivals, museums), aimed at investigating statistical features of pedestrian motion [1,2,3]. Via homemade high-fidelity tracking systems, we have collected datasets including millions of trajectories acquired with and without external influencing stimuli (i.e., crowd control measures, like signage or visual cues). In this talk, I will discuss the issue of modeling in (statistically) quantitative terms the observed dynamics, including PDFs of individual velocity, position, body rotation mutual-contact-avoidance, as well as path choice, based on Langevin-like equations and variational principles.

Based on works is in collaboration with: A. Gabbana, J. Meeusen, C. Lee, A. Muntean, R. Benzi, F. Toschi

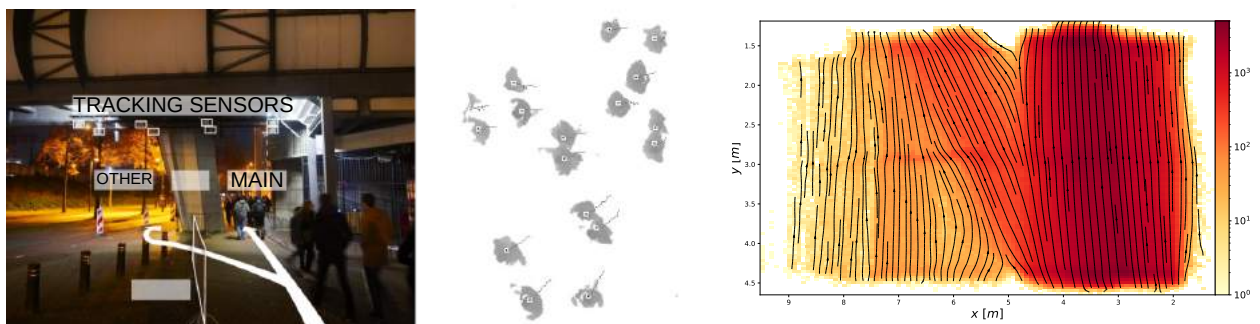


Figure 1 : Large-scale tracking experiment during the GLOW festival 2019 (Eindhoven, The Netherlands). About 200K trajectories have been collected and used to validate a stochastic variational model for crowd-level routing.

- [1] A. Corbetta, C. Lee, R. Benzi, A. Muntean, F. Toschi. Fluctuations around mean walking behaviours in diluted pedestrian flows. *Phys. Rev. E* 95, 032316, 2017
- [2] A. Corbetta, J.A. Meeusen, C. Lee, R. Benzi, F. Toschi. Physics-based modeling and data representation of pairwise interactions among pedestrians. *Phys. Rev. E* 98, 062310, 2018
- [3] J. Willems, A. Corbetta, V. Menkovski, F. Toschi. Pedestrian orientation dynamics from high-fidelity measurements. *Sci. Rep.* 10, 11653, 2020

Taking the exercise lab to the real world: What can we learn from big data in endurance sports?

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Laboratory performance tests provide the gold standard for running performance but often do not reflect real world conditions. In our latest work, we use a large dataset obtained from wearable exercise trackers to inform a validated model for running performance, and obtain a better understanding of the complex interplay between training and performance. The data set contains running activities of $\approx 14,000$ individuals, ≈ 1.6 million exercise sessions containing duration and distance, and a total collaborative distance of ≈ 20 million km ran. The inclusion of endurance as a model parameter offers novel insights into performance: a highly accurate race time prediction and the identification of key parameters such as the lactate threshold, commonly used in exercise physiology. Correlations between performance indices and training volume and intensity are quantified, pointing to an optimal training. Our findings hint at new methods to quantify and predict athletic performance under real-world conditions, detection of doping, and the assessment of new running shoe technologies.

[1] T. Emig, J. Peltonen, *Human running performance from real-world big data*,

Nature Communications **11**, 4936 (2020)

[2] M. Mulligan, G. Adam, T. Emig, *A Minimal Power Model for Human Running Performance*,

PLoS ONE **13**(11): e0206645 (2018)

