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"Extended lifetime of respiratory droplets in a turbulent vapor puff and its implications on airborne disease transmission"

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To mitigate the COVID-19 pandemic, it is key to slow down the spreading of the life-threatening coronavirus (SARS-CoV-2). This spreading mainly occurs through virus-laden droplets expelled at speaking, screaming, shouting, singing, coughing, sneezing, or even breathing. To reduce infections through such respiratory droplets, authorities all over the world have introduced the so-called 2-meter distance rule or 6-foot rule. However, there is increasing empirical evidence, e.g. through the analysis of super-spreading events, that airborne transmission of the coronavirus over much larger distances plays a major role, with tremendous implications for the risk assessment of coronavirus transmission. It is key to better and fundamentally understand the environmental ambient conditions under which airborne transmission of the coronavirus is likely to occur, in order to be able to control and adapt them.

Here we employ direct numerical simulations of a typical respiratory aerosol in a turbulent jet of the respiratory event within a Lagrangian-Eulerian approach with 5000 droplets, coupled to the ambient velocity, temperature, and humidity fields to allow for exchange of mass and heat and to realistically account for the droplet evaporation under different ambient conditions. We found that for an ambient relative humidity of 50% the lifetime of the smallest droplets of our study with initial diameter of 10 _m gets extended by a factor of more than 30 as compared to what is suggested by the classical picture of Wells, due to collective effects during droplet evaporation and the role of the respiratory humidity, while the larger droplets basically behave ballistically. With increasing ambient relative humidity the extension of the lifetimes of the small droplets further increases and goes up to 150 times for 90% relative humidity, implying more than two meters advection range of the respiratory droplets within one second. Smaller droplets live even longer and travel further. We also show that for low ambient temperatures the problem is even more serious, as the humidity saturation level of air goes down with decreasing temperature. Our results may explain why COVID-19 superspreading events can occur for large ambient relative humidity such as in cooled-down meat-processing plants or in pubs with poor ventilation. We anticipate our tool and approach to be starting points for larger parameter studies and for optimizing ventilation and indoor humidity controlling concepts, which both will be key in mitigating the COVID-19 pandemic.

This is joint work with Kai Leong Chong, Chong Shen Ng, Naoki Hori, Morgan Li, Rui Yang, and Roberto Verzicco.

Professor Detlef Lohse studied physics at the Universities of Kiel & Bonn (Germany), and got his PhD at Univ. of Marburg (1992). He then joined Univ. of Chicago as postdoc. After his habilitation (Marburg, 1997), in 1998 he became Chair at Univ. of Twente in the Netherlands and built up the Physics of Fluids group. Since 2015 he is also Member of the Max Planck Society and of the Max-Planck Institute in Göttingen and since 2017 Honorary Professor at Tsinghua Univ., Bejing. Lohse's present research interests include turbulence and multiphase flow, micro- and nanofluidics (bubbles, drops, inkjet printing, wetting), and granular & biomedical flow. He does both fundamental and more applied science and combines experimental, theoretical, and numerical methods. Lohse is Editor of J. Fluid Mech. and Ann. Rev. Fluid Mech. (among others journals) and serves as Vice-Chair for the Executive Board of the Division of Fluid Dynamics of the American Physical Society and Member of the Executive Board of IUTAM. He is Member of the (American) National Academy of Engineering (2017), of the Dutch Academy of Sciences (KNAW, 2005), the German Academy of Sciences (Leopoldina, 2002) and Fellow of APS (2002). He won various scientific prizes, among which the Spinoza Prize (NWO, 2005), the Simon Stevin Meester Prize (STW, 2009), the Physica Prize of the Dutch Physics Society (2011), the AkzoNobel Science Award (2012), two European Research Council Advanced Grants (2010 & 2017), the George K. Batchelor Prize (IUTAM, 2012), the APS Fluid Dynamics Prize (2017), the Balzan Prize (2018), and the Max Planck Medal (2019). In 2010, he got knighted to become "Ridder in de Orde van de Nederlandse Leeuw". Website: http://pof.tnw.utwente.nl