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Covid 19 Flows: Fundamentals and practical recommendations

Abstracts of invited talks

EXTENDED LIFETIME OF RESPIRATORY DROPLETS IN A TURBULENT VAPOR PUFF AND ITS IMPLICATIONS ON AIRBORNE DISEASE TRANSMISSION

Detlef LOHSE

Physics of Fluids Group, University of Twente, Netherlands

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.

HOW TO PREVENT SARS-COV-2 INFECTIONS VIA DROPLETS AND AEROSOLS

Christian J. KÄHLER

Institute for Fluid Mechanics and Aerodynamics, Bundeswehr University Munich, Germany
http://www.unibw.de/lrt7-en
https://www.youtube.com/channel/UCY-i8Gh3EQ6jG4Lht5_w-DQ/videos

The SARS-CoV-2 pandemic is currently presenting humanity with major challenges. Containing the spread of the virus requires enormous financial, technical and social efforts, and it is impossible to predict how well humanity will cope with the problem. Since the infectious disease not only has an acute course, but can also cause long-lasting systemic damage to infected individuals, prevention of infection is most important. It is generally accepted that the transmission of viruses is largely via droplets and aerosol particles. Therefore, the question of how these aerosol particles are generated and released and how they spread through the room and cause infection is particularly important to answer. Next, there is the question of how to best protect against infection. The answer to this question depends on the areas for which protection is to be established, because different protective measures have to be taken in a pedestrian zone than in buses and trains or in offices, schools and restaurants. To address these two problems, the first part of the talk will present the formation of aerosol particles in the body, their ejection by breathing, speaking, singing and coughing, and their dispersion in space. In the second part, the effectiveness of different protective measures is analyzed experimentally using laser based measurement data. In particular, the effectiveness of different masks for individual protection, as well as the usefulness of room air cleaners and protective walls, is demonstrated quantitatively. A deeper understanding of the spread processes and the protection options is imperative to effectively limit the spread of the pandemic and thus the costs for the state, the economy and society. Whether society is finally ready to protect itself effectively depends on the insight of the population, but also on the way the measures are implemented politically. This will also be discussed during the lecture, because this pandemic can only be contained if science, technology, politics and the population pull together.