Airborne Transmission of Covid-19

Anita Klein - Mariam Grigoryan - Steve de Rose

12 avril 2021

The Concept

- Covid 19 virus reported to the World Health Organization (WHO) on December 31, 2019.
- Reduce/Prevent its spread
- Cemosis and Synapse-Concept project 4fastsim-ibat.
- Air quality since Covid-19.

Collaboration Cemosis/Synapse

- Cemosis created in January 2013 by Christophe Prud'homme.
- Strasbourg Centre for Modelling and Simulation.
- Synapse-Concept created in November 1999.
- Specialised in engineering and technical studies.

Project

- Study of the airborne transmission of COVID-19 in an indoor space.
- The air in the room follows an advection-diffusion-reaction equation.
- With only one infectious person in the room.
- Rome of size $8m(l) \times 8m(w) \times 3m(h)$.
- Breathing/Talking with and without a face mask.

Illustration

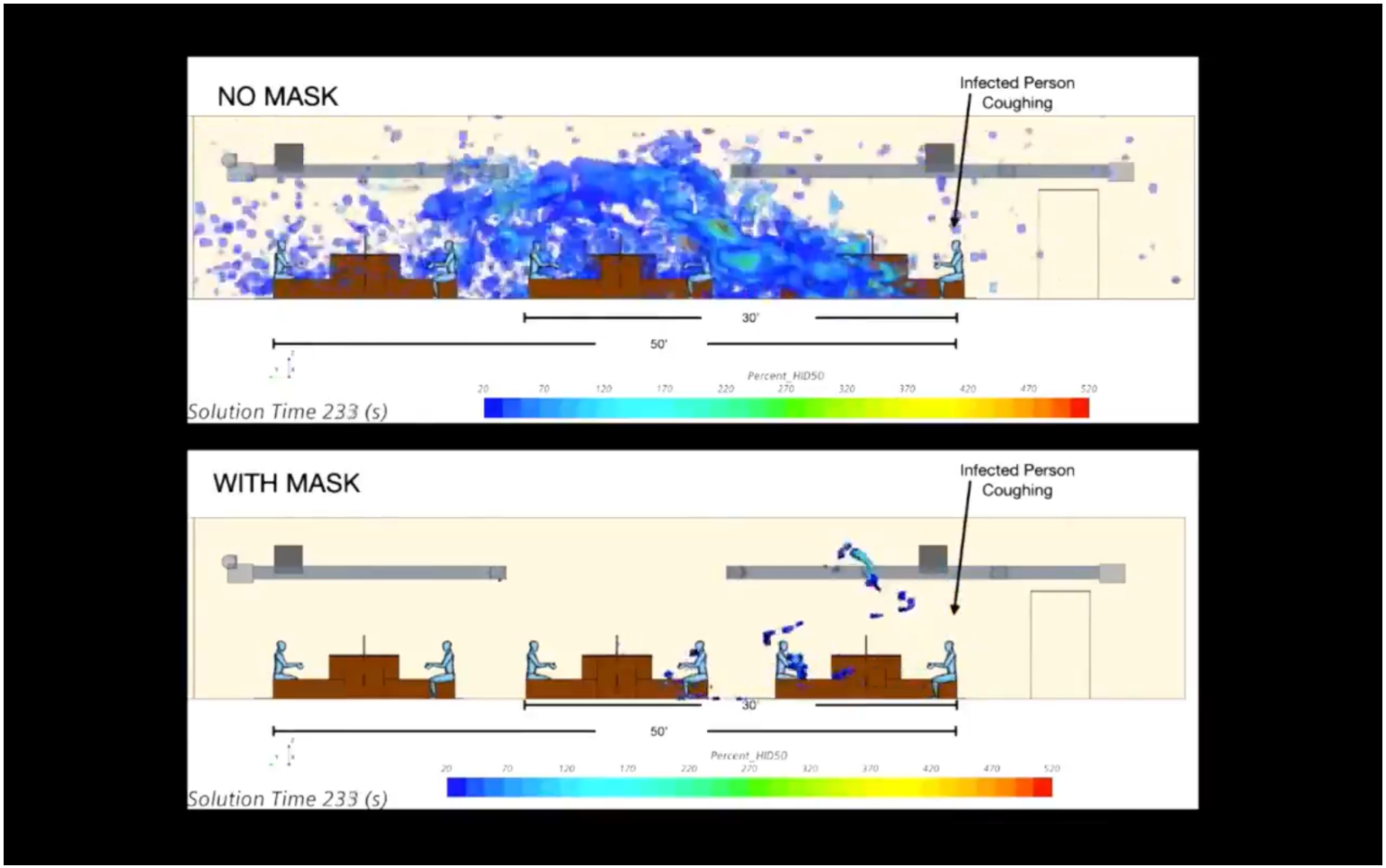

Figure – Virus airborne transmission in an office

Methodology I

- Firstly, 2D model to study/reproduce the concentration of airborne infectious particles.
- Using the advection–reaction–diffusion equation.
- Assumptions :
  - particles released from the infected person with zero initial velocity.
  - transported via advection due to the airflow in the room and diffusion due to turbulent mixing
  - the advection velocity of the air, $v(m/s)$ controlled by the air-conditioning unit.
  - the recirculation of air leads to turbulent mixing of the infectious particles.

ARD Equation

- Hence, the advection–reaction–diffusion equation :

$$\frac{\partial C}{\partial t} = \nabla.(K\nabla C) - \nabla.(\overrightarrow{v}C) + S.$$

- C = concentration of airborne infectious particles
  t = time
  ∇ = two-dimensional gradient operator
  K = isotropic eddy diffusion coefficient (turbulent diffusion)
  $\overrightarrow{v}$ = advection velocity of the air
  S = sum of sources and sinks of viral particles.

Methodology II

- Secondly, using «N-point ASOM» (air supply opening model).
- Developped in 2003 by Bin Zhaoa, Xianting Lib and Qisen Yanb at Tsinghua University, Beijing, China.
- Replace the real diffuser by several simple openings, maintaining the inlet momentum and mass flows.

The Tools

- Feel++ to solve advection–reaction–diffusion equation.
- Paraview to visualize the solution.
- Antora to generate the documentation site.
- Visual Studio Code.

References

- Z. Lau, K. Kaouri, I. Griffiths. Modelling Airborne Transmission of COVID-19 in Indoor Spaces Using anAdvection–Diffusion–Reaction Equation.School of Mathematics, Cardiff University and Mathematical Institute, University of Oxford.
- B. Zhao and X. Li. A simplified system for indoor airflow simulation. Building and Environment · April 2003
- Zohra Djatouti, Christophe Prud'homme, Vincent Chabannes, Romain Hild IBat Website `https://twitter.com/T_Fiolet/status/1378989583682179075?s=09`