

## Motivations and Aims

- Lack of models of soft aerosols as they interact dynamically with each other and surfaces. Relevant for many processes.
- Models particularly topical given Covid-19, where soft respiratory aerosols act as vectors for disease.
- Generic soft aerosol models may have many applications.

### Aims:



## What are Soft Aerosols?

- Soft materials exhibit complex behaviour lying somewhere between a solid and a fluid.
- They are soft to the touch and easily deformed by mechanical / thermal stress. Many common systems are considered soft, like polymers, colloids and gels.

- Examples of soft aerosolized material are rife in everyday life: Respiratory droplets, spray paint, superheated sand and more!
- These aerosols have non-Newtonian, viscoelastic properties that differ from purely elastic solid or viscous fluid systems.

- This gives complex stress - strain relationships. As seen here [1]:

$\sigma \propto \epsilon$  Elastic solid

$\sigma \propto \frac{d\epsilon}{dt}$  Viscous fluid

- Viscoelastic materials exhibit both properties leading to interest behaviour when they experience forces.



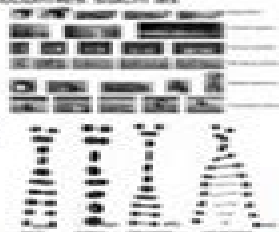
## Aerosol Mechanics

- Droplets impact surfaces with a variety of outcomes such as depositing, splashing and bouncing [2].

- Outcomes determined by droplet inertia, surface properties, impact parameters and material properties such as surface tension.

- Similar quantification of outcomes in droplet-droplet interactions with: coagulation, bouncing and coalescence all possible [3].

- Interactions can be assessed in terms of impact parameters and dimensionless numbers of the Weber and Reynolds numbers. The ratio of inertia / surface tension and inertia / viscosity.



## Computational Fluid Dynamics

- Lattice Boltzmann Methods (LBM) give an effective method to simulate viscoelastic droplets. LBMs take place on a mesoscopic scale and rely on kinetic principles to replicate fluid behaviour. Droplet simulated from smaller particles on discrete lattice. Particles move between lattice nodes and collide. [4]



$$f_i(x + \Delta x, t + \Delta t) = f_i(x, t) + \Omega_i$$

- Particles distributions on lattice sites evolve with some collision operator  $\Omega$  giving particles discrete velocities  $\mathbf{c}_i$ .
- $\Omega$  is scenario specific with initial conditions, boundary conditions can specify specific interaction type.
- Method will be implemented via walBerta framework in C++

## Experimental Methods

- Oscillatory shear rheometers induce a sinusoidal deformation in a material causing a stress response. Phase difference between stress - strain can quantify rheology. (if  $\delta = 0$  purely elastic [1])



- Pendant drop methods can measure surface tension by optically measuring droplet deformation under gravity.

- These techniques will be used to gather material properties of soft items created from polymers, surfactants etc.

- Droplet on demand systems will be used to create droplets of these substances.

- Experiments to probe the dynamics of these droplets will then be developed to test simulated models.



## Responsible Innovation and Challenges

- Since 2019, 500 million people have been infected with Covid-19, - massive amounts of research. Models could feed into research - best materials for mask, or contact points for infection etc.
- Other applications in engineering and industry. Example models for viscoelastic hot sand particles hitting jet engine blades in deserts.

### Challenges:



# Mechanics Of Aerosols

**Fuchs NA.**



## Mechanics Of Aerosols:

**The Mechanics of Aerosols** N. A. Fuks, 1964      The Mechanics of Aerosols N. A. Fuchs, 1989      The Fundamentals of Aerosol Dynamics C. S. Wen, 1996 During the past 30 years there have been advances in the understanding of multi particle hydrodynamic interactions in the field of aerosol dynamics Aerosol dynamics is developing from isolated particle stage into multi particle stage This book reviews these progresses and the subjects it covers include sedimentation coagulation mass or heat transfer effective viscosity and the evolution of the size distribution      **The Mechanics of Aerosols** Nikolaj A. Fuks, 1955      *Transport mechanics of aerosols : nonspherical particles* Isaiah Gallily, 2001      *Advances in the Mechanics of Aerosols* N. A. Fuks, 1961 The document digests the literature on aerosol mechanics published between 1954 and 1959 On some problems thermophoresis diffusion phoresis inertial settling of particles at large Reynolds numbers sound absorption by aerosols gravitational coagulation great successes have been achieved on other problems theory of sound coagulation experimental study of coagulation in a turbulent flux almost nothing has been done So much new theoretical and experimental data has been collected in this area that the need arose for this book      *The Mechanics of Inhaled Pharmaceutical Aerosols* Warren H. Finlay, 2019-06-01 The Mechanics of Inhaled Pharmaceutical Aerosols An Introduction Second Edition provides a concise but thorough exposition of fundamental concepts in the field of pharmaceutical aerosols This revised edition will allow researchers in the field to gain a thorough understanding of the field from first principles allowing them to understand design develop and improve inhaled pharmaceutical aerosol devices and therapies Chapters consider mechanics and deposition specifically in the respiratory tract while others discuss the mechanics associated with the three existing types of pharmaceutical inhalation devices This text will be very useful for academics and for courses taught at both undergraduate and graduate levels Because of the interdisciplinary nature of this book it will also serve a wide audience that includes engineers and scientists involved with inhaled aerosol therapies Provides a concise but thorough exposition of fundamental concepts in the field of pharmaceutical aerosols Allows researchers in the field to gain an up to date thorough understanding of the field from first principles Introduces the pharmaceutical aerosols field to the many engineers and scientists entering the area      *The Mechanics of Aerosols , Revised and Enlarged Edition (translated from the Russian)*. Fuchs NA., 1964      **ADVANCES IN THE MECHANICS OF AEROSOLS.** N. A. Fuks, FOREIGN TECHNOLOGY DIV WRIGHT-PATTERSON AFB OH., 1968 The document digests the literature on aerosol mechanics published between 1954 and 1959 On some problems thermophoresis diffusion phoresis inertial settling of particles at large Reynolds numbers sound absorption by aerosols gravitational coagulation great successes have been achieved on other problems theory of sound coagulation experimental study of coagulation in a turbulent flux almost nothing has been done So much new theoretical and experimental data has been collected in this area that the need arose for this book      Modern Pharmaceutics Gilbert S. Banker, Juergen Siepmann, Christopher Rhodes, 2002-05-24 Completely revised and expanded throughout Presents a

comprehensive integrated sequenced approach to drug dosage formulation design and evaluation Identifies the pharmacodynamic and physicochemical factors influencing drug action through various routes of administration

**Advances in Aerosol Gas Filtration** Kvetoslav R. Spurny,1998-03-27 Aerosols are generally associated with damaging effects to the ozone and human health however some aerosols enable productions of very clean highly dispersed materials Advances in Aerosol Filtration is dedicated to progress in aerosol science presenting newly developed theories filtration models and novel applications of aerosol gas filtration Topics include new filtration materials filter testing methods electrically enhanced filtration mechanical and chemical filter resistivity computational models and much more This book examines the history and development of aerosol filtration science and also considers research needs for the future

**Механика Аэрозолей. The Mechanics of Aerosols ... Translated ... by R.E. Daisley and Marina Fuchs. Translation Edited by C.N. Davies. Revised and Enlarged Edition** Nikolai Albertovich FUKS,R. E. DAISLEY,Charles Norman DAVIES,Marina FUCHS,1964 Aerosol Microphysics I W. H. Marlow,2013-03-08 The suggestion by Dr Franklin S Harris Jr that these books be written arose pursuant to the editor s complaints that despite the implicitly or explicitly acknowledged importance of both aerosols and particulate matter in innumerable domains of technology and human welfare investigations of these subjects were generally not supported independently of the narrowest conceivable domains of their applications Frank Harris who has long been a contributor in one of the important domains of aerosol macrophysics atmospheric optics challenged the editor to elaborate his views Ideally they would have taken the form of a monograph however there is as yet an insufficient body of information to present a unified treatment At the same time substantial efforts are in progress in the component fields to hold the promise for the emergence of unifying elements which will eventually facilitate their presentation to be made with a high degree of integrity There are numerous pertinent and systematic tie ins between project oriented aerosol work and basic physical investigations which are themselves quite closely akin to much classical and current work in physical science The most significant aspect of these tie ins is their potential for making substantial contributions to the functional needs of the applications areas while stimulating significant questions of basic physics For this to be possible it is necessary that the most relevant areas of physics be identified in such a manner as to make clear their relevance for aerosol related studies and vice versa *The Fundamentals Of Aerosol Dynamics* Ching-sung Wen,1996-08-23 During the past 30 years there have been advances in the understanding of multi particle hydrodynamic interactions in the field of aerosol dynamics Aerosol dynamics is developing from isolated particle stage into multi particle stage This book reviews these progresses and the subjects it covers include sedimentation coagulation mass or heat transfer effective viscosity and the evolution of the size distribution **Aerosols Physical Chemistry and Applications** Květoslav Spurný,1965 *Air and Water Pollution Annual Report* National Measurement Laboratory (U.S.),1962 Aerosol Science Ian Colbeck,Mihalis Lazaridis,2014-02-03 AEROSOL SCIENCE TECHNOLOGY AND APPLICATIONS Aerosols influence many

areas of our daily life They are at the core of environmental problems such as global warming photochemical smog and poor air quality They can also have diverse effects on human health where exposure occurs in both outdoor and indoor environments However aerosols can have beneficial effects too the delivery of drugs to the lungs the delivery of fuels for combustion and the production of nanomaterials all rely on aerosols Advances in particle measurement technologies have made it possible to take advantage of rapid changes in both particle size and concentration Likewise aerosols can now be produced in a controlled fashion Reviewing many technological applications together with the current scientific status of aerosol modelling and measurements this book includes Satellite aerosol remote sensing The effects of aerosols on climate change Air pollution and health Pharmaceutical aerosols and pulmonary drug delivery Bioaerosols and hospital infections Particle emissions from vehicles The safety of emerging nanomaterials Radioactive aerosols tracers of atmospheric processes With the importance of this topic brought to the public s attention after the eruption of the Icelandic volcano Eyjafjallaj kull this book provides a timely concise and accessible overview of the many facets of aerosol science

Fundamentals of Air Cleaning Technology and Its Application in Cleanrooms Zhonglin Xu,2013-10-10 Fundamentals of Air Cleaning Technology and Its Application in Cleanrooms sets up the theoretical framework for cleanrooms New ideas and methods are presented which include the characteristic index of cleanrooms uniform and non uniform distribution characteristics the minimum sampling volume a new concept of outdoor air conditioning and the fundamentals of leakage preventing layers Written by an author who can look back on major scientific achievements and 50 years of experience in this field this book offers a concise and accessible introduction to the fundamentals of air cleaning technology and its application The work is intended for researchers college teachers graduates designers technicians and corporate R D personnel in the field of HVAC and air cleaning technology Zhonglin Xu is a senior research fellow at China Academy of Building Research

**Handbook of Indoor Air Quality** Yinping Zhang,Philip K. Hopke,Corinne Mandin,2022-11-23 People live in indoor environment about 90% of lifetime and an adult inhales about 15 kg air each day over 75% of the human body s daily mass intake air food water Therefore indoor air quality IAQ is very important to human health This book provides the basic knowledge of IAQ and highlights the research achievements in the past two decades It covers the following 12 sections introduction indoor air chemicals indoor air particles measurement and evaluation source sink characteristics indoor chemistry human exposure to indoor pollutants health effects and health risk assessment IAQ and cognitive performance standards and guidelines IAQ control and air quality in various indoor environments It provides a combination of an introduction to various aspects on IAQ studies the current state of knowledge various advances and the perspective of IAQ studies It will be very helpful for the researchers and technicians in the IAQ and the related fields It is also useful for experts in other fields and general readers who want to obtain a basic understanding of and research advances in the field of IAQ A group of experts in IAQ research have been recruited to write the chapters Their research interests and experience cover the scope of the book In addition

some experienced experts in IAQ field have been invited as advisors or reviewers to give their comments suggestions and revisions on the handbook framework and the chapter details Their contribution guarantees the quality of the book We are very grateful to them Last but not least we express our heartfelt thanks to Prof Spengler Harvard University for writing the foreword of the current Handbook of Indoor Air Quality both as a pioneer scientist who contributed greatly to indoor air science and as an Editor in chief of Handbook of Indoor Air Quality 2001 1st ed New York McGraw Hill In addition to hard copies the book is also published online and will be updated by the authors as needed to keep it aligned with current knowledge These salient features can make the handbook fresh with the research development

**Transport Phenomena in Dispersed Media** G. I. Kelbaliyev, D. B. Tagiyev, S.R. Rasulov, 2019-09-26 Transport Phenomena in Dispersed Media addresses the main problems associated with the transfer of heat mass and momentum The authors focus on the analytical solutions of the mass and heat transfer equations the theoretical problems of coalescence coagulation aggregation and fragmentation of dispersed particles the rheology of structured aggregate and kinetically stable disperse systems the precipitation of particles in a turbulent flow the evolution of the distribution function the stochastic counterpart of the mass transfer equations the dissipation of energy in disperse systems and many other problems that distinguish this book from existing publications Key Selling Features Covers all technological processes taking place in the oil and gas complex as well as in the petrochemical industry Presents new original solutions for calculating design as well as for the development and implementation of processes of chemical technology Organized to first provide an extensive review of each chapter topic solve specific problems and then review the solutions with the reader Contains complex mathematical expressions for practical calculations Compares results obtained on the basis of mathematical models with experimental data

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