JSPS/SAC SEMINAR, MARCH 25-26, 2021: ON GAS KINETIC/DYNAMICS AND LIFE SCIENCE

MARCH 25 9:00-13:00 (SWEDEN)/17:00-21:00 (JAPAN),
MARCH 26, 9:00-10:00/17:00-18:00, & 12:00-14:00/20:00-22:00.

Book of Abstracts

MARCH 25, 9:00-13:00 (Sweden)/17:00-21:00 (Japan)

K1: Shigeru TAKATA: Plenary speaker (Kyoto University, Graduate School of Engineering, Department of Aeronautics and Astronautics)

Title: Some attempts on the simple kinetic modeling of dense gases with phase changes

Abstract: The origin of the kinetic theory study on dense gases can be traced back to the celebrated work by Enskog. Recently, numerical methods for the Enskog equation have been developed to activate researches of the dense gas behavior in the kinetic theory community. In this talk, we report our recent attempts on the modeling of phase changes by means of a much simpler kinetic model with dense gas effects. The talk is mainly based on the works in collaboration with T. Noguchi, M. Hattori, T. Matsumoto, A. Hirahara, and others.

References

1. T. & Noguchi, JSP (2018); https://doi.org/10.1007/s10955-018-2068-z
2. T., Matsumoto, Hirahara, Hattori, PRE (2018);
   https://doi.org/10.1103/physRevE.98.052123

C1: Tünde FÜLÖP (Chalmers, Department of Physics; Subatomic, High Energy and Plasma Physics)

Title: Kinetic modelling of runaway electrons in cooling plasmas

Abstract: The phenomena of runaway acceleration in plasmas has general importance in many fields of physics, for example it is a candidate mechanism for lightning initiation in thunderstorms and electron acceleration in solar flares. In fusion plasmas, understanding of runaways has a great practical importance, as the severity of runaway avalanches increases strongly with plasma current. Therefore, generation of runaways is expected to be a serious issue in ITER and other high-current reactor-scale fusion devices. We will discuss the characteristics and consequences of runaway generation, as well as possible mitigation strategies in fusion devices.

K2: Tetsuro TSUJI (Kyoto University, Graduate School of Engineering, Department of Aeronautics and Astronautics)

Title: Numerical analysis of a rarefied gas flow around a sphere induced by an abrupt onset of self-rotation

Abstract: We investigate a transient behavior of an infinite expanse of a rarefied gas around a sphere based on the linearized Bhatnager-Gross-Krook model of the Boltzmann equation and the diffuse reflection boundary condition on the spherical surface. Initially, the sphere and the gas are both stationary and in thermal equilibrium. At

time $t = 0$, the sphere starts self-rotation about one of its axes with a constant angular velocity, and the disturbance develops over space and time $t > 0$. This initial- and boundary-value problem is solved numerically using the method of characteristics that is able to capture the discontinuities of the molecular velocity distribution function. The profiles of macroscopic quantities, such as the flow velocity and the heat flow, are obtained for a wide range of the Knudsen numbers defined as the ratio between the mean free path of gas molecules at the initial equilibrium and the radius of the sphere. In particular, the approach to the steady state is shown to be proportional to $t^{-3/2}$ for sufficiently large t. This is a joint work with Satoshi Taguchi.

K3: Masanari HATTORI (Kyoto Unioversity, Graduate School of Engineering, Department of Aeronautics and Astronautics)

Title: Sound waves propagating in a slightly rarefied gas over a smooth solid boundary

Abstract: A time-evolution of a slightly rarefied gas from a uniform equilibrium state at rest is investigated on the basis of the linearized Boltzmann equation under the acoustic time scaling. By a systematic asymptotic analysis, a linearized Euler set of equations and acoustic-boundary-layer equations are derived, together with their slip and jump boundary conditions, as well as the correction formula in the Knudsen layer. Analysis is done up to the first order of the Knudsen number (Kn), as $Kn^(1/2)$ being the small parameter. Several rarefaction effects, which are known as the effects of the second order in Kn in the diffusion scaling, are enhanced to be of the first order in Kn. The occurrence of secular terms associated with the Hilbert expansion and a remedy for it are also given. Finally, as an application example, a sound propagation in a half space caused by an oscillation of flat plate is examined on the basis of the Bhatnagar-Gross-Krook equation.

C2: Philip GERLEE (Chalmers, Mathematical Sciences)

Title: Finite size effects in diffusive public goods games

Abstract: Many organisms produce costly goods that are released into the surrounding environment and benefits all nearby organisms (e.g. digestive enzymes released by bacteria). Mathematically this can be described as a diffusive public goods game (PGG). Diffusive PGGs games are difficult to analyze due to population assortment affecting growth rates of cooperators (producers) and free-riders. We study these growth rates using spectral decomposition of cellular densities and derive a finite cell-size correction of the growth rate advantage which exactly describes the dynamics of a randomly assorted population and approximates the dynamics under limited dispersal. The resulting effective benefit-to-cost ratio relates the physical parameters of PGG dynamics to the persistence of cooperation, and our findings provide a powerful tool for the analysis of diffusive PGG games, explaining commonly observed patterns of cooperation.

C3: Larisa BEILINA (Chalmers, Mathematical Sciences)

Title: An adaptive finite element method in non-invasive monitoring of hyperthermia

Abstract: An adaptive FEM for solution of an ill-posed problem appearing in microwave imaging will be presented. Numerical examples will show efficiency of the proposed method for data measured in microwave thermometry.

MARCH 26, 9:00-10:00 (Sweden)/17:00-18:00 (Japan)

K4: Kai KOIKE (Kyoto University, Graduate School of Engineering, Department of Aeronautics and Astronautics)

Title: Long-time behavior of a point particle moving in a 1D viscous compressible fluid

Abstract: A point particle moving in a fluid will slow down in time. When the particle moves in a 1D viscous compressible fluid, we previously showed that the velocity $V(t)$ of the point particle decays at least as $t^{-3/2}$. In this talk, we give a simple necessary and sufficient condition on the initial data for the occurence of the power-law behavior $t^{-3/2}$, that is, we prove a lower bound of $|V(t)|$ of the order of $t^{-3/2}$ under this condition. This is shown by analyzing the flow behavior in detail using Green's function.

K5: Hiroki TANAKA (Kyoto University, Institute for Integrated Radiation and Nuclear Science)

Title: Present status of accelerator-based neutron source for boron neutron capture therapy in Kyoto University.

Abstract: At the Institute for Integrated Radiation and Nuclear Science, Kyoto University, we have conducted clinical research on boron neutron capture therapy (BNCT) in more than 550 cases using a research reactor. Based on those experiences, we developed accelerator-based neutron source for BNCT that can be installed in a hospital using neutron transport Monte Carlo simulation. After clinical trials, the accelerator-based neutron source was approved for the manufacture and sale of medical devices, and medical institutions have started insurance medical treatment of BNCT. Medical device approval was also obtained for dose calculation software for treatment planning. In this presentation, we will report on the current status of dose calculation and accelerator neutron sources in BNCT.

Break 10.00-12.00
(due to the Sweden-Japan Academic Network meeting during that time)

MARCH 26, 12:00-14:00 (Sweden)/20.00-22:00 (Japan)

C4: Barbara Maria SCHNITZER (Chalmers, Mathematical Sciences)

Title: Pin pin korori in yeast: mathematical modelling of ageing, cellular rejuvenation and healthy lifespan

Abstract: Many cell types in nature distribute damaged components unevenly at cell division resulting in an ageing mother and a rejuvenated daughter cell with low damage levels and full replicative potential. Rejuvenation is essential for the viability of a cell population, but it comes at a price: mother cells accumulate damage faster and eventually lose their ability to proliferate, defined as replicative ageing. To elucidate underlying mechanisms of this trade-off, it is crucial to take into account both the single-cell and the population level, which is currently hard to do efficiently in experiments. We developed an ODE model of damage accumulation with discrete cell

division and cell death events, that allows mapping between individual strategies of damage control and properties of the cell population. To create more realistic populations, we incorporated cell-to-cell variability by applying non-linear mixed effects to model parameters, which then follow a log-normal distribution with a population fixed effect and an individual random mixed effect. By mathematical and computational analysis, we showed how increased damage asymmetry at cell division can ensure the survival of a large fraction of the lineage by diluting the damage over the whole population. At the same time, the cells' healthy lifespans are prolonged if damage repair is particularly effective during early divisions, and thus the burden on the single-cell level is minimised. Consequently, our framework allows to concretise terms like rejuvenation and healthy ageing and to combine them to test evolutionary hypotheses.

C5: Tobias GEBÄCK (Chalmers, Mathematical Sciences)

Title: Multiscale modeling of HPLC chromatography columns - homogenization and lattice Boltzmann simulations

Abstract: High pressure liquid chromatography (HPLC) has numerous industrial applications as a separation method. It is used both for analysis of mixtures, and in production for purification of e.g. pharmaceuticals.

A typical chromatographic column contains densely packed porous particles. The mixture with chemicals dissolved in a solvent is pushed through the column at high pressure, creating a flow through the packing, and molecules diffuse into the particles and bind to pore surfaces inside the particles with different affinity depending on the molecules and surface properties.

In this talk, we present a mathematical model of a chromatographic column at three length scales: tens of nanometers inside the pores, micrometers at the particle scale, and centimeters or larger for the full column. Homogenization methods are used to derive effective equations at the full column scale, where model parameters can be derived from cell problems at the smaller scales. Lattice Boltzmann simulations were also used to compute these parameters from real pore structures in 3D obtained using transmission electron tomography.

C6: Torbjörn LUNDH (Chalmers, Mathematical Sciences)

Title: Relation between the shape of a wound and its healing time

Abstract: We will discuss a classical question by Hippocrates why a circular wound does not heal. This was later picked up by Aristotle who stated: "It belongs to the physician to know that circular wounds heal more slowly, but it belongs to the geometer to know the reasoned fact." This ancient observation will be discussed from both a bottom-up and a top-down viewpoint, that will lead us to the questions of what it is to "know the reasoned fact" and what a good model is and how many parameters can we deal with and still "reason"? One analogous model I have worked with together with Philip Maini at Oxford, is actually a parameter-free model based on a single (ill-posed) partial differential equation in order to formulate Hippocrates' problem in not only a medical way, but also in an analogous mathematical, physical, and numerical manner.

C7: Anders LOGG (Chalmers, Mathematical Sciences)

Title: Digital Twin Cities

Abstract: Digital Twins are living digital models of physical systems. Digital Twins are used for planning, monitoring, maintenance & operation, and optimization of the physical system. Recent advances in technology have already enabled the creation of digital twins of cars or airplanes that can now be modelled, simulated and optimised before they leave the drafting table.

This progress is about to become reality for something as complex as whole cities. Digital Twins can simulate and visualize the pulse of the city in real time with layered data sources of buildings, urban infrastructure, utilities, businesses, movement of people and vehicles. Utilising this technology in the right way has enormous potential for tackling some of the most pressing urban challenges, such as segregation, flooding, pollution, traffic congestion, spreading of fire & diseases.

In this talk, I will present an overview of our activities at the Digital Twin Cities Centre, a Vinnova Competence Centre hosted by Chalmers University of Technology in Gothenburg, including some preliminary results of city model generation, simulation and visualization.