Vacuum Science and Technology Division
Fachverband Vakuumphysik und Vakuumtechnik (VA)

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Overview of Sessions

(Lecture hall H12)

Sessions

VA 1.1–1.3	Mon	9:30–11:30	H12	**Rarefied gas dynamics and novel numerical approaches**
VA 2.1–2.4	Mon	12:30–15:10	H12	**Vacuum technology: New developments and applications**

Invited Talks of the joint Symposium SKM Dissertation Prize 2022 (SYSD)

See SYSD for the full program of the symposium.

SYSD 1.1	Mon	10:15–10:45	H2	**Charge localisation in halide perovskites from bulk to nano for efficient optoelectronic applications** — •Sascha Feldmann
SYSD 1.2	Mon	10:45–11:15	H2	**Nonequilibrium Transport and Dynamics in Conventional and Topological Superconducting Junctions** — •Raffael L. Klees
SYSD 1.3	Mon	11:15–11:45	H2	**Probing magnetostatic and magnetotransport properties of the antiferromagnetic iron oxide hematite** — •Andrew Ross
SYSD 1.4	Mon	11:45–12:15	H2	**Quantum dot optomechanics with surface acoustic waves** — •Matthias Weiss

Invited Talks of the joint Symposium United Kingdom as Guest of Honor (SYUK)

See SYUK for the full program of the symposium.

SYUK 1.1	Wed	9:30–10:00	H2	**Structure and Dynamics of Interfacial Water** — •Angelos Michaelides
SYUK 1.2	Wed	10:00–10:30	H2	**A molecular view of the water interface** — •Mischa Bonn
SYUK 1.3	Wed	10:30–11:00	H2	**Motile cilia waves: creating and responding to flow** — •Pietro Cicuta
SYUK 1.4	Wed	11:00–11:30	H2	**Cilia and flagella: Building blocks of life and a physicist's playground** — •Oliver Bäumchen
SYUK 1.5	Wed	11:45–12:15	H2	**Computational modelling of the physics of rare earth - transition metal permanent magnets from $SmCo_5$ to $Nd_2Fe_{14}B$** — •Julie Staunton
SYUK 2.1	Wed	15:00–15:30	H2	**Hysteresis Design of Magnetic Materials for Efficient Energy Conversion** — •Oliver Gutfleisch
SYUK 2.2	Wed	15:30–16:00	H2	**Non-equilibrium dynamics of many-body quantum systems versus quantum technologies** — •Irene D'Amico
SYUK 2.3	Wed	16:00–16:30	H2	**Quantum computing with trapped ions** — •Ferdinand Schmidt-Kaler
SYUK 2.4	Wed	16:45–17:15	H2	**Breaking the millikelvin barrier in cooling nanoelectronic devices** — •Richard Haley
SYUK 2.5	Wed	17:15–17:45	H2	**Superconducting Quantum Interference Devices for applications at mK temperatures** — •Sebastian Kempf

VA 1: Rarefied gas dynamics and novel numerical approaches

Time: Monday 9:30–11:30 Location: H12

VA 1.1 Mon 9:30 H12

Direct Simulation Monte Carlo of diffusion pumps for the application in fusion reactors — •Tim Teichmann, Thomas Giegerich, and Christian Day — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

Active R&D is performed on developing of a continuously working pumping train for the future European demonstration fusion power plant (DEMO). Diffusion pumps operated with mercury have been identified as candidates for the high vacuum pumps. The numerical simulation of these pumps is challenging because they operate in a wide gas rarefaction range. A simulation framework based on the Direct Simulation Monte Carlo (DSMC) method has been established over the last years. The present talk aims to give an update on the present state of the simulations and their projected impact on the diffusion pump design for DEMO.

VA 1.2 Mon 10:10 H12

Transient modeling of the gas flows in the gas injection systems of fusion reactors — •Christos Tantos, Stylianos Varoutis, and Christian Day — Karlsruhe Institute of Technology, Karlsruhe, Germany

This work presents an assessment of the flow evolution inside the gas pipes of the gas injection system (GIS) of fusion reactors during a control action. A successful gas injection system design requires on the one hand the ability to meet the technical requirements under steady state conditions that are in line with the operating requirements of the reactor and on the other hand the appropriate prediction of the dynamic change of the system response times. In this framework, in the present work a state-of-the-art methodology has been utilized analyzing the transient behavior of the argon and deuterium-tritium gas flows in the GIS of DEMO (DEMOnstration Power Plant) fusion reactor. The applied methodology allows for an accurate description of the gas flow in the whole range of the gas rarefaction and compared to other widely applied particle-based approaches it requires low computational effort using an ordinary workstation. The main output of the present work, namely the delay time, representing the time it takes the flow to reach the outlet as well as the time needed to recover steady state conditions, is estimated in a wide range of the operating conditions and ratios length-to-diameter of the GIS tubes. The obtained data show that the response times of the GIS are unfeasibly high and this may have a strong impact on the design of the piping of the DEMO gas injection system.

VA 1.3 Mon 10:50 H12

The Regularized 13-Moment Equations for Rarefied Gas Simulations — •Manuel Torrilhon — RWTH Aachen University

The Regularized 13-Moment-Equations (R13) are using moment approximations for the Boltzmann equation in kinetic gas theory to describe gas flows when the Knudsen number - the ratio between mean free path and observation scale - becomes significant. Classical fluid theories like the constitutive laws of Navier-Stokes and Fourier are valid only close to equilibrium and fail for processes at Knudsen numbers as low as 0.05 because there are not sufficient particle collisions within the gas to maintain equilibrium.

The derivation of the R13-equations relies on the combination of moment approximations and asymptotic expansions in kinetic gas theory. The system has been shown to be stable and of high asymptotic accuracy yet using only a relatively small set of variables, namely density, velocity, temperature, stress deviator and heat flux - in total 13 fields. It has been demonstrated to succeed on the prediction of various non-equilibrium processes like shock waves or channel flows with Knudsen layers. The system of equations also exhibits desirable mathematical features like an entropy and is easy to use in numerical simulations. An overview of the equations and their features can be found in the review in Ann. Rev. Fluid Mech. 48, (2016), 429-458.

This talk will introduce the model and discuss recent developments like the efficient implementation in finite element frameworks, polyatomic collision models, and nonlinear extensions.

VA 2: Vacuum technology: New developments and applications

Time: Monday 12:30–15:10 Location: H12

VA 2.1 Mon 12:30 H12

Experimental characterisation of a NEG pump of novel size - a major step to its application in neutral beam injectors of future fusion devices — •Stefan Hanke[1], Christian Day[1], Thomas Giegerich[1], Xueli Luo[1], Fabrizio Siviero[2], Michele Mura[2], Enrico Maccallini[2], Paolo Manini[2], Emanuele Sartori[3], Marco Siragusa[3], and Piergiorgio Sonato[3] — [1]KIT, Karlsruhe, Germany — [2]SAES Getters, Lainate, Italy — [3]Consorzio RFX, Padova, Italy

Future fusion plants require plasma heating including neutral beam injectors (NBI), demanding pumping speeds of several 1000 m3/s. A concept to replace the currently used customized cryopumps is based on the high capacity getter ZAO. In a 6 years systematic technology development, the concept of a NBI NEG pump was derived, starting with comprehensive material characterisation, expanded to pumping and regeneration characteristics of ZAO and to heating and thermal management of larger arrangements for scalability and control. The recent step was design, manufacturing and operation of a large NEG pump for demonstration and to confirm scalability. The resulting pump with 15 kg of ZAO was tested in the TIMO facility at KIT. The achieved experimental results, regarding sorption characteristics (depending on pressure, gas flux, getter temperature, loading of the getter with gas, isotope) and regeneration behaviour are described. Subsequently the entire setup was replicated in detail in the TPMC code ProVak3D to find the real sticking factor. With this, the performance of any advanced future arrangement of NEG cartridges can be predicted now.

VA 2.2 Mon 13:10 H12

Design process of the DTT divertor cryopump — •Volker Hauer and Christian Day — Karlsruhe Institute of Technology, Institute for Technical Physics, Karlsruhe, Germany

DTT is a planned, superconducting tokamak, which is to be built in Italy in the next few years. It will provide enough flexibility to test different divertor concepts and find the best concept for a subsequent demonstration power plant.

The plasma chamber in the center of the tokamak is actively pumped during operation. Nine cryopumps are used for this purpose due to the high pumping speed required.

The presentation shows the design process of the cryopumps starting from the boundary conditions, the calculation of pumping speeds by means of Test Particle Monte Carlo Simulation (TPMC), the selection of the optimal design and the necessary calculations for mechanical stability to the planned design of the cryopumps.

VA 2.3 Mon 13:50 H12

Outgassing rate studies and Monte Carlo simulations for the design of the cryogenic vacuum system of the Einstein Telescope — •Katharina Battes, Stefan Hanke, Xueli Luo, and Christian Day — Karlsruhe Institute of Technology, Eggenstein-Leopoldshafen, Germany

The Einstein Telescope (ET) is a third-generation underground gravitational wave observatory, currently under development in Europe. It is designed as an equilateral triangle with 10 km long arms and detectors in each corner. Two interferometers will be used to detect both low-frequency (LF) and high-frequency gravitational wave signals.

In order to reduce thermal noise, the main optics will partly be cooled to cryogenic temperatures below 20 K for ET-LF. The integral ET vacuum system requires high to ultra-high vacuum conditions and comprises three different parts: (i) the beamline vacuum characterised by outgassing from the pipe walls, (ii) the tower vacuum characterised by outgassing from the suspension arrangement, and (iii) the cryogenic vacuum systems around the LF mirror.

In this paper, the outgassing behavior of potential materials such as mild steel is studied at the Outgassing Measurement Apparatus OMA. Using this input, a Test Particle Monte Carlo model has been established with the KIT in-house code ProVac3D, to allow for a system analysis of the cryogenic vacuum area. It assesses the impinging rate of residual gas on the cryogenic mirror, depending on the particle sources. With that, the expected speed of frost formation is estimated, which is critical due to degradations of the optical performance.

VA 2.4 Mon 14:30 H12

Prevention of Carbon Contamination in Transmission Electron Microscopy by Sample-Specific Preparation — •Julia Menten[1], Daniela Ramermann[1], Robert Schlögl[1,2], and Walid Hetaba[1] — [1]Max Planck Institute for Chemical Energy Conversion, Mülheim an der Ruhr, Germany — [2]Fritz Haber Institute of the Max Planck Society, Berlin, Germany

Transmission electron microscopy (TEM) offers a powerful tool for the analysis of specimens down to an atomic scale. In order to achieve the best possible image resolution and quality of obtained data, sample preparation is a crucial step. Many samples contain a high carbon content, e.g. as organic ligands or solvents. Electron beam exposure can lead to the deposition of carbon on the specimen surface and limit the quality of the measurements.

In our work we focus on the removal of undesirable carbon species before the sample is inserted in the microscope. Our sample cleaning setup allows for investigation of the influence of different preparation parameters, e.g. drying time or temperature, on how long solvents remain in the vacuum system and therefore can have an impact on the TEM analysis. Evaluation of the decrease in pressure while pumping our setup with a TEM sample gives insight in necessary drying times. The effect of our sample treatment can be verified in the TEM by contrast and thickness measurements after electron beam exposure of the sample.