

20th IUVSTA School on Vacuum Gas Dynamics: from theory to practical applications

17-21 September 2023, Porquerolles island, France
<https://www.iuvsta-school-2023.com/>

Report by
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Introduction

The 20th IUVSTA School was organised in the framework of the IUVSTA educational program on 17-21 September 2023 in Porquerolles island. The School was designed for scientists, engineers and post-graduate students who apply rarefied/vacuum gas dynamics in their every-day work but are not experts in this field. The main objective of the School was to educate and train the participants in applying vacuum gas dynamics and also to fill the gap between the complicated theory and practical needs.

The event has been co-chaired by Prof. Felix Sharipov (Brazil), Dr. Oleg Malyshev (UK) and Prof. I. Graur Martin (France), who was also the local Organiser. The School speakers (lecturers) included the three chairmen as well as Dr. Karl Jousten (Germany), Dr. Roberto Kersevan (Switzerland) and Prof. Dimitris Valougeorgis (Greece). The School was sponsored by IUVSTA. Totally 43 delegates participated in the School including 37 students, 6 lecturers.

School participants

The School students came from various countries in Europe and few of them from USA and Pakistan. A detailed list of the countries of work origin for all students is given in Table 1, where it is seen that they are coming from 10 countries. The type of working environment of participants is given in Table 2, which shows that 17 participants are from research institutes/centers, 16 from universities and 7 from the companies/industry, so in total from 25 different organisations. Their professional status is shown in Table 3, with most of them being Ph.D. students and vacuum scientists/engineers, while about 7 are senior engineers or group leaders.

From Tables 1, 2 and 3 it may be concluded that the School audience was diverse concerning the scientific background and interests of the participants in accordance with the organisers objectives. This diversity was very stimulating for the students triggering interesting questions to the lecturers during sessions and coffee breaks, making however, the lectures' presentations quite challenging in order to cover all questions and needs.

Table 1.

Country of origin of participants	Number of participants
France	9
Germany	5
Italy	5
Pakistan	3
Poland	1
Portugal	2
Slovenia	1
Spain	2
United Kingdom	7
USA	2
Total countries:	10

Table 2.

University	Research Institute/ Laboratory	Industry/Company	Total organisations
7	10	8	25

Table 3.

PhD students	Post-Docs	Vacuum scientists/engineers	Senior vacuum scientists/engineers	Group leaders	Others
6	1	23	2	2	3

School topics

Totally 10 Lectures and 8 Practical Sessions were presented covering many topics in the field of Vacuum Gas Dynamics (see the School Program in Appendix A).

The theoretical part was focused on kinetic theory, kinetic models, and gas-surface interaction. The modeling and simulation parts covered the Discrete Velocity method (DVM), Test Particle and Direct Simulation Monte Carlo methods (TPMC and DSMC), while the experimental part was focused on methods of measurements and standards in vacuum systems and vacuum metrology. The part related to applications was on vacuum gas dynamics in pipes, pumps, gauges, small and large vacuum systems (networks, accelerators) using Molflow software based on TPMC, numerical codes based on DSMC and discrete velocity methods as well as diffusion modeling.

An interesting part of the School was the Practical Sessions where the students were requested to solve specific problems and exercises related to the material of the lectures. These Sessions were running in-parallel in two groups supervised by two lecturers at the same time to help the students more effectively and to intensify the interaction between students and

lecturers. Most of the students were happily engaged in this process trying hard to get the correct answers which were delivered to the students for comparison purposes.

It is important to note that all material related to the Lectures and Practical Sessions has been uploaded to the School website about two weeks before its start and all registered participants had (and still have) access to it in order to better prepare themselves for all sessions. Updated versions of the Lectures and Practical Sessions will be available for downloading until the end of October 2023.

At the beginning of the event (Monday morning) a short presentation on IUVESTA was given emphasising on the importance of IUVESTA on educational activities (schools, fellowships, etc.). The duration of all Lectures and Practical Sessions was 1 hour 15 min. with a coffee break of 30 min. between the sessions.

The detailed program of the School is given in Appendix A, the picture of the website with the lecture materials is provided in Appendix B, while some photos of the School may be found in Appendix C.

School evaluation and concluding remarks

In the last day of the event questionnaires were delivered and filled by the students. There was a very positive reply by the vast majority of the participants being very much satisfied by the School and saying that they would recommend a similar School to their colleagues. They were also very much satisfied by the scientific level of the lectures finding them comprehensive and interesting. There were some concerns about the practical sessions saying that although they were well connected to the lectures it was difficult to follow and proposing having more time to tackle the exercises and even have some kind of “homework” with further connection with the lecturers. The participants found the 30 min. coffee breaks between the intensive sessions very helpful for discussions and relax. A longer duration (5 days) for a future school(s) was suggested (with a half-day on the 3rd day to recover from very intense learning).

From the lecturers' point of view, the feedback was also very positive in spite the diversity of the audience and extension of the material to be covered in short time. Overall, it is considered as a very successful school fulfilling all its objectives.

Appendix A

17 September	
19:00	boat departure
19:30	Dinner
18 September	
07:30-08:00	Registration
08:00-08:30	General information
08:30-09:30	Lecture 1: Basic in kinetic theory, vacuum gas dynamic (FS)
09:30-10:00	coffee
10:00-11:15	Lecture 2: Model kinetic equations (IG)
11:15-11:45	break
11:45-13:00	Lecture 3: Test particle Monte Carlo method (TPMC) and its realization in Molflow code (RK)
13:00-14:40	Lunch
14:30-15:45	Practical session 1: Kinetic theory (FS, IG), Group 1 Practical session 2: TPMC (RK, OM), Group 2
15:45-16:15	coffee
16:15-17:30	Practical session 1: Kinetic theory (FS, IG), Group 2 Practical session 2: TPMC (RK, OM), Group 1
17:30-18:00	discussion
18:30-19:30	Welcome reception
19:30	Dinner
19 September	
08:15-09:30	Lecture 4: Gas-surface interaction (FS)
09:30-10:00	coffee
10:00-11:15	Lecture 5: DSMC (FS)
11:15-11:45	break
11:45-13:00	Lecture 6: Pipes flows, time dependent flows, mixtures and polyatomic gases (DV)
13:00-14:30	Lunch
14:30-15:45	Practical session 3: Model equations (IG, DV), Group 1 Practical session 4: DSMC, Group 2 (FS)
15:45-16:15	coffee
16:15-17:30	Practical session 3: Model equations (IG, DV), Group 2 Practical session 4: DSMC, Group 1 (FS)
17:30-18:00	discussion
19:30	Dinner
20 September	
08:15-09:30	Lecture 7: Experimental data and input parameters for modelling in UHV (OM)
09:30-10:00	coffee
10:00-11:15	Lecture 8: Modelling of vacuum system for particle accelerator (OM)
11:15-11:45	break
11:45-13:00	Lecture 9: Pumps and gauges modeling (DV)
13:00-14:30	Lunch
14:30-15:45	Practical session 5: Modeling of vacuum system for particle accelerators (OM, RK), Group 1 Practical session 6: Pipes flows, time dependent flows (DV, IG), Group 2
15:45-16:15	coffee
16:15-17:30	Practical session 5: Modeling of vacuum system for particle accelerators (OM, RK), Group 2 Practical session 6: Pipes flows, time dependent flows (DV, IG), Group 2
17:30-18:00	Discussions
19:30	Dinner
21 September	
08:15-09:30	Lecture 10: Experimental methods and standards in vacuum (KJ)
09:30-10:00	coffee
10:00-11:15	Practical session 7: Molflow tools applications (RK, OM), Group 1 Practical session 8: Metrology in vacuum, (KJ), Group 2
11:15-11:45	coffee
11:45-13:00	Practical session 7: Molflow tools applications (RK,OM), Group 2 Practical session 8: Metrology in vacuum, (KJ), Group 1
13:00-14:30	Lunch
14:30-16:00	School evaluation, discussion and future actions
17:00	boat departure

Appendix B

Lectures: [Lecture 1](#), [Lecture 2](#), [Lecture 3a](#), [Lecture 3b](#), [Lecture 4](#), [Lecture 5](#), [Lecture 6](#), [Lecture 9](#), [Lecture 10](#)
Practice: [Practice 1](#), [Practice 2a](#), [Practice 2b](#), [Practice 3](#), [Practice 4](#), [Practice 6](#), [Practice 8](#).

Numerical codes:

[Generation of virtual gas](#)

[Calculation of moments of virtual gas 1](#)

[Calculation of moments of virtual gas 2](#)

[Diffuse-specular scattering](#)

[Hard sphere collisions](#)

[Couette and Fourier problems](#)

[Free fortran compiler](#)

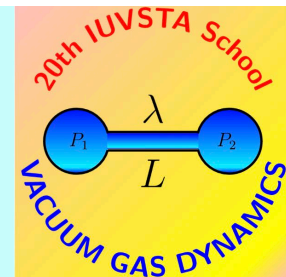
Scattering matrices for DSMC codes: [He-3](#), [He-4](#), [Ne](#), [Ar](#), [Kr](#), [Xe](#)

These and other matrices are in Supplementary material to this [paper](#).

Viscosity and thermal conductivity database:

[He, Ne, Ar, Kr and mixtures. Paper.](#)

[Xe. Paper.](#)



Appendix C

