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SPHERIC
NEWSLETTER

31st issue

SPH rEsearch and engineeRing International Community

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Editorial

Prof. Benedict D. Rogers

Chair of the SPHERIC Steering Committee

Dear SPHERIC Members,

As the disruption from the global Covid-19 pandemic continues, it is a real pleasure to see so many initiatives around the world taking place to keep the SPH community connected. The Chinese virtual SPH group and the SPH Online II workshop are excellent examples of our community staying active and keeping in touch.

Continuing this theme, SPHERIC now has monthly global seminars! This is a brand-new initiative to keep the international SPH community remains connected (see the dedicated article in this newsletter). At this point, we say a huge thank you to our speakers and leading international SPH experts who have kindly agreed to give these seminars. The first two seminars took place in November and December and are now available for all to watch on the SPHERIC YouTube Channel.

Despite the disruption due to Covid-19, the SPHERIC Steering Committee (SC) has been determined that the annual SPHERIC Workshop will go ahead. The current situation prevents us from travelling and meeting up face-to-face. So, this year will see the first completely virtual SPHERIC Workshop 8-11 2021. This event is being run by Dr Angelo Tafuni from the New Jersey Institute of Technology https://www.spheric2021.com . I encourage you all to engage with this event, by submitting abstracts for presentation so that we can all see the progress in SPH research around the world.

Finally, following the open call for expressions of interest, there has been a change of membership of the SPHERIC Steering Committee. After many years of service, we say a big thank you to Prof. Damien Violeau (EDF R&D) and Dr Jean-Christophe Marongiu (Andritz) who have played such important roles on the SC since the foundation of SPHERIC. In their place, we welcome to the SC Dr Pierre Sabrowski (Dive Solutions) and Prof. Abbas Khayyer (Kyoto University) and look forward to their contribution.

With Covid vaccination programmes now being commissioned around the world, there is finally light at the end of the tunnel. Until we see each other, either online or in person, stay safe everyone.

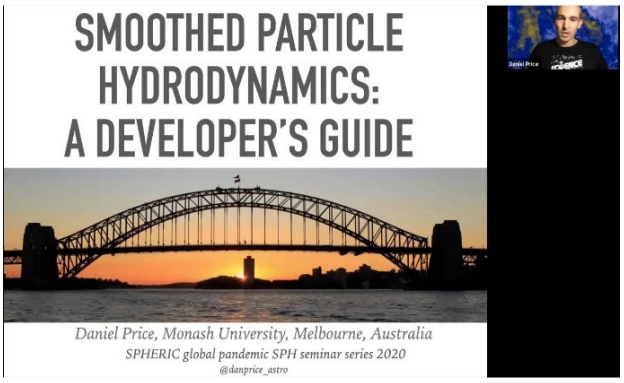
Global SPH Seminars!

Benedict D. Rogers[1], Nathan J. Quinlan[2], Angelo Tafuni[3]

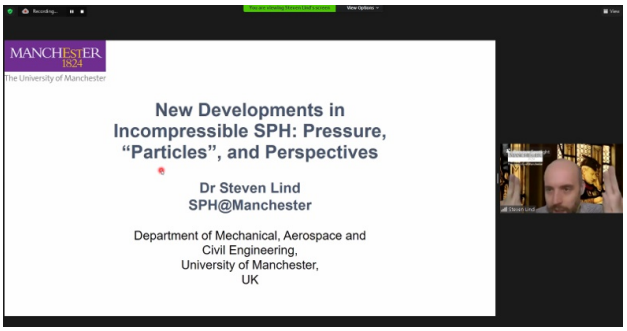
[1] Department of Mechanical, Aerospace and Civil Engineering, University of Manchester, UK

[2] Mechanical Engineering, National University of Ireland Galway, University Road, Galway, Ireland

[3] School of Applied Engineering and Technology, Department of Mechanical and Industrial Engineering, New Jersey Institute of Technology, Newark, NJ 07103, USA



Seminar given by Prof. Daniel Price.



Seminar given by Dr Steve Lind.

To respond to the challenge of the continued Covid-19 pandemic, the SPHERIC Steering Committee has created a new initiative with Global SPH Seminars each month: https://spheric-sph.org/global-seminars. At a time when we are unable to meet up and discuss the latest ideas in person, these seminars are a fantastic way to keep international SPH community connected fostering collaboration and progress. Together, Benedict Rogers, Nathan Quinlan and Angelo Tafuni have organised a series of seminars throughout 2020-2021 with some of the leading SPH experts from around the world.

The first two seminars took place in November and December by Prof. Daniel Price of Monash University and Dr Steve Lind from the University of Manchester, respectively, to over 160 delegates from across the world! These seminars are now available for all to watch on the SPHERIC YouTube Channel.

As we move into 2021, we have an exciting list of speakers lined up:

- Prof. Moubin Liu (Peking University) February 2021
- Dr Renato Vacondio (University of Parma) March 2021
- Dr Jean-Christophe Marongiu (Andritz) April 2021
- Prof. Fei Xu (Northwestern Politecnical University) May 2021

To book your place for the next seminars, please register via the link on the SPHERIC website.

Participants of the SPH Super Group Meeting

Chinese virtual SPH Super Group Meeting

Chi Zhang
c.zhang@tum.de
Department of Mechanical Engineering, Technical University of Munich, Germany

As the first Chinese SPH virtual seminar, the SPH Super Group Meeting (SPH-SGM) is organized monthly. The meeting aims at bringing Ph.D. students and young developers together to discuss latest developments, including, but not limited to, new algorithms, applications and variants of SPH method through two invited talks and a following panel discussion. Through the meeting, we hope that the research level of the research groups can be improved, and mutual understanding and cooperation among the research groups can be increased.

So far, the SPH-SGM has been held three times and each workshop lasted for about 70 minutes thanks to the welcome message by the chair, a professor from a research group, the two impressive presentations (each lasts 20 minutes, including a question-and-answer session) and the following panel discussion (lasted 20 minutes). The details are as follows:

The 1st workshop, September 25, 2020, was chaired by Prof. Xiangyu HU from Technical University of Munich. After the opening speech, the two impressive presentations were given: i) Multi-physics modelling of human heart with SPHinXsys, an open-source library, given by Dr. Chi ZHANG from Technical University of Munich; ii) Improvement on the kernel estimation of SPH method-SFDM and DSFPM, given by MSc. Lu WANG from Northwestern Polytechnical University.

The 2nd workshop, December 29, 2020, was chaired by Prof. Xing ZHENG from Harbin Engineering University. After the opening speech, the two impressive presentations were given: i) Pairwise-relaxing SPH: a conservative and consistent SPH scheme, given by Prof. Xiaoxing LIU from Sun Yat-sen University; ii) Numerical simulation of ship-ice-wave coupling based on SPH method, given by Dr. Ningbo ZHANG from Harbin Engineering University.

The 3rd workshop, November 27, 2020, was chaired by Dr. Min LUO from Zhejiang University. After the opening speech, the two impressive presentations were given: i) Multiphase SPH Modeling of Supercooled Large Droplets Impingement and Solidification for In-flight Icing Conditions, given by MSc. Xiangda CUI from McGill University; ii) Study on sediment erosion and movement based on consistent particle method, given by MSc. Xiaoqing TANG from National University of Singapore.

The recorded videos of these workshop were uploaded to Youtube and Bilibili.

When Worlds (Literally) Collide: Atmospheric Erosion by Giant Impacts onto Terrestrial Planets

Jacob Kegerreis*[1], Vince Eke[1], Richard Massey[1], Luis Teodoro[2]

jacob.kegerreis@durham.ac.uk

[1]Institute for Computational Cosmology Durham University Durham, UK

[2]BAERI/NASA Ames Research Center, Moffett Field, CA; USA,

Giant impacts can dominate the accretion and evolution of many planets and their atmospheres, and motivated some of the earliest applications of smoothed particle hydrodynamics (SPH) simulations [1]. Terrestrial planets are thought to form from tens of roughly Mars-sized embryos that crash into each other after accreting from a protoplanetary disk. At the same time, they grow atmospheres by accreting gas from the nebula, releasing volatiles delivered by impactors, and outgassing from their interior. Giant impacts can erode or even entirely remove a growing atmosphere (as can the solar wind and smaller impacts over time).

The Earth is a compelling example where we can both observe an atmosphere that has survived to the present day and be confident that it suffered the late giant impact that created the Moon. Furthermore, the now thousands of observed terrestrial exoplanets show a remarkable diversity of atmospheres, even among otherwise similar planets. Erosion by giant impacts could play a key role, but the actual fraction of an atmosphere that an impact can remove was poorly understood.

The main challenge is that the low density of a thin atmosphere compared with the rest of a planet requires very high resolution to model. For this reason, previous studies have primarily focused on 1D models or thick atmospheres, often also limited to only head-on impacts. We ran several hundred 3D SPH simulations like the one shown in Fig. 1 to study the erosion of atmospheres by giant impacts, for the first time across a wide range of impact angles, target and impactor masses, planet compositions, and speeds [2, 3] (animations of four simulations: icc.dur.ac.uk/giant_impacts/atmos_fid_1e8_u_anim.mp4). We used the open-source SWIFT code – presented

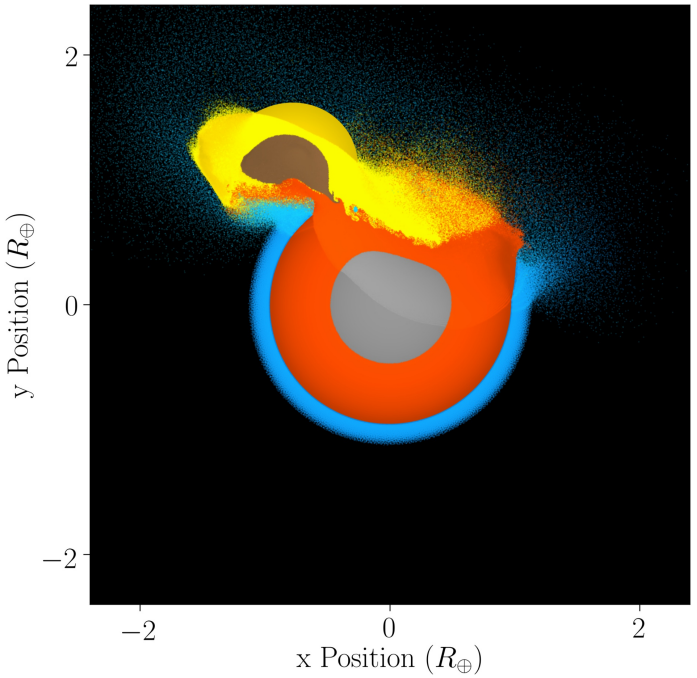


Figure 1 - An early cross-section snapshot from a high-speed, grazing impact simulation using ~10^8 SPH particles, coloured by their material. The colour luminosity varies with the internal energy.

previously at SPHERIC for its parallelisation and astrophysical applications (www.swiftsim.com/) – to model the planets with up to 10^8 particles. Compared with the 10^5 to 10^6 particles typically used for impact simulations, this allowed us to resolve the violent and messy disruption of the atmosphere and planets.

Different collision scenarios lead to extremely different behaviours and consequences for the planets. The impactor can eject atmosphere by ploughing it out of the way, by sending shock waves through the planet to blast material off the far side, and by disrupting the planet into strong oscillations and splash-back plumes not unlike those created by dropping a stone in a pond.

Our 3D results for the local fraction of lost

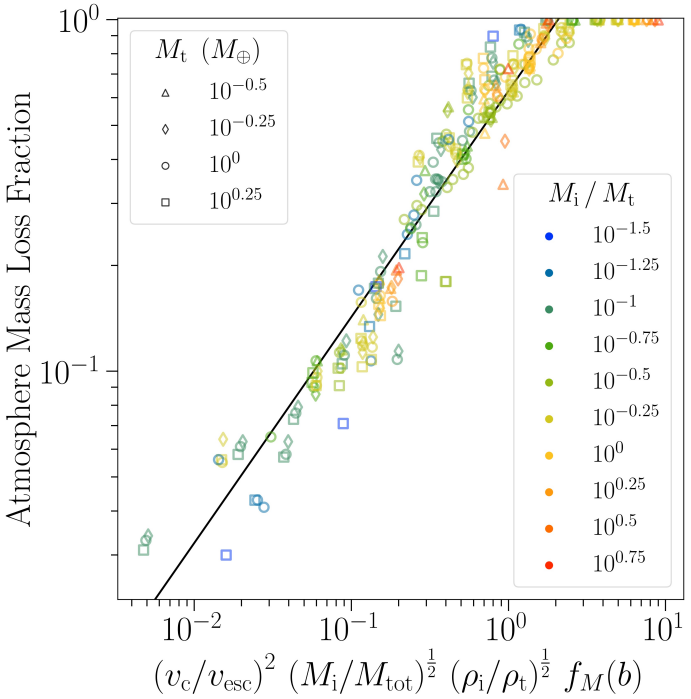


Figure 2 - The lost mass fraction of atmosphere from one set of 259 simulations, as a function of the speed, masses, densities, and impact angle [3]. The black line shows the scaling law. The colours and shapes indicate the impactor:target mass ratio and the target mass, respectively.

atmosphere above specific spots on the surface agree well with 1D simulations of local erosion for the given ground speed driven by the shock [4]. This is also encouraging given the fairly vanilla SPH formulation we use, the main extra ingredient being the complicated and multiple equations of state for the different materials.

In spite of the great differences between scenarios, we find the fraction of lost atmosphere from any of this wide range of impacts is fitted well by a power law, as a function of the speed, masses, densities, and impact angle, as shown in Fig. 2. Giant impacts can readily remove anything from almost none to all of an atmosphere.

The implication for the Moon-forming impact is that ~10–60% of the atmosphere would have been lost directly, depending on the hypothesised scenario. The scaling law itself can also be incorporated into wider models of planet formation and evolution.

References

[1] Benz, W., Slattery, W. L., and Cameron, A. G. W. Icarus, 66:515-535, 1986.

[2] Kegerreis, J. A., Eke, V. R., Massey, R. J., & Teodoro, L. F. A. ApJ, 8 97, 161, 2020.

[3] Kegerreis, J. A., et al., ApJL, 901, L31, 2020.

[4] Genda, H., & Abe, Y. Icarus, 164, 149, 2003.

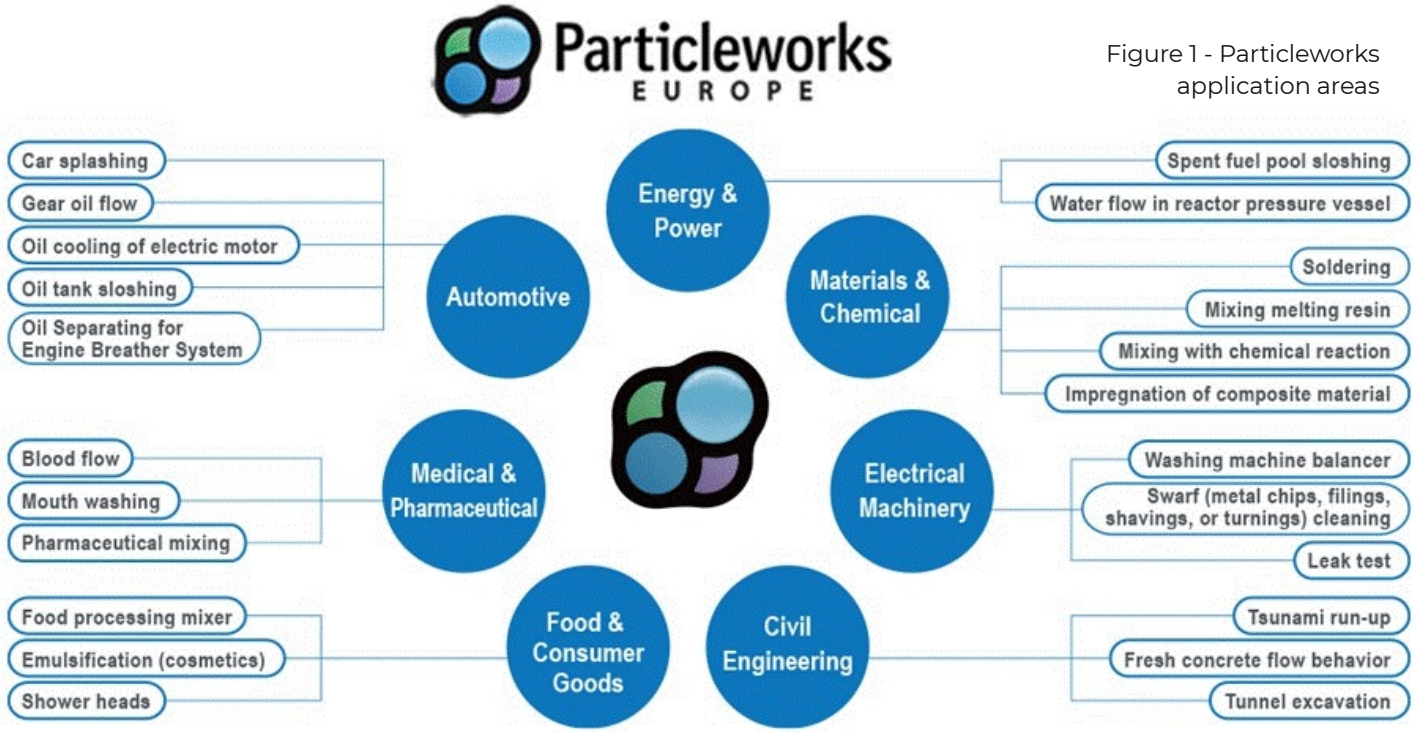


Figure 1 - Particleworks application areas

Particleworks Europe: introduction of a venture company in Trento

S. Koshizuka

koshizuka@sys.t.u-tokyo.ac.jp

Department of Systems Innovation, Graduate School of Engineering, The University of Tokyo

The Moving Particle Semi-implicit (MPS) method has been developed by Koshizuka and Oka (1996) to analyze incompressible flow with complex free surface behavior using particles. A difference-like formulation is used for spatial discretization in the MPS method, which differs from Smoothed Particle Hydrodynamics (SPH).

Prometech Software, Inc. was established in 2004 and developed a commercial software for fluid dynamics based on the MPS method. The developed software, called Particleworks, has been applied to fluid flow simulation with complex motion of free surfaces mostly in Japan (Koshizuka et al., 2018). The particle methods, based on meshless and Lagrangian approaches, are expected to solve complex industrial fluid dynamic and multi-physics phenomena, particularly when the flow exhibits violent motion of free surfaces or interfaces. Particleworks takes advantage of Graphics Processing Units (GPUs) to speed-up the simulation process, but the software can also efficiently run on multi-core hardware.

EnginSoft SpA, a European CAE Company, started investigating the industrial application of the MPS method in 2016, and in 2019 founded Particleworks Europe Srl, a Joint-Venture with Prometech Software, Inc, with the aim of distributing the MPS software in Europe. Particleworks has a wide range of industrial applications (Figure 1), including lubrication analysis of transmission systems, bearings and IC engines, cooling simulation of piston and e-drives, wading and water management for different kinds of vehicles. Beside the automotive sector, Particleworks has been employed in several others industries, from the food and beverage to the bio-medical sectors, from the power generation to the chemical industry.

An example of Particleworks application is described in Figure 2, showing the oil flow in an oil cooled e-motor designed by Ricardo. High power density e-motors are in demand for hybrid and

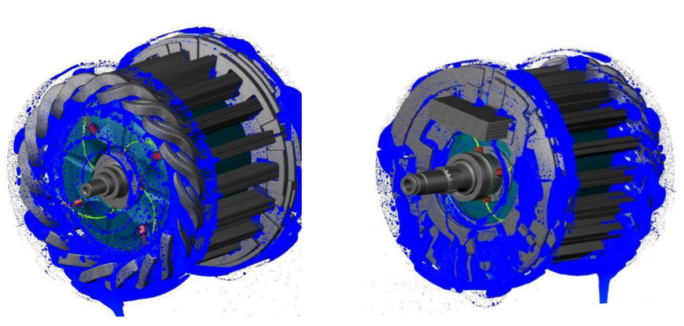


Figure 2 - Spray cooling simulation of e-drive (Courtesy of Ricardo)

electric powertrains, and jet cooling is one of the most efficient cooling systems. Ricardo is a global strategic engineering and environmental consultancy and it has been involved in the H2020 ECOCHAMPS project (https://innovations.ricardo.com/projects/ecochamps-en). In the frame of this project Ricardo led and delivered a wide range of activities, including the development and manufacturing of prototype oil-cooled high-power density 48V e-motor and power electronics for eDCT. Moreover, Ricardo was responsible for the advanced energy management and developed the multi-temperature cooling system, with heat pump and waste heat recovery. Ricardo evaluated the feasibility and accuracy of Particleworks simulations for the temperature predictions of oil-cooled e-drives. Particleworks was used both for the calculation of the oil flow distribution in the shaft and rotor and for the multi-phase air-oil flow simulation in the e-drive. The calculated oil flow impinging on the windings is shown in Figure 2. The heat transfer coefficient from Particleworks was mapped onto a FEA (Finite Element Analysis) model for the e-motor temperature prediction. The comparison between calculated temperature values and experimental data showed a good match, with a maximum difference of 2.8°C. The particle method proved to be fast, accurate and useful to support the design of oil cooled e-motors.

A second application is related to the piston cooling of a Ducati motorbike. Ducati won the MOTOGP 2020 Constructor's World Championship and in its effort to improve the engines performances using Particleworks to maximize the piston cooling efficiency, while trying to minimize the oil consumption. The particle method was used to predict the oil flow from the nozzle to the piston and the heat transfer coefficient distribution on the undercrown of the piston. Four different designs of the nozzle and 5 operating conditions of the engine were simulated and compared in a short time. The comparison of the average heat transfer coefficient on the undercrown showed that the reference design was the one with the highest cooling efficiency, but a new design with comparable performance and lower oil consumption was identified and selected for further investigation.

References

[1] Koshizuka, S. and Oka, Y. (1996), Moving-particle semi-implicit method for fragmentation of incompressible fluid, Nucl. Sci. Eng. 123: 421.

[2] Koshizuka, S., Shibata, K., Kondo, M. and Matsunaga, T. (2018), Moving particle semi-implicit method - a meshfree particle method for fluid dynamics, Academic Press.

Acknowledgments

The author would like to acknowledge Martin Brada of Ricardo, Gaspare Argento of Ducati Motor Holding, Massimo Galbiati of Particleworks Europe Srl and Akiko Kondo of Prometech Software, Inc for the provided material.

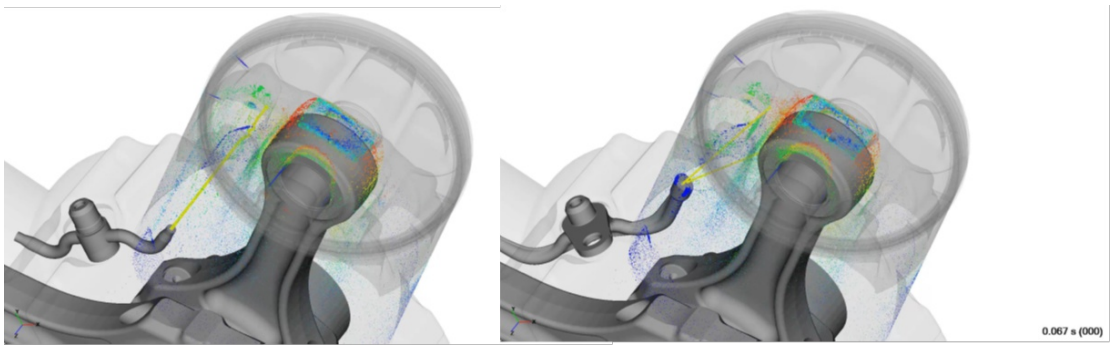


Figure 3 - Simulation of oil flow on the underside of a racing piston using Particleworks. Reference (left) and modified nozzles (right) (Courtesy of Ducati Motor Holding – Ducati Corse Division)

15th SPHERIC International Workshop, Newark NJ (June 8-11, 2021)

Angelo Tafuni
atafuni@njit.edu
School of Applied Engineering and Technology, Department of Mechanical and Industrial Engineering,
New Jersey Institute of Technology, Newark, NJ 07103

Key dates

February 15, 2021
Abstract Submission Deadline

March 1, 2021
Announcement of Selected Abstracts

May 3, 2021
Full Paper Submission Deadline

May 3, 2021
Author Registration Deadline

May 3, 2021
Registration Deadline (Early Bird Rate)

June 7, 2021
Virtual Training Day with the DualSPHysics team

June 8-11, 2021
SPHERIC Virtual Workshop

The SPHERIC International Workshop is the annual global forum for the development and application of Smoothed Particle Hydrodynamics (SPH) and related methods. During the workshop, the latest advances in the SPH method are presented. In addition, the optional training day offered the day before the start of the workshop offers an intensive introduction to the theory and application of SPH.

The 2020 edition of the SPHERIC Workshop was canceled due to the COVID-19 pandemic. This year the SPHERIC International Workshop will take place virtually on June 8-11, 2021. The optional training day will also be run virtually on June 7, 2021. The 15th edition of the workshop will be organized by the Newark College of Engineering at New Jersey Institute of Technology in Newark (NJ), led by Assistant Professor Dr. Angelo Tafuni. Four keynote lectures from renowned scientists and researchers around the globe are scheduled. The three finalist papers selected for the Libersky Prize and additional three highly-ranked abstracts will be recommended for publication in the SPH Special Issue "*Latest Advances in SPH for Fluid Mechanics*," to be published in the *European Journal of Mechanics B/Fluids*.

Additional info is available at **www.spheric2021.com**.

We look forward to your submissions and to sharing a successful and enjoyable meeting with you!

Three Special Issues ON SPH accepting submission in 2021

Abbas Khayyer and Corrado Altomare
khayyer@particle.kuciv.kyoto-u.ac.jp and corrado.altomare@upc.edu
Kyoto University and UPC Universitat Politècnica de Catalunya

There will be three SPH Special Issues to be published by three international journals in 2021. These special issues include:

Three Call for Papers for Three SPH Special Issues with the Following Main Focuses:

I. Ocean/Coastal Engineering

II. Fluid Mechanics

III. Computational Mechanics

Advances and Applications of SPH in Ocean Engineering

To be published by: ***Applied Ocean Research***

Submissions are accepted from January 10th, 2021 until April 10th, 2021

More information: https://www.journals.elsevier.com/applied-ocean-research/call-for-papers/advances-and-applications-of-sph-in-ocean-engineering

Latest Advances in SPH for Fluid Mechanics

To be published by: ***European Journal of Mechanics B/Fluids***

Submissions are accepted from June 1st, 2021 until October 1st, 2021.

More information: https://www.journals.elsevier.com/european-journal-of-mechanics-b-fluids/call-for-papers/call-for-papers-latest-advances-in-sph-for-fluid-mechanics

Latest Developments and Application of SPH using DualSPHysics

To be published by: ***Computational Particle Mechanics***

Submissions are currently open.

More information: https://dual.sphysics.org/5thusersworkshop/special-issue

Interested researchers are invited to submit their excellent contributions to above-mentioned Special Issues considering both the focus of the special issue as well as the specified timeline for submissions.

For questions or inquiries related to Special Issues I and II, please contact: Abbas Khayyer at khayyer@particle.kuciv.kyoto-u.ac.jp. For questions or inquiries related to Special Issue III, please contact: Corrado Altomare at corrado.altomare@upc.

A Brief Online Workshop on SPH March 29, 2021 (8:00 – 11:10 GMT)

Abbas Khayyer
khayyer@particle.kuciv.kyoto-u.ac.jp
Kyoto University

This brief online workshop aims to bring SPH experts and potential future developers together to discuss the latest developments and future perspectives corresponding to Turbulence and Boundary Layers.

The workshop is free of charge and all participants will receive the recorded Zoom video of the workshop.

Following the first SPH Online workshop on August 17, 2020, we are pleased to announce that the second SPH Online workshop, i.e. SPH Online II, will be held on Monday, March 29, 2021. With respect to the panel discussion of SPH Online I, the focus of SPH Online II will be on ***Turbulence and Boundary Layers.***

We will have two invited talks by Dr. Andrea Colagrossi and Dr. Damien Violeau that will be delivered after the opening speech by Professor Frederic Dias. We will invite three presenters after reviewing the applications for presentation. We will also have a panel discussion related to the focus topics that will be chaired by Professor Benedict D. Rogers. SPH Online II will be concluded by a closing remarks speech by Professor Peter Stansby.

SPH experts and researchers who would like to deliver a talk on their latest achievements corresponding to the focus topics of SPH Online II, i) turbulence and ii) boundary layers, are invited to submit the following Application for Presentation form. In particular, we would like to invite experts who have had at least one article published on these focus topics during the past two years in one of the leading international journals. Interested researchers who would like to join this online workshop are invited to fill in the Application for Participation form. Please submit the following forms by February 15, 2021.

Application for Participation
https://forms.gle/FCxBtTR77CcSyRRf6

Application for Presentation
https://forms.gle/xv52qKiuFVueVkkD6

For questions or inquiries please contact:
Abbas Khayyer at khayyer@particle.kuciv.kyoto-u.ac.jp

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Contact: benedict.rogers@manchester.ac.uk

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