Alexandra Vallet

Interdisciplinary physicist
Seven years research experience post PhD
32 years old
Tel: 0033 6 64 00 66 69
E-mail: alexandra.vallet@imft.fr
Website : https://alexandra-vallet.eu

I am a physicist with interdisciplinary expertise, motivated by the modelling of complex multi-scale and multi-physics problems. I acquired a solid background in physics in a graduate engineering school and a PhD in high energy density physics [5-9]. After completing my PhD, I got a permanent position at the CEA as the principal investigator for experimental campaigns on the Megajoule Laser facility. I used complex multi-physics, multi-code simulations to both design and interpret experiments reproducing 'mini stars' in the laboratory for a few nanoseconds. This position also required the coordination and integration of multi-disciplinary activities from several teams such as target manufacturing, laser pulse shaping, diagnostics development and data post-processing. The confidential nature of my studies did not allow me to collaborate with non-CEA teams nor to publish my research work. I realised that solving exciting problems was not rewarding enough for me if this could not be applied to direct societal concern and not shared with the international scientific community. Thus, I decided to tackle a new research field and to establish bridges between physics and medical research as I already had a positive research experience in biomechanics during my studies, before my PhD [10]. I obtained a postdoctoral fellowship to interpret an extensive database from a cohort of patients with neurodegenerative diseases, using a biomechanical approach [3]. Seeing promise in this approach, I am building an interdisciplinary research project about the physical determinants of neurodegeneration based on my expertise as a physicist.

Field of expertise

Biomechanics, fluid dynamics, particle transport, mathematical modeling, clinical data processing , brain ageing

Professional experience

01/09/2020 – present	**Department of mathematics, University of Oslo** *RCN-funded post-doctoral fellowship (PI K. A. Mardal)*, Oslo (Norway). Modelling of the perivascular flow of CSF (1 D and 3D modelling) driven by the pulsation of blood vessels. Analysis in-vivo data from patients and mouse models. Analysis of brain clearance during sleep due to active vasodilatation [1].
25/02/2019 – 24/02/2020	**CNRS UMR 5502 IMFT** *ERC-funded post-doctoral fellowship (PI S. Lorthois)*, Toulouse (France). Analysis of the coupling between the vascular system, the cerebrospinal fluid and the cerebral tissue at the mesoscale level with a network modelling approach
13/12/2017 – 12/12/2018	**INSERM UMR 1214 ToNIC** *Post-doctoral research funded by the region Occitanie*, Toulouse (France). Exploratory study on the altered biomechanical properties of the central nervous system in pathological brain aging [2-4]
10/12/2014 – 12/12/2017	**CEA** *Research engineer*, Paris (France). Radiative-hydrodynamics simulations, design and interpretation of high energy density physics experiments on the Megajoule Laser facility *Confidential work*

20/02/2013 – 20/05/2013 **LLE** *Long term mission*, Rochester (New-York state, USA). Study of strong spherical shock pressure generation, design and interpretation of experiments on the OMEGA laser facility [7,8]

01/05/2011 – 30/09/2011 **CEA** *Internship*, Paris (France). Instabilities seeded by surface roughness in self-similar ablation flow in inertial confinement fusion [5]

14/06/2010 – 25/03/2011 **INSERM U703 / École Centrale de Lille LML-UMR 8107** *Project in parallel with my studies*, Lille (France). Finite element quasi-static model of pelvic mobility [10]

Education - Diploma

18/05/2015 **PhD, CELIA UMR 5107, University of Bordeaux**
"Hydrodynamic modelling of the shock ignition scheme for inertial confinement fusion"
Inertial confinement fusion is a way to reproduce fusion reactions (the origin of the energy unleashed by the sun and stars) in a laboratory. A pellet target is compressed and heated with high-energy beams of laser light until the needed extreme conditions of stellar interiors are reached. This PhD study investigates theoretically and experimentally how to get ignition with a converging shock wave. [6-9]
Advisors: V. Tikhonchuk, X. Ribeyre

27/10/2011 **Master of Science in Mechanics and Engineering with a specialty in fluid mechanics, University of Lille –** First rank

28/09/2011 **Diploma in Engineering, École des Mines de Douai –** First rank

Funding of my research

- **Alzheimer's physics project Fellowship,** Funded by the Norwegian Research Council (NRC grant agreement , FRIPRO, 12 MNOK), PI K.A. Mardal, Norway, September 2020-August 2022
- **BrainMicroFlow Fellowship,** Funded by the European Research Council (ERC grant agreement n°615102), PI S. Lorthois, France, February 2019 - February 2020
- **FluidBrain Fellowship,** Funded by the Occitania Region (RPBIO 2015 n°14054344), PI E. Schmidt, France, December 2017 – December 2018
- **CEA PhD grant**, CEA - CELIA – Université de Bordeaux, France, October 2011 – October 2014

Prizes and Awards

2014	European Physical Society best poster award
2013	Fusion Science Center Award for Excellence in Poster Presentation
2011	Oscar Waquet award 2500 euros (First rank student at EMD school)
2010	Merit award (4000 euros) for my study in biomechanics (INSERM, EC Lille)

Peer-reviewed journal publications

[1] Sleep-state specific norepinephrine-driven vascular dynamics regulate the size of paravascular space and fluid flow in the brain L. Bojarskaite, **A. Vallet,** D. Bjørnstad M. Kuchta,K. Mardal, R. Enger, **–** *in preparation*

[2] Homocysteinemia is Associated with Frailty and Biomechanical Response of the CNS in NPH-suspected Patients, S. Guillotin, **A. Vallet**, S. Lorthois, P. Cestac, E. Schmidt, N. Delcourt, - *submitted to Journal of Gerontology: Biological Sciences*

[3] Assessment of Pressure-Volume Index During Lumbar Infusion Study: What Is the Optimal Method? **A. Vallet**, L. Gergelé, E. Jouanneau, E. A Schmidt, R. Manet. Acta neurochirurgica. Supplement, Vol 131, P 335-338. 2021

[4] Biomechanical response of the CNS is associated with frailty in NPH-suspected patients. **A Vallet**, N Del Campo, E Hoogendijk, A Lokossou, O Baledent, Z Czosnyka, L Balardy, P Payoux, P Swider, S Lorthois, and E Schmidt. Journal of Neurology – 2020

Between 2015 – 2017 : confidential reports at the CEA

[5] Transient effects in unstable ablation fronts and mixing layers in HEDP. J-M Clarisse, S Gauthier, L Dastugue, **A Vallet** and N Schneider. Physica Scripta – Volume 91 – Issue 7 – Pages 074005. 2016

[6] Physics of laser-plasma interaction for shock ignition of fusion reactions. VT Tikhonchuk, A Colaïtis, **A Vallet**, E Llor Aisa, G Duchateau, Ph Nicolaï, X Ribeyre. Plasma Physics and Controlled Fusion – Volume 59 – Issue 1 – Pages 014018 . 2015

[7] Spherical strong-shock generation for shock-ignition inertial fusion. W Theobald, R Nora, W Seka, M Lafon, KS Anderson, M Hohenberger, FJ Marshall, DT Michel, AA Solodov, C Stoeckl, DH Edgell, B Yaakobi, A Casner, C Reverdin, X Ribeyre, A Shvydky, **A Vallet**, J Peebles, FN Beg, MS Wei, R Betti. Physics of Plasmas – Volume 22 – Issue 5 – Pages 056310 . 2015

[8] Gigabar spherical shock generation on the OMEGA laser. R Nora, W Theobald, R Betti, FJ Marshall, DT Michel, W Seka, B Yaakobi, M Lafon, C Stoeckl, J Delettrez, AA Solodov, A Casner, C Reverdin, X Ribeyre, **A Vallet**, J Peebles, FN Beg, MS Wei. Physical review letters – Volume 114 – Issue 4 – Pages 045001, 2013

[9] Finite Mach number spherical shock wave, application to shock ignition. **A Vallet**, X Ribeyre, V Tikhonchuk. Physics of Plasmas – Vol 20 – Issue 8 – Pages 082702 . 2013

[10] Simulation of normal pelvic mobilities in building an MRI-validated biomechanical model. Michel Cosson, C Rubod, **A Vallet**, JF Witz, P Dubois, M Brieu. International urogynecology journal – Volume 24 – Issue 1 – Pages 105-112 . 2013

International conference/seminar presentations

- **IESC – Cargese, France.** **A. Vallet** , M. Kuchta, L. Bojarskaite , D. M. Bjørnstad, R. Enger and K. A. Mardal . Poster, *Modeling of perivascular flow during sleep using a fluid-poroelastic structure interaction approach*, July 2021
- **Coupled 2021, Online.** **A. Vallet** , M. Kuchta, L. Bojarskaite , D. M. Bjørnstad, R. Enger and K. A. Mardal . Oral, *Modeling of perivascular flow during sleep using a fluid-poroelastic structure interaction approach*, June 2021
- **6th Oxford International Neuron and Brain Mechanics Workshop, Oxford, United Kingdom, A. Vallet**, M. Kuchta, L. Bojarskaite , D. M. Bjørnstad, R. Enger and K. A. Mardal . Oral, *Investigation of the intracranial pulsatile behavior and effect of dispersion*, June 2021
- **OxMBM Seminar , Oxford, United Kingdom, A. Vallet,** Invited seminar, *Brain biomechanics and brain ageing*. October 2020
- **BRAIN & BRAIN PET 2019, Yokohama – Japan.** **A Vallet**, S Lorthois, N Chauveau, P Swider, Z Czosnyka, N Del Campo, L Balardy, P Peran, A Lokossou, O Baledent, P Payoux, E Schmidt. Poster, *Intracranial fluids dynamics alterations and cortical thickness.* July 2019
- **Neuroscience 2018, San Diego – USA.** **A Vallet,** A Lokossou, S Lorthois, P Swider, P Assemat, L Risser, Z Czosnyka, M Czosnyka, N Del Campo, L Balardy, P Peran, O Balédent, P Payoux, E Schmidt. Poster, *Biomechanical approach of brain aging, neurodegenerative diseases and frailty*. November 2018
- **Hydrocephalus 2018, Bologna – Italy.** **A Vallet**, A Lokossou, S Lorthois, P Swider, P Assemat, L Risser, Z Czosnyka, M Czosnyka, N Del Campo, L Balardy, P Peran, O Balédent, P Payoux, E Schmidt. Oral, *Biomechanical approach of brain aging, neurodegenerative diseases and frailty*. October 2018
- **International conference on inertial fusion sciences and applications, Saint Malo - France.** **A Vallet**, F Girard, E Falize, B Villette, R Rosch, G Oudot, G Soullie, J Fariaut, F Durut, F Seguineau, M Klein and D

Raffestin. Poster, *Laser Mégajoule experiments of X-ray driven heat waves in sub-sonic diffusive* regime. September 2017

- **International congress on plasma physics, Lisbon – Portugal. A Vallet**, X. Ribeyre, V. Tikhonchuk. Oral, *Hydrodynamic modeling of shock ignition*. September 2014
- **EPS conference on plasma physics, Berlin – Germany. A Vallet**, X. Ribeyre, V. Tikhonchuk. Poster, *Semi-analytic modeling of shock ignition*. June 2014
- **HEDP summer school, Columbus - Ohio state, US. A Vallet**, X. Ribeyre, V. Tikhonchuk. Poster, *Finite Mach number spherical shock wave - analytical criterion for shock ignition*. July 2013
- **SPIE - Laser energy workshop, Prague - Czech Republic. A Vallet**, X. Ribeyre, V. Tikhonchuk. Poster, *Study of converging spherical shock wave with a finite Mach number in the context of shock ignition*. April 2013

Supervising and mentoring activities

01/03/2021 – 05/08/2021	Supervising of Alice Hamon, MSc student. Master internship about the "Heart rate variability association to the coupling between blood pressure and intracranial cerebrospinal fluid pressure"
04/03/2019 – 03/08/2019	Supervising of Jose Ramon Camacho Bosca, MSc student. Master internship about the "Modelling of the cerebrospinal fluid transport in the perivascular space"
01/09/2019 – present	Mentoring activities as part of action of the "Femmes & Sciences" association aiming at promoting sciences for women

Teaching Experiences (>80h)

2019 -2021	**ISAE-SUPAERO**, Biomechanics, Lecture
2015	**University of Oxford**, Spherical shock wave - self similar solutions, Lecture
2013	**University of Bordeaux**, Fluid mechanics, Practical works
2012 - 2013	**IUT mesures physiques de Bordeaux**, Fluid mechanics, Tutorials/Practical works

Committees

Doctoral progress committee – *Doctoral school « ASTRONOMIE & ASTROPHYSIQUE D'ILE-DE-FRANCE » PhD student L. Van Box Som, (LERMA - CEA)* – 2017

Referee for

- Fluids and Barriers of the CNS journal
- Brain Multiphysics journal

Outreach activities

Team leader for the European Researchers' Night 2019, Quai des Savoirs, Toulouse: "The mysterious crime of Mr. Brain". Game activity about the physical approach of neurodegenerative diseases.

Interests

Music : playing the violin for 20 years, chamber music, orchestra, jazz band, rock band ; Photography

Major research achievements

Demonstrated the relevance of a biomechanical approach to the brain pathological aging

I used a multimodal approach and a simple biomechanical model to analyze a cohort of 100 patients suspected of normal pressure hydrocephalus (NPH). **I demonstrated that brain vulnerability to mechanical stressors**, measured through a biomechanical marker called the CNS elastance coefficient, **is associated with frailty, a syndrome of general health deficits making an individual at risk for negative health outcomes, including dementia.**

The CNS elastance coefficient was measured by combining intracranial pressure data (from lumbar infusion test, see Fig.1 A and B) and intracranial blood flux data (from PCMRI, see Fig. 1 C and D). Frailty was measured as an index based on 40 variables of health deficits.

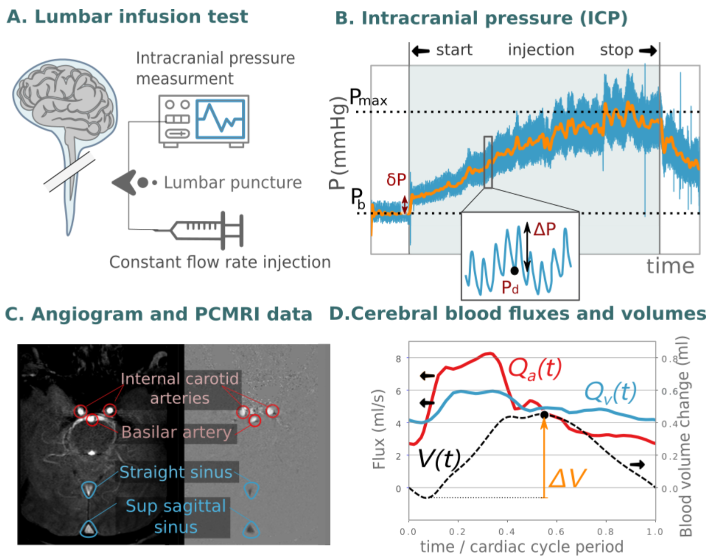

Figure 1: A - Scheme of the lumbar infusion test where the intracranial pressure (ICP) is measured while saline is injected at a constant rate. B. Typical ICP curve from the infusion test. C. Angiogram and phase contrast magnetic resonance imaging. D. Typical cerebral blood fluxes and volume changes deduced from PCMRI data.

I showed that the observations were **not specific to a particular neurological condition** since the patients of the cohort exhibited neurobiological markers of several neurodegenerative diseases: NPH, Alzheimer's diseases, Parkinsonian syndrome and vascular dementia. Hence, the data reinforced the concept that pathological brain aging is an accumulation of various pathologies.

These findings are relevant because they **provide a novel framework to investigate *in vivo* the mechanisms underlying brain pathological aging** that I think would be relevant for an objective characterization of the preclinical stage of dementia and therefore be valuable for preventive strategies. This work was possible thanks to a **transdisciplinary collaboration between clinical neuroscientists, imaging experts and physicists** leading to a novel and promising approach to brain aging.

Work valued in [4]

Designed and interpreted a successful campaign of experiments on the Laser Megajoule facility

I designed and interpreted a campaign of experiments on the Laser Mégajoule (LMJ) facility (see Fig. 2)**,** dedicated to the propagation of a subsonic radiation heat wave in a diffusive regime. **The experiments aimed to better understand the complex multidimensional dynamics** behind a subsonic radiative Marshak wave. They were designed in such a way that the energy flux was dominated by the **photon transport**. This is similar to astrophysical plasmas when a compact object (young stellar object, white dwarf or neutron star) irradiates the surrounding clumpy and cloudy interstellar medium.

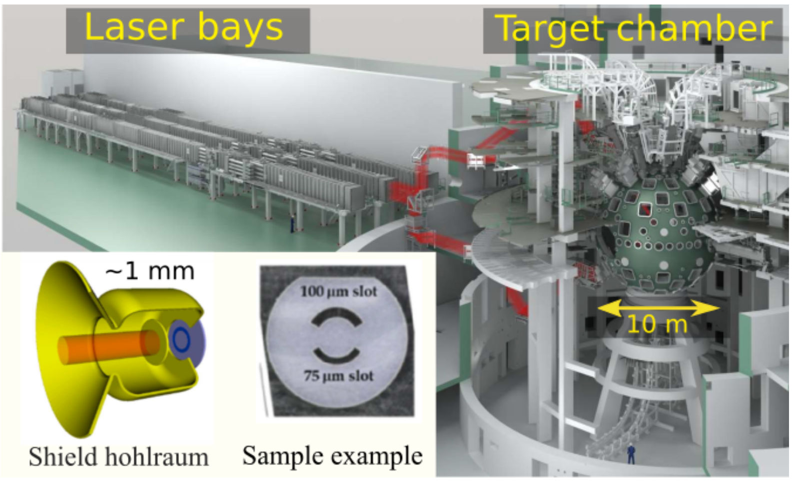

Figure 2: Laser Mégajoule facility and target

I coordinated and integrated multi-disciplinary activities from several teams. One LMJ quadruplet with pulse duration of 4 ns and total energy of 11 kJ irradiated a shield hohlraum to create, behind the shield, a Planckian X-ray radiation source of 110 eV without photons in the AU M-band energy range. An aluminum sample with annular slots covered the opposite side of the hohlraum (see Fig. 2). Two Broad-band X-ray Spectrometers, DMX and miniDMX, measured the X-ray flux coming from the Laser Entrance Hole and the sample respectively.

After one year of preparation, the eight experiments, planned on a time window of eight days, were successful. They provided the data needed to select the modeling technique (multi-code, multi-physics approach) that best describes the photon transport in the regime of interest.

Confidential work: only internal reports.

Highlighted key processes in the shock ignition scheme for inertial confinement fusion

Mankind has a continuously increasing demand for energy. Fossil energy leads to carbon dioxide emission, which contributes to global warming, while nuclear energy produces dangerous radioactive waste and has a risk of reactor accident and renewable energy are predicted to not be enough. Therefore, a new source of energy is needed. The **energy from fusion reactions,** the origin of the energy unleashed by the sun and stars, seems promising as it would have **plenty of resources on earth, a low climate impact, a low level of radioactive wastes** and a very low risk of accidents. However, fusion reactions are not yet controlled on earth. **Inertial confinement fusion** is one of the research avenues toward controlled fusion reactions in a laboratory. A pellet target is compressed and heated with high-energy beams of laser light until the needed extreme conditions of stellar interiors are reached. The shock ignition scheme uses an intense power spike at the end of the target compression to ignite the fusion reactions.

The modelling of multi-physics processes was required to highlight phenomena that are hard or even impossible to assess experimentally. I developed a new semi-analytical hydrodynamic model to describe a spherical converging shock wave in a pre-heated hotspot. I demonstrated that a minimal shock pressure of 20 Gbar is needed when it enters the hotspot. I analysed the shock dynamics in the imploding shell, *i.e.* the shock propagation into a non-inertial medium with a high radial pressure gradient and a shock collision with a returning shock coming from the compression phase. An analytical theory allowed me to describe the shock pressure and strength evolution in a typical shock ignition implosion. I demonstrated that a generated shock pressure of the order of 300-400 Mbar is needed in order to reach a shock pressure of 20 Gbar in the hot spot. Finally, I helped in the design/interpretation of experiments performed on the OMEGA laser facility dedicated to strong shock generation. These experiments demonstrated that a shock pressure close to 300 Mbar is reached with an absorbed laser intensity up to 2×10^{15} $W.cm^{-2}$ and a laser wavelength of 351 nm. This value is two times higher than the one expected from collisional laser energy absorption. I developed a simple model that explained the significant pressure enhancement by the contribution of hot electrons which are generated by non-linear laser/plasma interaction in the corona.

Work valued in [5-9].