Position Description

1. General Information

Name of the position	**Physics of dense granular media**
Foreseen date of enrolment	1 October 2024
Position is funded by	• COFUND, Marie Skłodowska-Curie Actions (MSCA), Horizon Europe, European Union • Aix-Marseille Université (AMU) • The University of Sydney (USYD)
Research Host	Aix Marseille Université
PhD awarding institutions	Aix-Marseille Université & The University of Sydney
Locations	Primary: Marseille, France Secondary: Sydney, Australia
Supervisors	Dr Bloen Metzger (AMU) A/Prof. Pierre Rognon (USYD)
Group of discipline	Physics, Granular Matter, Soft Matter, Mixing, Rheology

2. Research topics (only one of these projects will be funded)

Project 1: *Mixing in Granular materials*

Mixing granular materials such as sand, ores, powders, and cereals is key to many industrial processes. These include glass production as well as food and mineral processing. It is typically achieved by large, energy-intensive and costly machines which design requires a precise understanding of the physical mechanisms controlling mixing in granular matter. However, these mechanisms remain elusive, which makes predicting the behaviour of mixing machines difficult.

To address this problem, this PhD will seek to identify robust, physically based models describing the mixing of granular materials. In this aim, laboratory experiments and numerical simulations will be used to perform granular flows and reveal how the mixing behaviour is influenced by parameters such as grain size, rate of shear. Experiments will use a "stadium shear device", purposely built to shear granular materials and track individual grain trajectories. These will be complemented by numerical simulations based on a discrete element method, which will allow to explore a wider range of grain and flow properties.

The experimental part will be primarily conducted in Marseille under the supervision of B. Metzger. The numerical part will be done in Sydney under the supervision of P. Rognon. The project will benefit from a collaboration with P. Jop from CNRS/Saint Gobain who will provide us with scientific and industrial inputs.

This project has received funding from the European Union's Horizon Europe research and innovation programme under the Marie Skłodowska-Curie grant agreement № 101081465

Supervisors: Dr Bloen Metzger (AMU) & A/Prof. Pierre Rognon (USYD)
Research Fields: Physics, soft matter, Granular materials, Mixing

Project 2: *Flowing behaviour of granular materials*

Flow of granular materials are common in nature (e.g. landslides, snow avalanches and earthquakes) and in industrial processes (e.g. mineral and food processing, concrete mixing, glass production). Accurately predicting these flows is vital to mitigate natural hazards and to design effective industrial processes. Recent strides in research have revealed how the behaviour of granular flows differs from that of common fluids like water, and identified physical laws to capture this behaviour. These account for the specificities of the grains, be they sand, snow flakes or powders. However, the behaviour of granular flows near fixed boundaries remains elusive, which undermine predictions of the overall flow dynamics in all practical settings.

To address this problem, this PhD will seek to identify robust, physically based models describing the flowing behaviour of granular materials near fixed boundaries. In this aim, laboratory experiments and numerical simulations will be used to perform granular flows and reveal how their dynamics is influenced by the proximity of a boundary. Experiments will use a "stadium shear device", purposely built to shear granular materials and track individual grain trajectories. These will be complemented by numerical simulations based on a discrete element method, which will allow to explore a wider range of grain and flow properties.

The experimental part will be primarily conducted in Marseille under the supervision of B. Metzger. The project will benefit from a collaboration with P. Jop from CNRS/Saint Gobain who will provide us with scientific and industrial inputs.

Supervisors: Dr Bloen Metzger (AMU) & A/Prof. Pierre Rognon (USYD)
Research Fields: Physics, soft matter, Granular materials, rheology, non-local effects

Project 3: *Drag force in dilatant suspensions*

Dilatant fluids are very concentrated particulate suspensions which must dilate to be able to flow. Dilation of the granular network under shear induces a pore-pressure feedback having dramatic consequences on the flow response, particularly in transient situations. Such coupling occurs in macrosocopic frictional suspensions initially prepared above their critical volume fraction (e.g. in dense sediments), or in concentrated shear-thickening suspensions above a critical applied stress. It has been shown to control the initiation of granular avalanches and to lead to a spectacular hardening of granular beds when submitted to an impact.

These experiments will then be extended to the case of shear-thickening suspensions for which the effect of dilation and associated pore-pressure feedback has never been studied, yet we expect it plays a key role in their transient behaviour. Major progresses have recently been done in the comprehension of shear-thickening, now understood as a frictional transition occurring above an onset stress required to overcome repulsive forces between particles. This framework shows that shear-thickening suspensions have two rheological branches with distinct critical jamming fractions; Whenever the suspension is prepared at a volume fraction lying between these two critical jamming fractions and sheared above the onset stress, dilation effects should become dominant as the micro-metric particle size in shear thickening suspension imposes strong Darcy flow resistance, which in turn must results in strong pore pressure feedback effects. The ultimate goal will be to describe how such dilatancy effects set the drag force on objects moving in dilatant fluids -- a key question to elucidate the behaviour of impact hardening materials.

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The experimental part will be primarily conducted in Marseille under the supervision of B. Metzger. The numerical part will be done in Sydney under the supervision P. Rognon. The project will benefit from a collaboration with P. Boustingorry from Chryso/Saint-Gobain who will provide us with scientific and industrial inputs.
Supervisors: Dr Bloen Metzger (AMU) & A/Prof. Pierre Rognon (USYD)
Research Fields: Physics, soft matter, Granular suspensions, rheology, dilatancy effects

3. Employment Benefits and Conditions

Aix-Marseille Université offers a 36-months full-time work contract (with the option to extend up to a maximum of 42 months).

The remuneration, in line with the European Commission rules for Marie Skłodowska-Curie grant holders, will consist of a gross annual salary of 28,764 EUR. Of this amount, the estimated net salary to be perceived by the Researcher is 1,926 EUR per month (before the deduction of tax at source). However, the definite amount to be received by the Researcher is subject to national tax legislation.

Benefits include

- Becoming a Marie Skłodowska-Curie fellow and be invited to join the Marie Curie Alumni Association.
- Access to all the necessary facilities and laboratories at Aix-Marseille Université and The University of Sydney.
- Tuition fee waiver at both PhD awarding institutions.
- Yearly travel allowance to cover flights and accommodation for participating in AUFRANDE events.
- 10,000 EUR allowance to cover flights and living expenses for 12 months in Australia.
- 25 days paid holiday leave.
- Contractual doctoral students are subject to the same sick leave rights as other contractual employees of the State Civil Service, namely: the contractual agent in activity benefits, on presentation of a medical certificate, during twelve consecutive months if its use is continuous or during a period including three hundred days of effective services if its use is discontinuous, of sick leave within the following limits
    - After 4 months of service: 1 month on full pay and 1 month on half pay;
    - After 2 years of service: 2 months on full pay and 2 months on half pay;
    - After 3 years of service:3 months on full pay and 3 months on half pay.
- Parental leave: if the employee has at least 1 year's seniority at the date of the child's birth, he/she is entitled to parental leave at his/her request (after maternity leave for the mother or paternity leave for the father). This leave ends at the latest when the child is 3 years old. The leave is granted for renewable periods of 2 to 6 months. He/She must apply for it at least 2 months before the start of the parental leave.

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4. PhD enrolment

Successful candidates for this position will be enrolled by the following institutions and must comply with their specific entry requirements, in addition to AUFRANDE's conditions.

Applicants must hold a Master's degree performed at a high academic standard, and which includes a substantial component of original research; or an equivalent qualification that demonstrates research experience, excellence and capability.

Applicants must prove their English language proficiency equivalent to an overall IELTS score of 6.5 with no band below 6.0 (see: https://www.sydney.edu.au/study/how-to-apply/international-students/english-language-requirements.html).

More information on Aix-Marseille Université's requirements

Doctoral candidates holding a Master's degree outside the Bologna process or a degree equivalent to a Master's degree must submit an application for a Master's Degree for validation to the doctoral school secretariat prior to their enrolment.

Visit the website: https://college-doctoral.univ-amu.fr/en

More information on the University of Sydney's requirements

Meeting the minimum requirements for eligibility does not guarantee admission. Admission remains at the discretion of the Associate Dean (Higher Degree by Research) for each faculty.

Visit the website: https://www.sydney.edu.au/study/how-to-apply/postgraduate-research.html

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