Journées autour des écoulements granulaires

Report of Contributions

https://indico.math.cnrs.fr/e/9704

Contribution ID: **80** Type: **Présentation**

Viscous to Inertial transition in dense granular suspensions

Wednesday, July 5, 2023 9:00 AM (50 minutes)

Dense granular suspensions exhibit different regimes based on boundary conditions and stress distribution. The flow is mainly controlled by the shear rate to particle pressure ratio, which can be described by a frictional approach for dilatant granular media. However, as the shear rate increases and the fluid viscosity decreases, the flow can transition from a viscous to an inertial regime. Dimensional analysis alone cannot provide the crucial information to determine this transition, and experimental evidence is limited to numerical works.

This study presents experimental evidence of the viscous-inertial transition for suspensions of non-colloidal rigid particles. A pressure-and-volume imposed rheometer is used to explore the dense regime systematically by varying interstitial fluid, shear rate, and packing fraction. The transition occurs at a specific Stokes number independent of the packing fraction. The algebraic power law for the viscosity divergence is also shown to be independent of the regime. These results provide important insights into the behavior of dense granular suspensions and have implications for a variety of fields

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Presenter: TAPIA, Franco

Session Classification: Mercredi matin

Track Classification: Présentation orale

Contribution ID: **81** Type: **Présentation**

Instabilités hydrodynamiques de suspensions rhéo-épaississantes

Tuesday, July 4, 2023 11:50 AM (50 minutes)

Les suspensions rhéo-épaississantes, comme par exemple des grains d'amidon de maïs dans de l'eau, ont un comportement spectaculaire consistant en une augmentation, parfois brutale, de leur viscosité à forte contrainte. Longtemps resté une énigme, ce phénomène est désormais décrit de manière cohérente par le modèle de transition frictionnelle. Pour des suspensions hyperconcentrées, ce modèle prédit des lois rhéologiques ré-entrantes susceptibles d'affecter la stabilité d'un écoulement. Ma présentation discutera différents types d'instabilités hydrodynamiques résultant de cette rhéologie singulière, notamment, les mécanismes physiques sous-jacents et les structures d'écoulement qu'elles engendrent. Après une introduction détaillée du modèle de transition frictionnelle, je décrirai, en particulier, trois écoulements emblématiques: le plan incliné, l'écoulement de Couette et l'écoulement dans une conduite cylindrique. J'évoquerai aussi les limitations actuelles dans la description de ces instabilités hydrodynamiques, ainsi que les perspectives.

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Presenter: BOUGOUIN, A. (IUSTI)

Session Classification: Mardi matin

Track Classification: Présentation orale

Contribution ID: **82** Type: **Présentation**

Self-channelisation in Dry Granular Flows

Wednesday, July 5, 2023 11:00 AM (50 minutes)

Dense granular flows can spontaneously self-channelise by forming a pair of parallel-sided static levees on both sides of a central flowing channel. This process prevents lateral spreading and maintains the flow mobility for longer, enabling the avalanche to run out considerably further than a spreading flow. Since levees commonly form in hazardous geophysical mass flows, such as snow avalanches, debris flows, and pyroclastic flows, this has important implications for risk management in mountainous and volcanic regions. In this talk, we will discuss the process of self-channelisation and levee formation in three different scenarios, starting with the fundamental ingredients responsible for self-channelisation in monodisperse avalanches down an inclined plane. By applying a depth-averaged model we show that not only a non-monotonic friction law is required to incorporate frictional hysteresis, but higher-order viscous-like terms are crucial in uniquely selecting the fully-developed state observed experiments. This equilibrium state will then be used to gain insight into the three-dimensional particle-size segregation which occurs in bidisperse self-channelised flows. To conclude, we will discuss a monodisperse avalanche down a cone, where the granular front becomes unstable and breaks into a series of self-channelised channels, generating an unexpected and beautiful fingering pattern, in striking contrast to a flow down an inclined plane.

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Session Classification: Mercredi matin

Track Classification: Présentation orale

Contribution ID: **84** Type: **Présentation**

A fast implicit primal-dual method for steady viscoplastic flows

Tuesday, July 4, 2023 9:50 AM (50 minutes)

Constitutive laws for viscoplastic materials involve a multivalued nonlinearity. Duality methods for such equations are known to converge, but the convergence is slow, the error is in general of the order of $1/k$ with k the number of iterations.
We consider here an iterative method of classical implicit primal-dual type with a particular form with strong implicitation. An analysis via Lyapunov functional yields admissible values of the parameters, whereas a linearized analysis for scalar problems indicates the potentially best values. An adaptive choice of the parameters enables to achieve a fast convergence.
Numerical tests show that we obtain an optimal accuracy in less than five iterations for simple problems, and about fifteen iterations for stiff problems, each iteration having the cost of a Laplace problem. Bingham or Herschel-Bulkley laws are considered.

Primary author: BOUCHUT, Francois (CNRS & Université Gustave Eiffel)

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Session Classification: Mardi matin

Track Classification: Présentation orale

Contribution ID: **85** Type: **Présentation**

Conditions aux limites pour les écoulements granulaires confinés par des parois frottantes planes.

Tuesday, July 4, 2023 11:00 AM (50 minutes)

Dans l'étude numérique [1], nous avons fourni une condition aux limites pour les écoulements granulaires s'écoulant sur des bords lisses. Nous avons montré qu'il existe une loi universelle reliant le coefficient de frottement effectif local à un nombre de Froude local 〖Fr〗_loc=V⁄√(P⁄ρ) (où V et P sont respectivement la vitesse et la pression locales à la frontière, et ⊠ la masse volumique des particules). Des recherches plus approfondies nous ont permis de découvrir une condition aux limites supplémentaire qui relie la fraction volumique locale au nombre de Froude local [2].

Interestingly, the form of these two relations is preserved when expressed at a global scale to relate the effective friction ⊠⊠ and the average packing fraction ⊠⊠ at the base of the flow to the Froude number: 〖Fr〗_B=V_B⁄√gHcosθ where VB is the particle sliding velocity at the base, ⊠ is the inclination angle of the channel and H the particle holdup (defined as the depth-integrated particle volume fraction). Similar relations relating the effective friction ⊠W and the average packing fraction ⊠W at the lateral walls of the flow to the wall Froude number are also valid.

Il est intéressant de noter que la forme de ces deux relations est préservée lorsqu'elles sont exprimées à l'échelle globale pour relier le frottement effectif ⊠⊠ et la fraction volumique moyenne ⊠⊠ à la base de l'écoulement au nombre de Froude : 〖Fr〗_B=V_B⁄√gHcosθ où VB est la vitesse de glissement des particules à la base, ⊠ est l'angle d'inclinaison du canal et H le « particle holdup » (défini comme la fraction volumique des particules intégrée sur la profondeur). Des relations similaires reliant le frottement effectif ⊠W et la fraction volumique moyenne ⊠W aux parois latérales de l'écoulement au nombre de Froude de la paroi sont également valables.

Dans un travail expérimental récent [3], nous avons introduit une hauteur de frottement caractéristique de l'écoulement : Z=(2P_B)⁄(∫_0^∞⊠P(z) dz), qui peut être interprétée comme la hauteur sur laquelle l'écoulement subit un frottement important de la part des parois latérales.

Les simulations numériques [2] révèlent que la hauteur de frottement Z normalisée par H est liée à la fraction volumique moyenne de l'écoulement par une relation universelle. Cette relation ainsi que les deux autres (μ(Fr) et ⊠(Fr)), combinées à un simple bilan de force, nous donnent un modèle à l'échelle globale permettant de prédire la vitesse de glissement d'un écoulement granulaire dans un canal lisse d'angle d'inclinaison et de particule holdup donnés.

Ref.
[1] Zhu, Y., Delannay, R. & Valance, A. High-speed confined granular flows down smooth inclines: scaling and wall friction laws. Granular Matter 22, 82 (2020). https://doi.org/10.1007/s10035-020-01053-7
[2] Zhu, Y., Delannay, R. & Valance, A. Boundary conditions for rapid granular flows bounded by flat, frictional surfaces, Submitted to PRF (2022).
[3] O. Roche, S. van den Wildenberg, A. Valance, R. Delannay, A. Mangeney, L. Corna, and T. Latchimy. Experimental assessment of the effective friction at the base of granular chute flows on a smooth incline. Phys. Rev. E 103, 042905 (2021)

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Session Classification: Mardi matin

Track Classification: Présentation orale

Contribution ID: **86** Type: **Présentation**

Crossing approaches to better understand (and model) bedload transport and granular media

Monday, July 3, 2023 2:00 PM (50 minutes)

Bedload transport can be seen as an interaction between a granular medium and a fluid flow. This perspective and the associated modelling can benefit to both field, by on one hand considering a granular media approach to better understand and model bedload transport, and on the other hand challenging classical granular media description analyzing the complex bedload transport configuration.
The present approach is developed using numerical simulations at the particle scale together with a theoretical modelling approach based on two-phase continuum model. Bedload transport is used as a rheometer to span the whole granular regimes as a function of the depth with each simulation. While the results challenges granular regime transition description, a mu(I) approach is shown to describe bedload transport at first order in a two-phase continuous model. In a second time, starting from a theoretical analysis of the slope influence in bedload transport from the granular perspective, keys are given to understand the evolution of the vertical granular structure as a function of physical parameters and a scaling law for bedload transport is predicted and recovered in numerical simulations. The latter evidences the central role of the granular threshold of motion and of hysteresis for bedload transport modelling and leads us to study these phenomena in dry granular flows to better understand and model granular media and more generally geophysical processes.

Primary author: MAURIN, Raphael

Presenter: MAURIN, Raphael

Session Classification: Lundi après-midi

Track Classification: Présentation orale

Contribution ID: **87** Type: **Présentation**

Précurseurs d'avalanche

Wednesday, July 5, 2023 9:50 AM (50 minutes)

Les précurseurs d'avalanche sont de petits déplacements de surface quasi-périodiques, observés expérimentalement lors de l'inclinaison lente d'un lit granulaire. L'avalanche apparaît dans la séquence des précurseurs, comme le point culminant d'une séquence d'événements qui le procède. Une compréhension des précurseurs éclairerait donc le déclenchement des écoulements granulaires.

Une piste est d'étudier les précurseurs dans des modèles numériques. Le modèle unidimensionnel proposé dans (A. Amon et al, PRE 96 033004 (2017)) est une variation sur le modèle de tremblements de Terre de Burridge-Knopoff : Une ligne de patins reliés par des ressorts est placée sur un plan rugueux, qui est ensuite lentement incliné. On observe des petits mouvements quasi-statiques avant que tout le système se mette à glisser sur le plan.

Nous présentons un modèle bidimensionnel, intermédiaire entre ce modèle unidimensionnel et les expériences tridimensionnelles habituellement réalisées. Dans notre modèle, des disques sont placés sur un plan rugueux. Ils interagissent avec leurs voisins et avec les bords selon les interactions typiques de la dynamique moléculaire granulaire. Le modèle reproduit de manière robuste des événements quasi-périodiques qui ressemblent à des précurseurs.

Notre modèle et le modèle unidimensionnel semblent apparemment en accord,
cependant les deux modèles mènent à une vision différente de la nature des précurseurs. Après avoir présenté quelques résultats de chaque modèle, les différences d'interprétation seront discutées. Finalement, des pistes pour avancer sur ces questions seront mentionnées.

Primary authors: DELANNAY, Renaud (Université de Rennes, Institut de Physique de Rennes); MCNAMARA, Sean (Institut de Physique de Rennes, Université de Rennes)

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Session Classification: Mercredi matin

Track Classification: Présentation orale

Contribution ID: **88** Type: **Présentation**

A well-balanced entropy scheme for a shallow water type system describing two-phase debris flows

Monday, July 3, 2023 4:50 PM (50 minutes)

In the context of modeling two-phase debris flows involving grains and fluid, some shallow water systems arise with internal variables.
Our work focus on such a shallow water system with two internal variables and a topography b which adds a nonconservative term. \\

For numerical purposes, it is desirable to deal with a system where the mathematical entropy (the physical energy of the system) is convex with respect to the chosen conservative variables. Then at the numerical level, we can look for a scheme satisfying a semi-discrete entropy inequality. It also preserves the steady state at rest, so-called "well-balanced".

Our system is written as

\begin{equation}
\partial_t h+\nabla_x(hv)=0,
%\label{eq:h}
\end{equation}
\begin{equation}
\partial_t\bigl(hv\bigr)+\nabla_x\Bigl(h v\otimes v \Bigr)+g_c\nabla_x\Bigl(r
\frac{h^2}{2}\Bigr)+g_c h\nabla_x(b+\tilde b)=T,
%\label{eq:hv}
\end{equation}
\begin{equation}
\partial_t\rho+v\cdot\nabla_x\rho=\Phi_1,
%\label{eq:rho}
\end{equation}
\begin{equation}
\partial_t r +v\cdot\nabla_x r = \Phi_2,
%\label{eq:r}
\end{equation}
with the energy
\begin{equation}
E = h\frac{|v|^2}{2}+g_ch(b+\tilde b)
+g_cr\frac{h^2}{2}.
%\label{entropy}
\end{equation}

The physical unknowns of the system are the total mass h, the velocity v, the density of the mixture layer ρ and a variable r depending on the proportion of fluid between the layers.
Sources terms Φ_1, Φ_2 and T contains multivalued friction and dilatancy effects. \\

Writing the system with conservative variables for which the energy is convex, we derive a well-balanced scheme satisfying a semi-discrete entropy inequality.
A numerical test case of injection of some mixture and fluid into a box will be discussed to illustrate the importance of the dilatancy effect.

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Presenter: DRACH, Elias (Université Gustave Eiffel)

Session Classification: Lundi après-midi

Track Classification: Présentation orale

Contribution ID: **89** Type: **Présentation**

Influence of the grain size polydispersity on the collapse of immersed granular columns

Tuesday, July 4, 2023 9:00 AM (50 minutes)

The granular column collapse is a benchmark experiment for studying granular flows. Granular flows are found in varying scales from handling purposes to natural debris flows and can occur in subaerial or submerged environments. Out of convenience, granular flows are commonly studied with a monodisperse distribution of grains; however, the variety of grain sizes, known as polydispersity, is an important feature often found in these flows. Understanding the role of polydispersity remains a challenging task to be addressed experimentally and that requires a series of simplifications when studied numerically. Therefore, our research focuses on exploring the influence that polydispersity has on the collapse of dry and immersed granular columns with two methodologies. We study the collapse of granular columns in dry and immersed conditions with a coupled Finite Element Method (FEM) and Discrete Element Method (DEM) capable of managing high polydispersity levels. Additionally, we do an experimental campaign to study the three-dimensional nature of the process. We define the polydispersity level as the ratio between the biggest and the smallest grain and study systems with a polydispersity level ranging from 1.2 to 20. We show that polydispersity has stronger effects on immersed collapses than in dry collapses. Notably, the collapse sequence and final runout of immersed columns are affected by increasing the level of polydispersity. We reveal that the differences between monodisperse and polydisperse columns arise from differences in the evolution of the pore pressure changes. Moreover, we propose a simplified model that scales the column runout with the spreading front kinetic energy that works for all polydispersity levels, and for dry and immersed collapses. This model scales results from numerical simulations and from the experiments and it may prove useful in comprehending mass movements in areas where the only available data is the mobility and an interpretation of the initial geometry.

Primary authors: Mr POLANIA, Oscar (Université de Montpellier); Dr AZÈMA, Emilien (Université de Montpellier); Dr RENOUF, Mathieu (Université de Montpellier); Dr CABRERA, Miguel (TU Delft); Dr ESTRADA, Nicolas (Universidad de los Andes)

Presenter: Mr POLANIA, Oscar (Université de Montpellier)

Session Classification: Mardi matin

Track Classification: Présentation orale

Contribution ID: **90** Type: **Présentation**

Fluidisation d'écoulements granulaires denses par pression interstitielle.

Tuesday, July 4, 2023 2:00 PM (50 minutes)

Un modèle non moyenné prenant en compte la pression du gaz interstitiel, ici de l'air, dans un milieu granulaire dense est présenté. IL est obtenu à partir des équations de Jackson modélisant un mélange fluide-solide. L'équation de la quantité de mouvement du fluide interstitiel est simplifiée de telle sorte que l'équation de conservation de la masse de ce dernier permet d'écrire une équation de diffusion-convection de la pression du gaz interstitiel. Pour ce qui est des particules solides, la rhéologie $\mu(I)$ est utilisée. L'effet de la pression du gaz interstitiel est de diminuer la friction entre les particules solides et ainsi de permettre à un écoulement granulaire de parcourir une plus grande distance lorsqu'il est fluidisé.
Après avoir introduit le modèle fluidisé nous étudierons sa stabilité au sens des travaux de Barker *et al* réalisés sur la rhéologie $\mu(I)$. Nous montrerons que la prise en compte de la fluidisation par une équation de diffusion pour la pression interstitielle n'améliore pas la stabilité du modèle $\mu(I)$ incompressible. Nous montrerons néanmoins par des simulations numériques que lors de la phase dynamique d'un écroulement d'une colonne granulaire fluidisée les solutions obtenues, notamment la pression solide, ne présentent pas d'oscillations de mailles comme celles observées lors de simulations d'écoulements non fluidisés. Des oscillations apparaissent lorsque la pression interstitielle diminue et ne compense plus la pression solide, notamment dans la phase de décélération.
Enfin, en comparant les résultats de simulations numériques d'écroulements de colonnes granulaires fluidisées à des résultats expérimentaux réalisés en laboratoire, nous montrerons que le modèle fluidisé permet de retrouver un résultat fondamental mis en évidence expérimentalement par O. Roche : une colonne granulaire fluidisée parcourt une distance environ deux fois plus grande qu'une colonne non fluidisée.

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Co-author: CHUPIN, laurent (UCA)

Presenter: DUBOIS, Thierry (Université Clermont Auvergne)

Session Classification: Mardi après-midi

Track Classification: Présentation orale

Contribution ID: **91** Type: **Présentation**

Ultrasonic monitoring in granular suspensions

Tuesday, July 4, 2023 2:50 PM (50 minutes)

The dynamics of geophysical dilute turbulent gas-particles mixtures depends to a large extent on particle concentration, which in turn depends on the particle settling velocity. In the first part of this talk, we present the experimental investigation of dilute air-particle mixtures by acoustic probing and air pressure measurements. We show hat there are two settling mechanisms depending on the coupling of the particles with the gas, namely, hindered settling or cluster-induced enhanced settling. These mechanisms result in settling velocities significantly different from those of single particles.

In the second part of this talk we discuss the pratical challenge of localizing an intruder submerged in a strongly scattering medium, such as a dense granular suspension. Here we extract the coherent ultrasonic echo from a steel ball submerged in a dense glass-bead packing saturated by water, by using a standard single-element ultrasonic transducer and configuration averaging processes. Different configurations of the granular packing are created by the nonaffine motion of the beads with a mixing blade, akin to the Brownian motion, in the vicinity of the intruder. We investigate the efficiency of this process to reduce the so-called material noise from multiply scattered ultrasound.

Presenter: VAN DEN WILDENBERG, Siet (Laboratoire Magmas et Volcans)

Session Classification: Mardi après-midi

Track Classification: Présentation orale

Contribution ID: **92** Type: **Présentation**

Numerical analysis at the particle scale of granular flow hysteresis on an inclined plane

Monday, July 3, 2023 2:50 PM (50 minutes)

Granular media are ubiquitous in environmental processes and geophysical phenomenon such as sediment transport, landslides or avalanches. Granular media can be classified into three different regime : solid (quasi-static), liquid (dense flow) and gas (dilute flow). The transition between the motionless solid state and the dense flow state corresponding to the initiation of motion is an important issue for the study of natural hasards such as snow avalanches or landslides. In particular, this transition is subjected to a phenomenon of hysteresis : the angle at which an avalanche starts on an inclined plane is greater than the one at which the flow stops. While this hysteretical behavior has a major influence on avalanche or
debris flow propagation, both its description and the underlying basic physical mechanisms still remain open questions.

In this framework, the present work focuses on the fundamental small scale mechanisms related to the hysteresis observed in granular media at the transition between dense granular flow and rest.

Hysterical behavior has been highlighted in laboratory experiments using either a rotating drum configuration [1], [3] or an inclined plane configuration [5], [4] as the difference of critical angles obtained to initiate and stop granular flow made of monodisperse solid grains. This mechanism has since been often
attributed to particle inertia [1], [2]. Yet, more recent works [3], [4] show on that the inter-particle friction is a dominant mechanism in the hysteresis at the expense of the inertia of grains.

To understand this apparent contradiction and the mechanisms at play, the present study focuses on inclined plane simulation at the particle scale. Using a discrete element method modelling the behavior of each particles, flow arrest and avalanche onset are studied by varying the inclination angle of the inclined plane with respect to gravity. Studying the influence of inter-particle friction, it is shown that the inter-particle friction is not the dominant mechanisms responsible for the hysteresis in dry granular flows. Variation of grains inertia are also studied in order to explain the different results on the subject.

[1] S. Courrech du Pont et al. “Granular Avalanches in Fluids”. In : Phys. Rev. Lett. 90 (4 jan. 2003), p. 044301.
[2] E DeGiuli et M Wyart. “Friction law and hysteresis in granular materials”. In : Proc Natl Acad Sci 114(35) (2017), p. 9284-9289.
[3] Hugo Perrin et al. “Interparticle Friction Leads to Nonmonotonic Flow Curves and Hysteresis in Viscous Suspensions”. In : Phys. Rev. X 9 (3 août 2019), p. 031027.
[4] Hugo Perrin et al. “Nonlocal Effects Reflect the Jamming Criticality in Frictionless Granular Flows Down Inclines”. In : Phys. Rev. Lett. 126 (juin 2021), p. 228002.
[5] O. Pouliquen et Y. Forterre. “Friction law for dense granular flows : application to the motion of a mass down a rough inclined plane”. In : Journal of Fluid Mechanics 453 (jan. 2002), p. 133-151.

Presenter: LAMBERT, Clovis

Session Classification: Lundi après-midi

Track Classification: Présentation orale

Contribution ID: **93** Type: **Présentation**

Grain size segregation in bedload sediment transport

Monday, July 3, 2023 4:00 PM (50 minutes)

Bedload, the coarser material transported in contact with the bed by turbulent flow in stream channels, has major consequences for public safety, water resources, and environmental sustainability. Size sorting also named size segregation is responsible for our limited ability to predict sediment flux and river morphology, especially in mountains where steep slopes drive an intense transport of a wide range of grain sizes.

We will first talk generally on a research effort in Grenoble on bedload transport multi-scale size segregation modelling within the framework of the ANR project SegSed (size Segregation in Sediment transport). Using a combination of flume experiments at Irstea/Inrae laboratory and a coupled fluid-discrete element model, it was possible to carry out both 'real' experiments and numerical 'experiments' on a variety of bedload configurations, probing the depth structure and the vertical segregation dynamics. Comparing to 'real' laboratory experiments, discrete models allow access to the internal structure and to variables difficult to measure in the laboratory. These variables allow deriving constitutive relationships and size segregation equations that can be upscaled in Eulerian-Eulerian two-phase flow continuum models.

In a second part, we will focus on size segregation due to finer grain input in bedload transport. Two-size experiments were carried out by A. Dudill (joint UGA/UBC PhD) to study the influence of (1) the grain size ratio (coarse to fine) and (2) the percentage of the fine feed rate in the total feed. Depending on these parameters, the slope of the bed evolved eventually reaching a new two-size equilibrium value either larger (aggradation) or smaller (degradation) than the one-size slope.
Each experiment was recorded using a high-speed camera. Work in progress involve improving our image processing algorithms to analyse depth profiles of particle velocity and concentration of the coarse beads once the two-size equilibrium is reached. Depending on the grain size ratio and the percentage of the finer feed rate in the total feed, coarse grains moved either in concentrated low velocity clusters or individually at higher velocity.

Better understanding of bedload size segregation at the grain scale should ultimately permit improvement of sediment transport and river morphology modelling.

Primary author: FREY, Philippe (UGA, INRAE, ETNA, IGE, Grenoble)

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Session Classification: Lundi après-midi

Contribution ID: **94** Type: **not specified**

Ultrasonic monitoring in granular suspensions

The dynamics of geophysical dilute turbulent gas-particles mixtures depends to a large extent on particle concentration, which in turn depends on the particle settling velocity. In the first part of this talk, we present the experimental investigation of dilute air-particle mixtures by acoustic probing and air pressure measurements. We show hat there are two settling mechanisms depending on the coupling of the particles with the gas, namely, hindered settling or cluster-induced enhanced settling. These mechanisms result in settling velocities significantly different from those of single particles.

In the second part of this talk we discuss the pratical challenge of localizing an intruder submerged in a strongly scattering medium, such as a dense granular suspension. Here we extract the coherent ultrasonic echo from a steel ball submerged in a dense glass-bead packing saturated by water, by using a standard single-element ultrasonic transducer and configuration averaging processes. Different configurations of the granular packing are created by the nonaffine motion of the beads with a mixing blade, akin to the Brownian motion, in the vicinity of the intruder. We investigate the efficiency of this process to reduce the so-called material noise from multiply scattered ultrasound.

Primary author: VAN DEN WILDENBERG, Siet (Laboratoire Magmas et Volcans)

Presenter: VAN DEN WILDENBERG, Siet (Laboratoire Magmas et Volcans)

Track Classification: Présentation orale

Contribution ID: **95** Type: **not specified**

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debris flow propagation, both its description and the underlying basic physical mechanisms still remain open questions.

In this framework, the present work focuses on the fundamental small scale mechanisms related to the hysteresis observed in granular media at the transition between dense granular flow and rest.

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attributed to particle inertia [1], [2]. Yet, more recent works [3], [4] show on that the inter-particle friction is a dominant mechanism in the hysteresis at the expense of the inertia of grains.

To understand this apparent contradiction and the mechanisms at play, the present study focuses on inclined plane simulation at the particle scale. Using a discrete element method modelling the behavior of each particles, flow arrest and avalanche onset are studied by varying the inclination angle of the inclined plane with respect to gravity. Studying the influence of inter-particle friction, it is shown that the inter-particle friction is not the dominant mechanisms responsible for the hysteresis in dry granular flows. Variation of grains inertia are also studied in order to explain the different results on the subject.

[1] S. Courrech du Pont et al. “Granular Avalanches in Fluids”. In : Phys. Rev. Lett. 90 (4 jan. 2003), p. 044301.
[2] E DeGiuli et M Wyart. “Friction law and hysteresis in granular materials”. In : Proc Natl Acad Sci 114(35) (2017), p. 9284-9289.
[3] Hugo Perrin et al. “Interparticle Friction Leads to Nonmonotonic Flow Curves and Hysteresis in Viscous Suspensions”. In : Phys. Rev. X 9 (3 août 2019), p. 031027.
[4] Hugo Perrin et al. “Nonlocal Effects Reflect the Jamming Criticality in Frictionless Granular Flows Down Inclines”. In : Phys. Rev. Lett. 126 (juin 2021), p. 228002.
[5] O. Pouliquen et Y. Forterre. “Friction law for dense granular flows : application to the motion of a mass down a rough inclined plane”. In : Journal of Fluid Mechanics 453 (jan. 2002), p. 133-151.

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