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Uncovering Transient Dynamics and Equilibrium States of Particle Aggregates with Raúl Bayoán Cal

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Welcome to PDXPLORES, a Portland State Research podcast featuring scholarship innovations and discoveries, pushing the boundaries of knowledge practice and what is possible for the benefit of our communities and the world.

My name is Raúl Bayoán Cal and I'm a professor here at Portland State University in the Department of Mechanical and Materials Engineering.

In this National Science Foundation and Center for the Advancement of Science in Space jointly funded project, we are interested in observing dynamics of groups of particles in an air/water interface and in the bulk of the fluid through time in the absence of gravity. The aim is to explore transport phenomena research in the International Space Station with benefits to life on earth. When removing gravity, we get to disentangle the effects that are otherwise obscuring really small forces. And these forces are called capillary forces that can be affected by the contact angle between the particle and the fluid and buoyancy forces. In this case, we would be turning off the buoyancy forces. And we are also interested in forcing that fluid at a particular frequency to observe how this forcing and immersion forces cause the particles to aggregate or not. The proof of concept is to be able to turn off gravity, and based on that, we manage to observe these forces which otherwise would be obscured altogether when otherwise you would see them.

The findings from this research can broadly help us solve important problems, such as the fate of where is it that plastic particulates might go, and how also the population of algal blooms and how is it that those might grow or might come together? So microcystics produces a harmful toxin that can lead to a dizziness and vomiting potentially, and even further damage, and it's quite bad for humans. Also, in general, these are known to be harmful to marine life, and our research also translates to many industrial processes that depend on the mixing of these particulates in the case of a bulk.

Capillary flotation is when the particle experiences the influence of gravity, which is otherwise known as buoyancy. And capillary immersion is the cause by the forces that are created due to the angle that is formed between the liquid and the particle, which is otherwise called wettability. And we know that at 90 degrees, the particle wishes to stay in place. And at smaller contact angles, the surface is hydrophilic, which is otherwise wetting. And at larger contact angles, the surface is hydrophobic, which is otherwise non-wetting.

By applying a harmonic forcing, we can introduce a known forcing into the system, which in practice we know that on earth these particles are constantly being forced by the motion of, let's say, waves or other types of motions that they might experience. The difficulty of studying this problem under gravity is that gravity obscures or entangles different effects that are being felt by these particles. And effects that could be or not be seen over time are also not attainable, because we cannot sustain a low gravity environment.

Our lab is very, very dynamic. We get to work on many different problems. And in this instance, we get to do things like sending experiments to space, for example.

Our research tasks are three of them. We wish to perform experiments in our drop tower. We wish to perform experiments in the International Space Station, and from what we gather there, we wish to potentially develop models that can help our understanding of aggregation. Which is otherwise, how is it that these particles come together. We conduct experiments on our drop tower, which provides 2.1 seconds of microgravity. The experiments are done to have an initial understanding of the phenomena and narrow on potentially important cases and parameters. In these, we take videos and analyze them to understand the movement of the particles. And the aim is that once we've narrowed into particular cases, we can then study these particular cases in the International Space Station. We then want to send our experiments to space to have long periods of microgravity. In these, we get to observe the particles for a longer time and hopefully we get to uncover the full range of dynamics that these particles experience.

The students taking part of this research get to come to an understanding of the problem and get introduced to fundamental concepts in fluid mechanics. They get to work on problems where we do not have all the answers. They also get to use very unique instrumentation and equipment, such as our drop tower. And also they get to perform an experiment in space in the International Space Station.

We are partnering with ZIN technologies in the design of the experiments, and preparing ourselves to send our experiments to space. They will help us in getting our experiments flight ready. They will help us in performing the experiments with the astronauts, and they will be the ones who will be manipulating the experiments effectively. The students need to be, in general, curious. They need to be ready to have fun and to be excited and passionate about working on these different problems and uncovering things in science that otherwise they would've not known. At the end, the aim is that the student develops

an ability for solving different and difficult problems and be able to become an independent thinker.

We wish to take part on the science communications program at the Oregon Museum of Science and Industry, which aids in more easily communicating our science to a broader audience. The program allows to design and build a demonstration that one can use to facilitate the explanation of the concepts that we are researching. For instance, how is it that the particles behave differently with and without gravity? And how is it that a surface can be wetting or non-wetting? And we get to explain these to a broad audience through our demonstrations.

We are also intending to develop curricula for K through 12 students by researching with a high school teacher. The aim is to introduce the concept of gravity or lack thereof, and how is it that that impacts science in general? The teacher will come here and do experiments in the drop tower, and then we will develop together with the graduate students, these concepts and be able to introduce that to the kids, to the K through 12 students, And actually they will also be designing their experiments and they will be able to drop their experiments in the drop tower, which is quite exciting. They will be able to see their results and analyze videos, even at their age, which is amazing.

My name is Raúl Bayoán Cal, and our group aims to understand physical processes in fluid mechanics with the hope that we can improve different systems or technologies.

Thank you for listening to PDXPLORES. If you liked what you heard on this episode, please read and follow the show anywhere you get your podcasts.