Collective Dynamics of Walking Droplets

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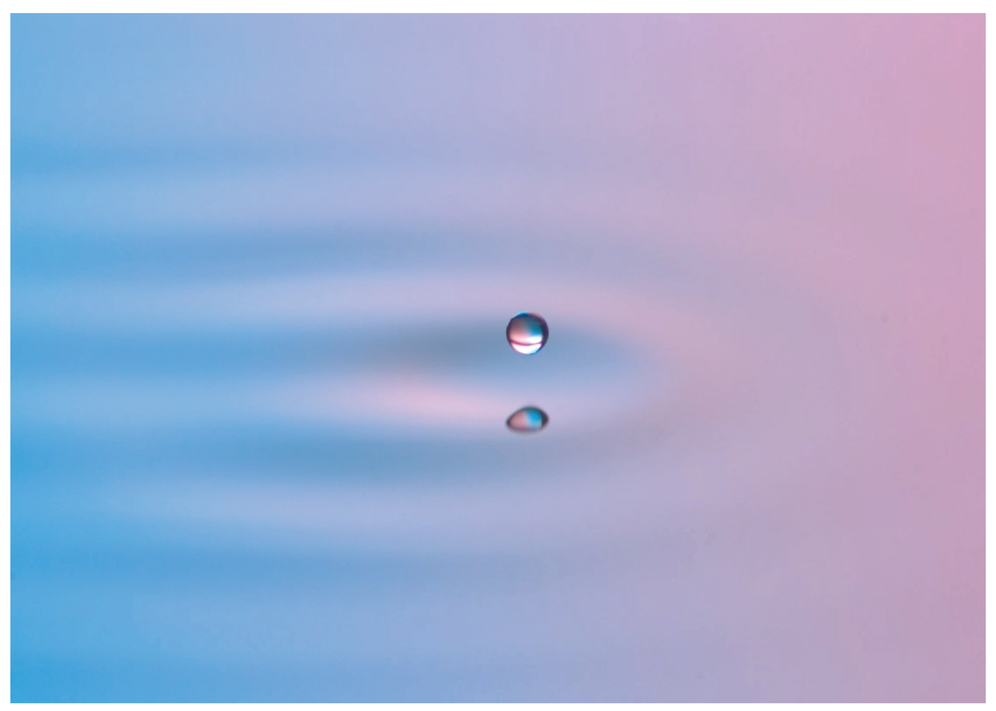
Background

Force a fluid bath with periodic acceleration $\Gamma = \gamma \sin(2\pi f t)$. Droplets may self-propel across the interface due to a resonant reaction with their own wavefield.

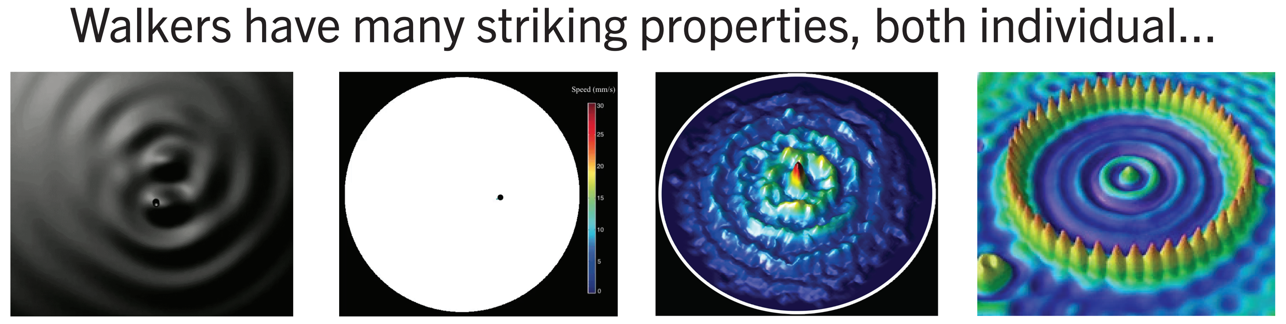


This wave-particle duality is analogous to the same wave-particle nature in the quantum realm. The discovery of bouncing and 'walking' droplets led to the creation of a new field, *Hydrodynamic Quantum Analogs*.

But what happens with many droplets?

Motivation

Walkers have many striking properties, both individual...



The position histogram of a walker in a circular corral develops wavelike statistics akin to those of quantum orbitals.

and collective...

Orbiting Pairs *Crystals* *Spin Lattices*

But free interaction between droplets has always been forbidden!

Acknowledgements

[1] Abraham, A., 2023.

[2] Harris, D.M. and Bush, J.W.M., 2014. Droplets walking in a rotating frame: from quantized orbits to multimodal statistics, *Journal of Fluid Mechanics*, **739**, 444–464.

[3] Oza, A.U., Siefert, E., Harris, D.M., Molacek, J. and Bush, J.W.M., 2017. Orbiting pairs of walking droplets: Dynamics and stability, *Phys. Rev. Fluids*, **2**, 053601.

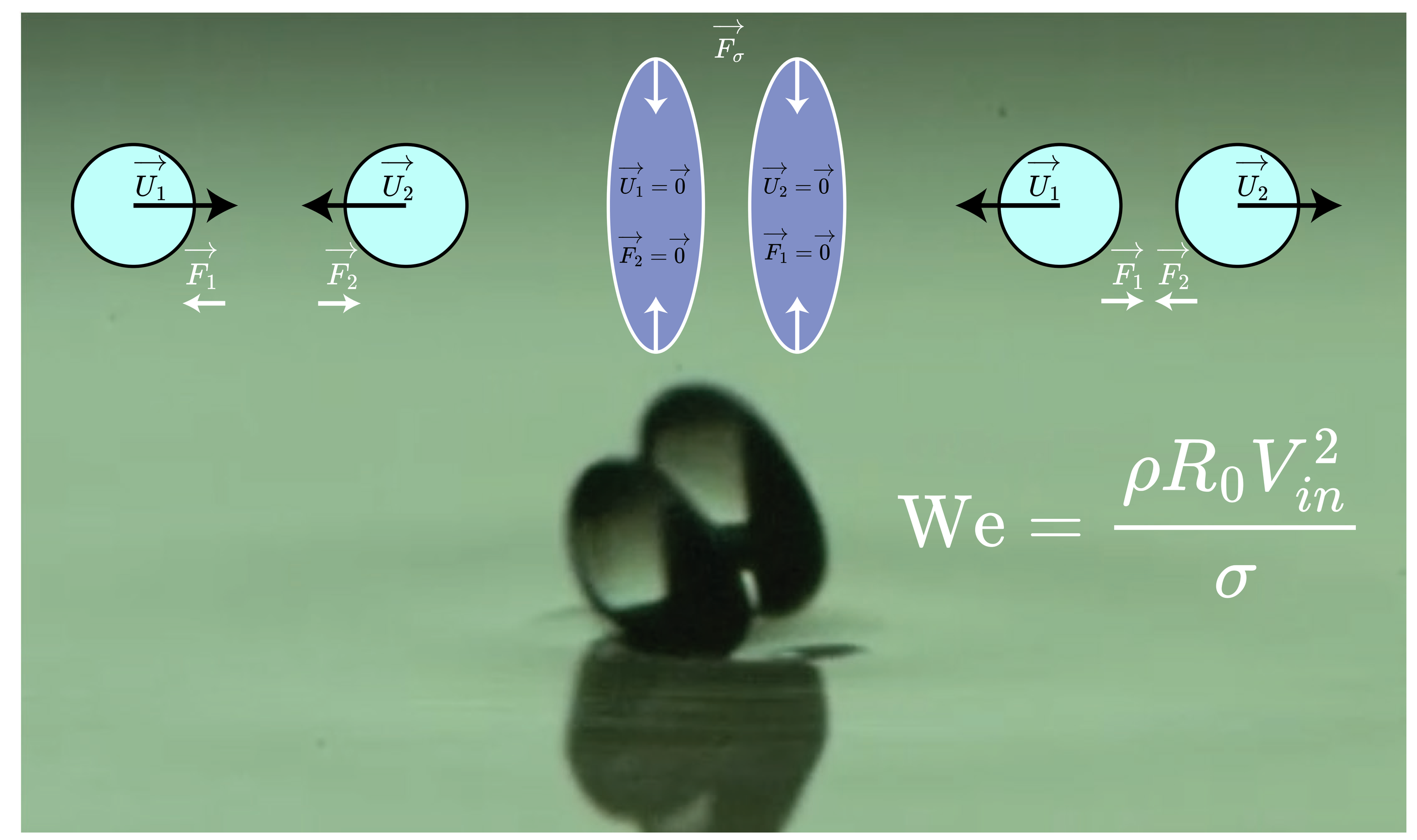
[4] Darrenougue-Chassagne, J., 2022.

[5] Bush, J.W.M., 2015. Pilot-Wave Hydrodynamics, *Annual Review of Fluid Mechanics,* **47**, 269–292.

Influence of Pressure

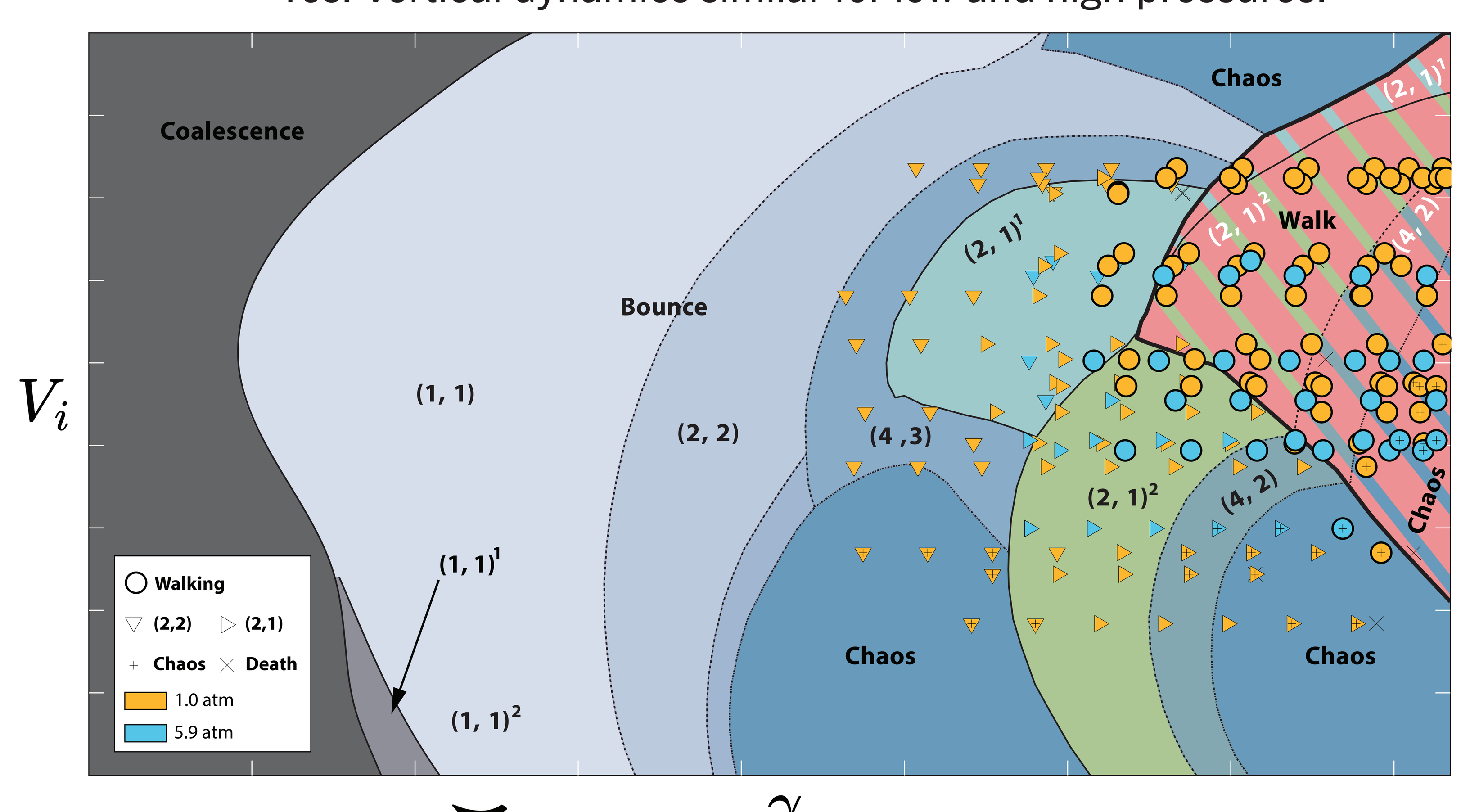
Problem: Droplets can coalscence upon impact with each other.

Based on lubrication theory: as droplets approach, an air layer may ***prevent them from coalescing*** for certain Weber numbers (We).

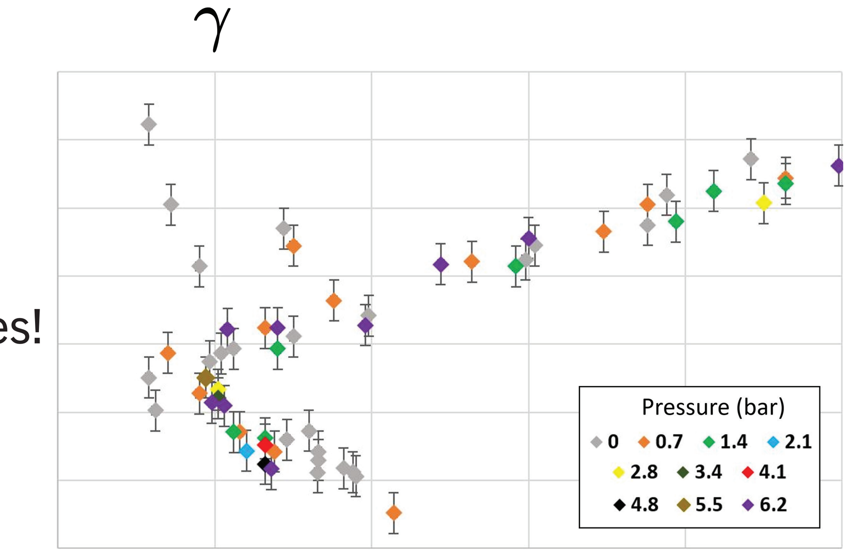


But, do walkers under high ambient pressure still behave like the typical walkers at standard ambient pressure which are well-studied?

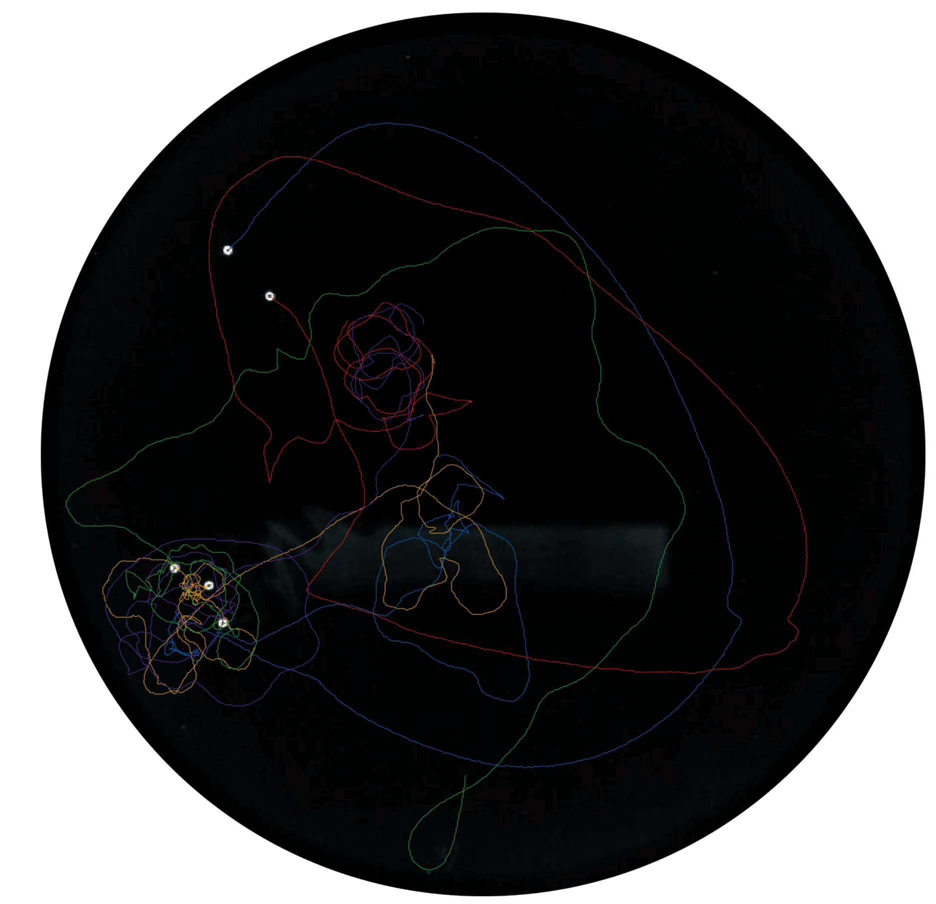
Yes! Vertical dynamics similar for low and high pressures!



Bouncing threshold also similar for range of pressures!



Results

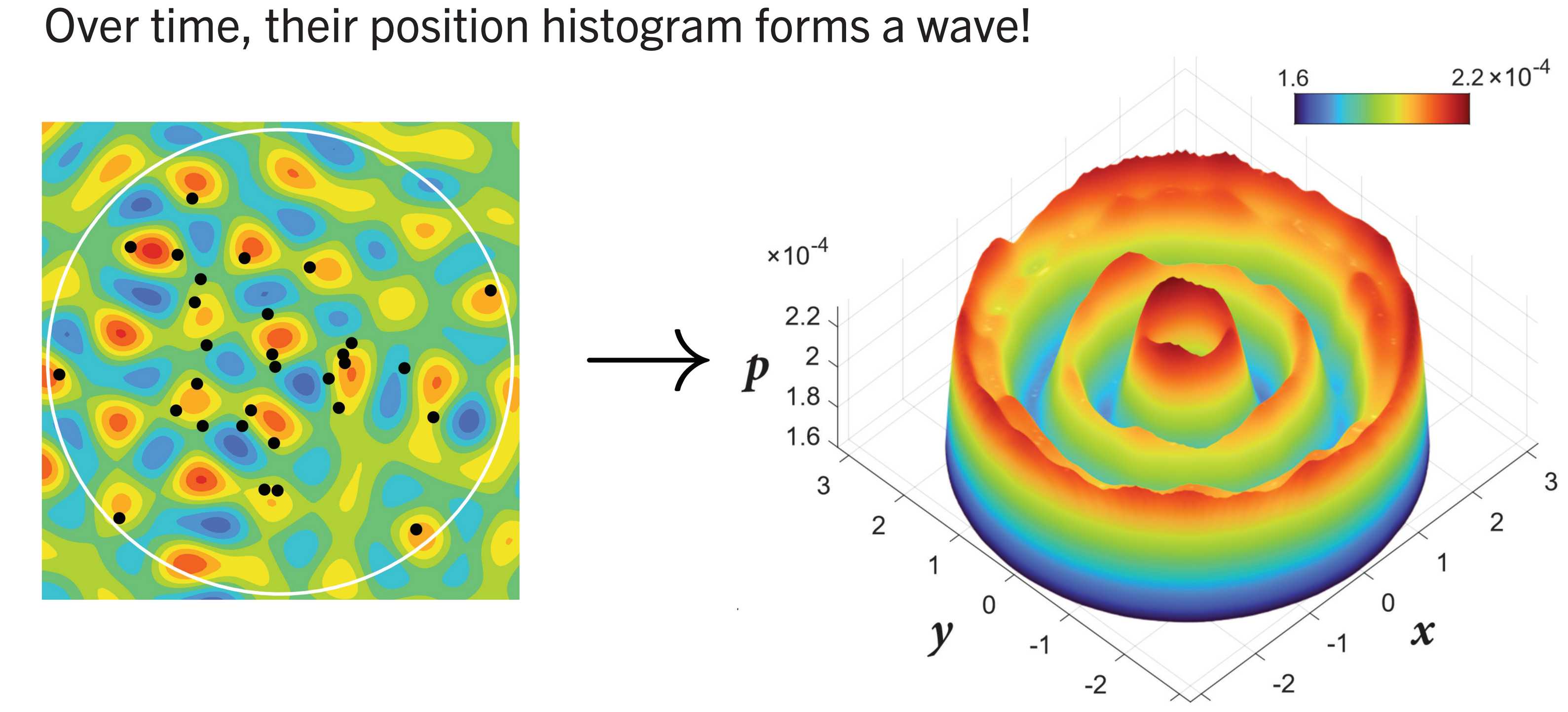


Place droplets in sealed chamber, then increase ambient air pressure, increase acceleration past walking threshold, then release them with magnet-driven gates.

At high pressure, 15+ droplets freely interact and collide for multiple hours with no coalescence!

Future Work

We have simulated many walking droplets interacting in a corral. Over time, their position histogram forms a wave!



BUT, can we reproduce this in an experiment? There are many challenges, such as the right corral size and the relative vertical phase of the droplets, which may change upon collision.

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