How scientists inverted the Cheerios effect

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Liquid drops on soft solid surfaces interact by an 'inverted Cheerios effect', which can be tweaked so that the droplets move towards or away from each other, according to an international group of scientists publishing in the journal *Proceedings of the National Academy of Sciences*.

The phenomenon of the famous breakfast cereal clumping together when floating in a milk bowl is known as the Cheerios effect. The 'inverted Cheerios effect', identified in this paper for the first time, describes a similar scenario but with the roles of liquid and solid being interchanged: liquid droplets interact when resting on a solid—but soft—surface.

In recent years, the classical Cheerios effect has inspired a new set of manufacturing technologies for advanced materials and helped physicists understanding the gravitational collapse of galaxies. Similarly, the newly discovered 'inverted Cheerios effect' may open up new opportunities in engineering and the life sciences.

"Tuning the movement of liquid droplets could have implications for the performance of engineering technologies which rely on drops of water and other liquids," said co-author Dr Lorenzo Botto from Queen Mary University of London's School of Engineering and Materials Science (London, UK).

"For example, the physical phenomena we have highlighted in this paper suggest ways to design surfaces that prevent fogging or control heat transfer; for instance to create car windows that are always transparent despite high humidity or surfaces that improve heat management in conditioners or boilers. By making surfaces softer or harder, and changing the thickness of the soft layer, we will be able to control how the drops coalesce and spread on the substrate."

The international team of scientists suggest the interactions of the liquid particles can be tuned to repel each other or move towards each other by changing the thickness and softness of the substrate.

Co-author Stefan Karpitschka, who recently moved from University of Twente (Enschede, The Netherlands) to Stanford University (California, USA), said: "The droplets deform the surface on which they live, and due to this deformation, they interact; somewhat reminiscent of general relativity, from which we know that galaxies or black holes interact by deforming space around them.

"What is remarkable about our case though is the fact that the direction of the interaction can be tuned by the medium, without modifying the particles themselves."

Dr Botto added: "While the science is quite young, there are exciting implications of our work not just limited to engineering. For example, quantifying the forces at play when drops sit on a soft layer will also help us understand how cells interact with each other and with the soft tissues on which they live."

More information: Liquid drops attract or repel by the inverted cheerios effect, *PNAS*, www.pnas.org/cgi/doi/10.1073/pnas.1601411113

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