French team demonstrates paramagnetic properties of liquid oxygen drops

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(Phys.org) -- A team of French scientists studying the properties of Leidenfrost drops has found that liquid oxygen drops can be manipulated and controlled using a magnetic field at room temperature. They describe their work and the properties they've uncovered in a paper to be published in the journal *Physical Review E.*

Leidenfrost drops come about when a liquid is dropped onto a surface that is significantly hotter (above its boiling point) than it is, trapping vapor underneath which allows the drop to not only avoid instant evaporation, at least right away, but to hover over the surface. The effect is commonly seen when water is tossed into a hot pan; the drops that form move around faster than they normally would due to the absence of friction.

Leidenfrost drops are used in a variety of industrial processes despite a lack of research into their physical properties. To learn more, the research team from Ecole Polytechnique looked to liquid oxygen drops because of their room temperature boiling point and also because they are paramagnetic and very easy to make.

To make drops of liquid oxygen, the team poured liquid nitrogen into a metal container. As they did so, drops of liquid oxygen formed on the outside of the container due to condensation. Once the drops were produced, the team put them on a glass plate where under normal conditions they would slide around chaotically as water does in a hot pan. To control them, the team placed a small magnet underneath the glass.

The team found that by moving the magnets they could control the paths the drops took and that angling the magnet caused different behavior; some were deflected while others swooped around the magnet, emulating the sling-shot effect scientists use to fling spacecraft away from a planet towards an established destination. Through trial and error they also found that in some instances they could cause the drop to actually orbit around the magnet.

Interestingly, the group also found that the degree of friction involved with the drops appeared to fluctuate depending on the shape of the drops as they moved around, which might just lead to better processes for controlling Leidenfrost drops in industrial applications.

The team believes their research might also lead to space travel modeling as the actions of the drops they manipulated with their magnets so closely mimic that of actually space travel situations. To further their research they have begun adding different particles to the drops to see how different materials impact their behavior.

More information: Magnetic control of Leidenfrost drops, by Keyvan Piroird, Christophe Clanet, and David Quéré, *Physical Review E*, Accepted Monday Apr 30, 2012

Abstract
We show how a magnetic field can influence the motion of a paramagnetic drop made of liquid oxygen, in a Leidenfrost state on solids at room temperature. It is demonstrated that the trajectory can be modified both in direction and velocity and that the results can be interpreted in terms of classical mechanics as far as the drop does not get too close to the magnet. We study the deviation and report that it can easily overcome 180 and even diverge under certain conditions, leading to situations where a drop gets captured. In the vicinity of the magnet, another type of trapping is observed, due to the deformation of the drop

in this region, which leads to a strong energy dissipation. Conversely, drops can be accelerated by moving magnets (slingshot effect).