Levitating Samples in the Air

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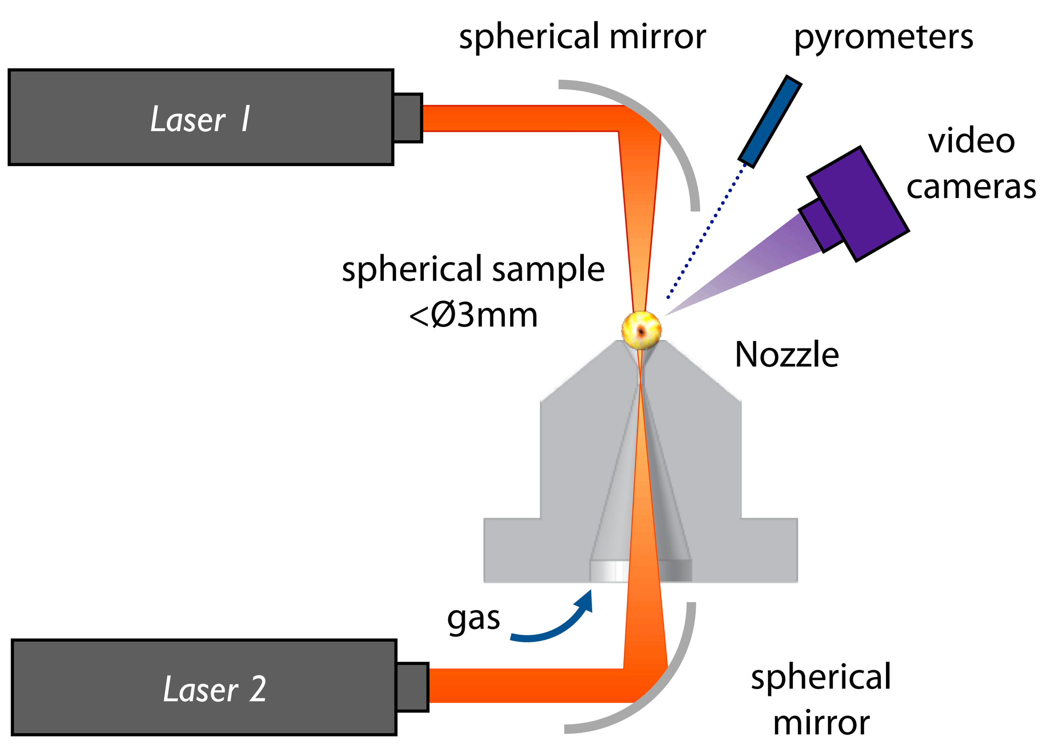
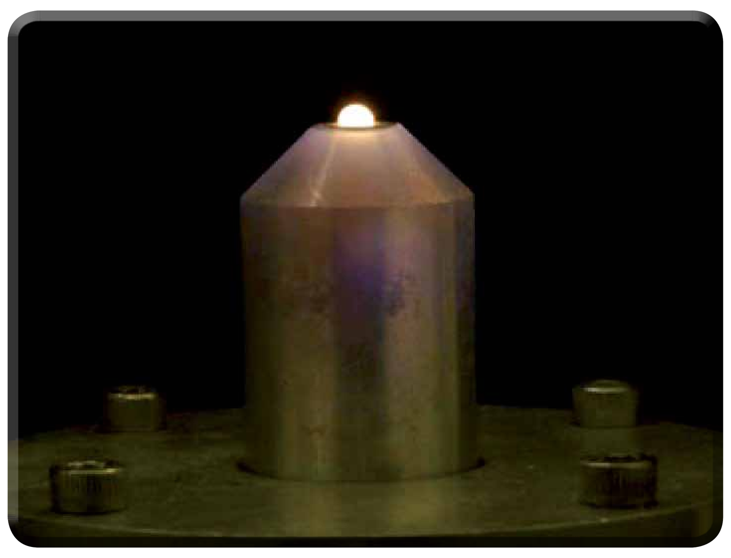


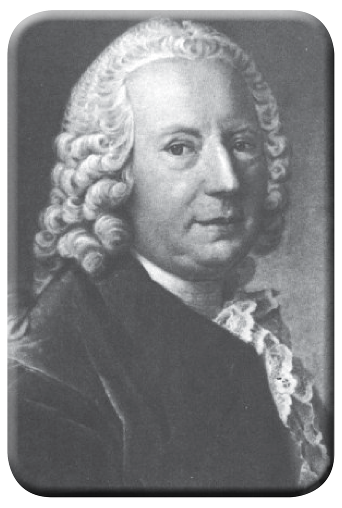
standard aerodynamic levitation setup

Motivated by the results of recent experiments performed in a furnace exploiting the aerodynamic levitation technique, we have investigated the possibility to levitate the sample well above the nozzle.


standard aerodynamic levitation

With the present technique, only two third of the sample escape the nozzle and scatter neutrons. Even with an efficient collimation one cannot prevent some neutrons to be scattered by the nozzle and this leads to spurious signal in the detector. With this standard technique, the gas exiting the nozzle applies a force on the sample which is slightly lifted. The horizontal position of the sample is not very stable but the oscillations are limited by the edges of the nozzle.

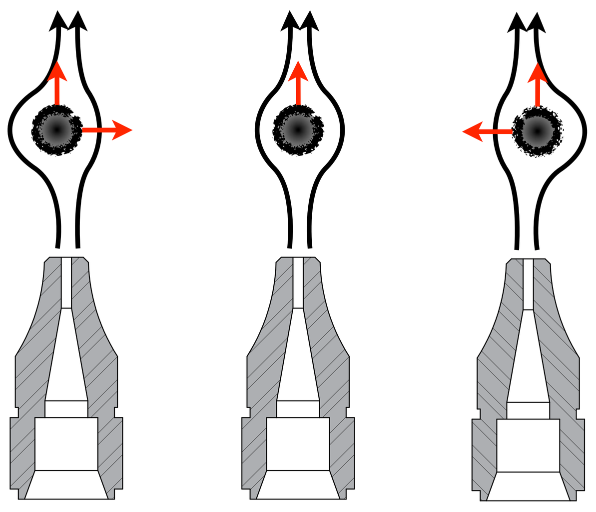
If we increase the gas flow, we can take advantage of the Coandă effect: the jet is drawn to the upper surface and curves around, diverting the flow downwards over the back. This change in the momentum of the gas flow is reacted out in the reduced pressure on the upper surface of the ball, this suction being sufficient to overcome the weight of the ball.



$$\frac{v^2}{2.g} + z + \frac{p}{\rho.g} = C^{te}$$

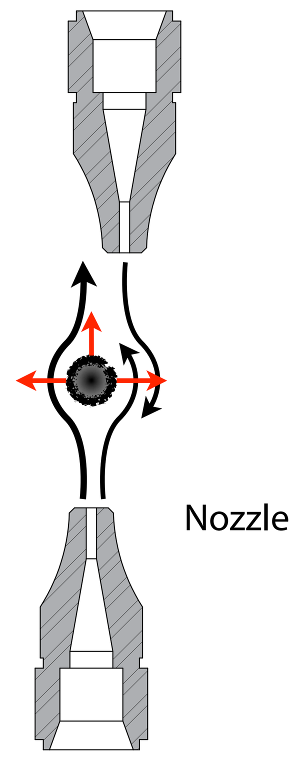
v is the fluid flow speed at a point on a streamline,
g is the acceleration due to gravity,
z is the elevation of the point above a reference plane,
p is the pressure at the point,
ρ is the density of the fluid at all points in the fluid.

Bernouilli's equation

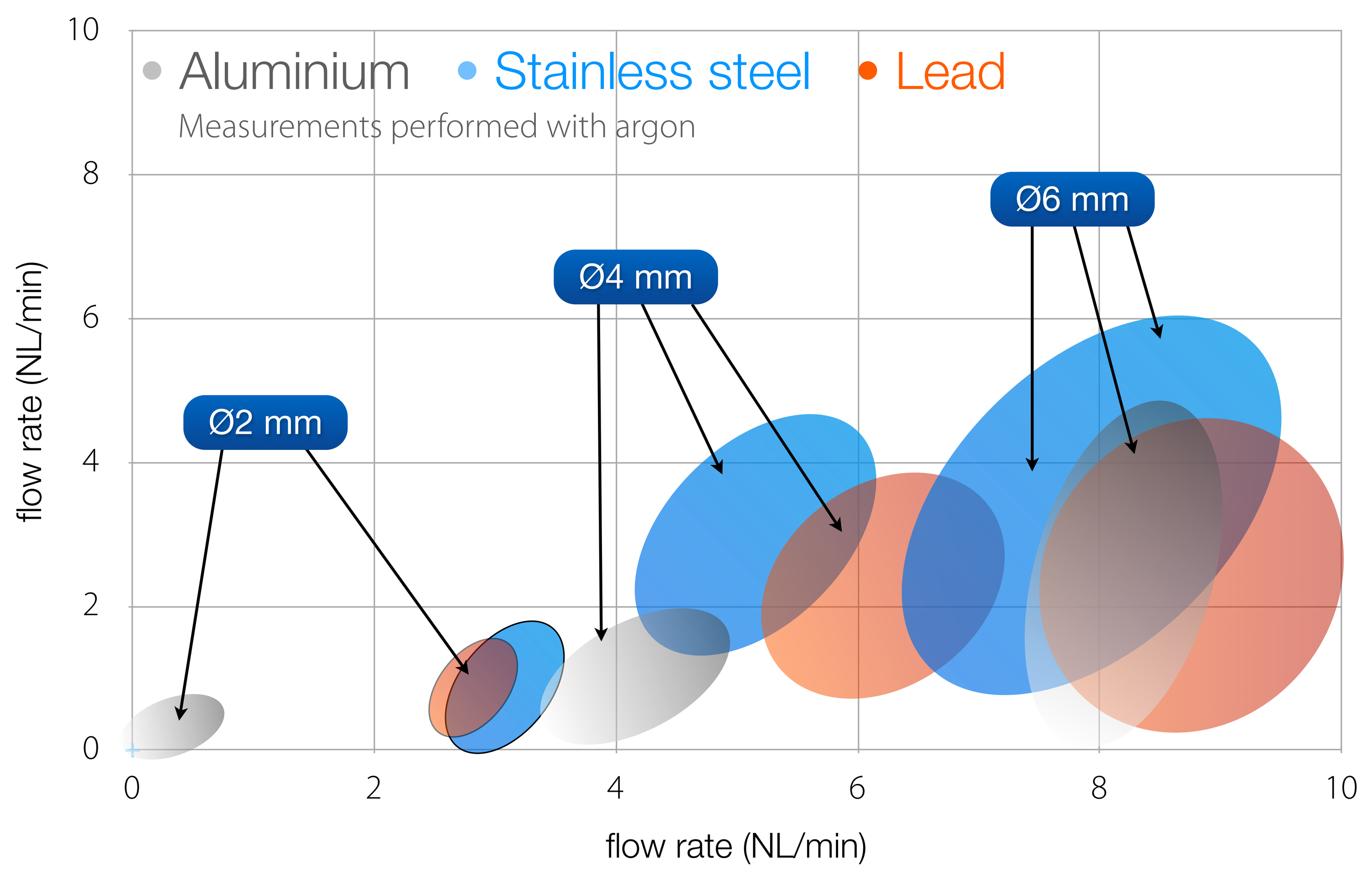


Indeed, owing to the Bernouilli's principle, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy. Moreover, when the sample moves horizontally, the pressure difference resulting from the variation of the speed of the gas flowing on each side of the sample pushes the sample to come back to the axis position.

Bernouilli's principle and Coandă effect applied to levitation: the suction is sufficient to overcome the weight of the ball and the pressure differences tend to maintain the sample on the axis.



In reality, the flow is not laminar and the equilibrium is quite unstable. To circumvent that problem, we add a secondary jet parallel to the main jet but directed in the opposite direction and off-centred by the size of the sample. This technique breaks the symmetry of the main jet and stabilizes perfectly the horizontal position of the sample. Similarly, the addition of a third jet in a perpendicular (horizontal) and offset direction reduces the vertical oscillations. Schlieren photography measurements are planned to investigate the influence of the secondary jets.

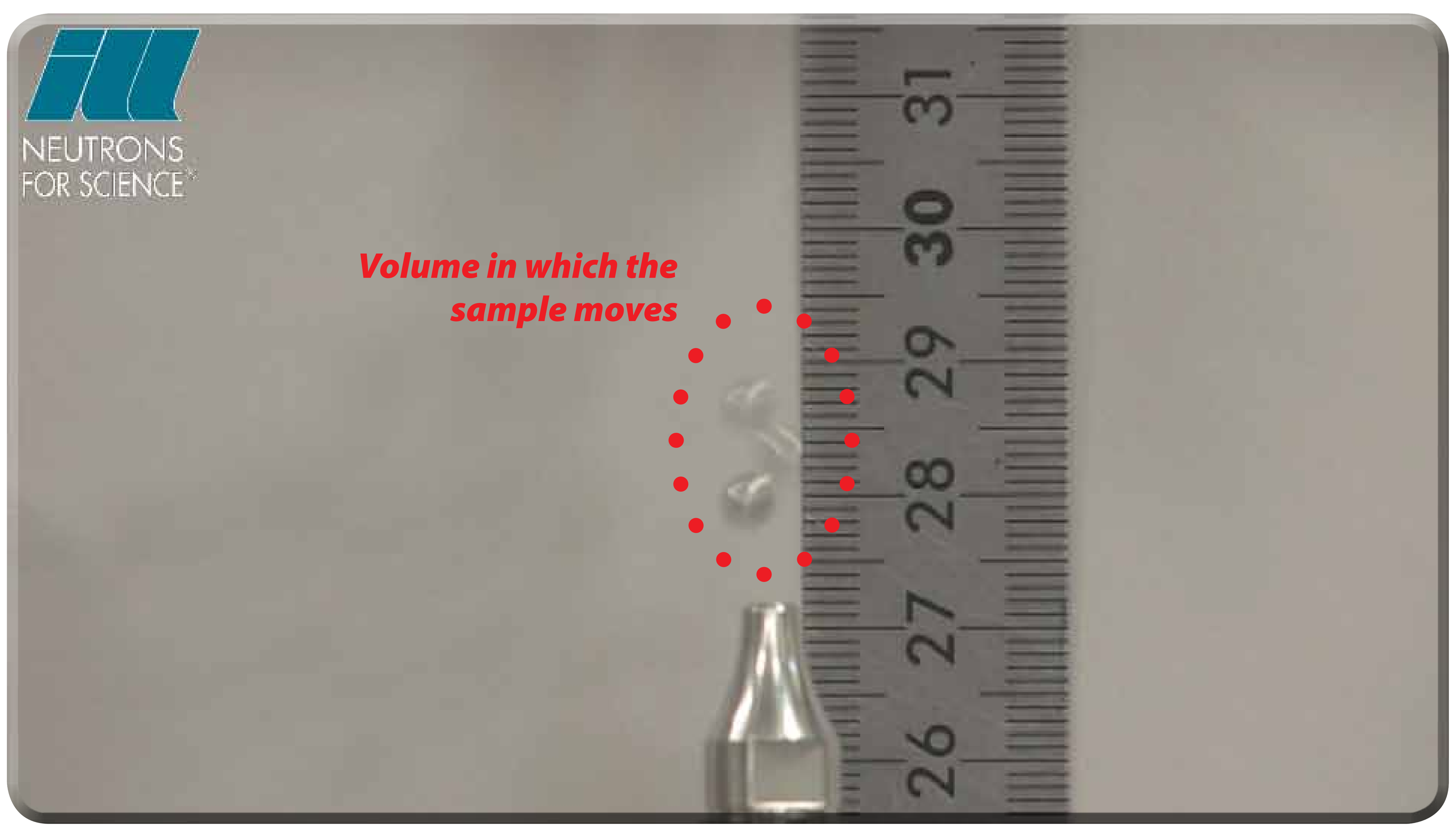


optimum flow rates applied to different samples

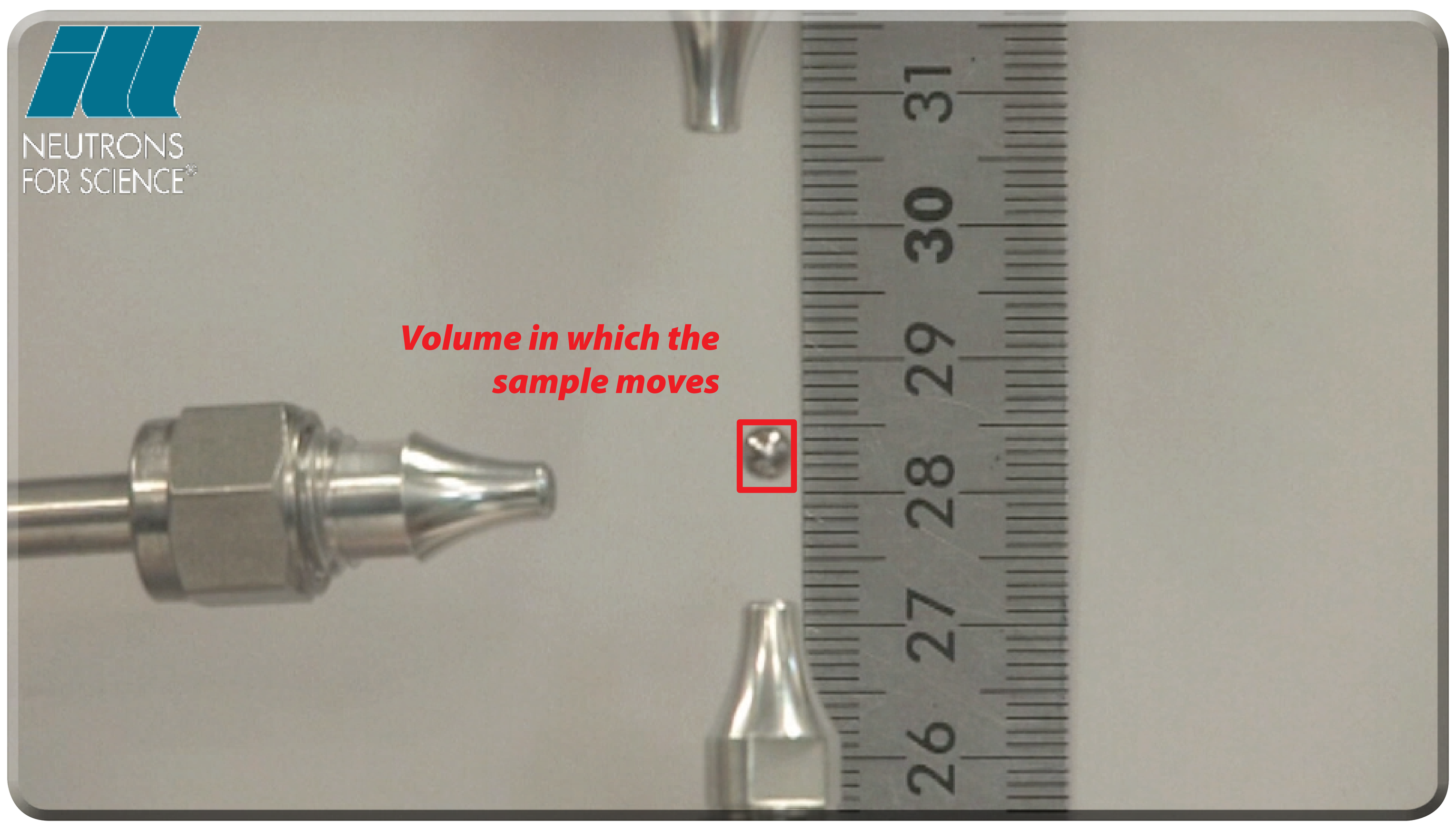
We have extensively tested this new technique with samples of different sizes and densities, different geometries of nozzles and several gases. We summarise in the graph the optimum argon flow rates for Ø2, Ø4 and Ø6 mm samples made from aluminium, stainless steel and lead. The horizontal and vertical axes are the flow rates for the main and secondary nozzles.

This multi-nozzle technique is very efficient and permits to levitate light and heavy samples. The choice of the gas remains however important and the best results are obtained with high-density gases. The horizontal movements of the samples do not exceed 0.1 mm and the vertical ones are reduced to about 0.5 mm.

In a very near future, the technique will be tested with 10µm pulsed lasers with the aim to verify the possibility to levitate melted samples. In case of success, we will design and build a 3000K containerless furnace.



highly unstable levitation with one jet



stable levitation with three jets

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Working meeting on prospects of levitation techniques
http://www.ill.eu/sane/about-us/events/nmi3-levitation-techniques/

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