NEUTRONS FOR SCIENCE

Levitating Samples in Neutron Beams

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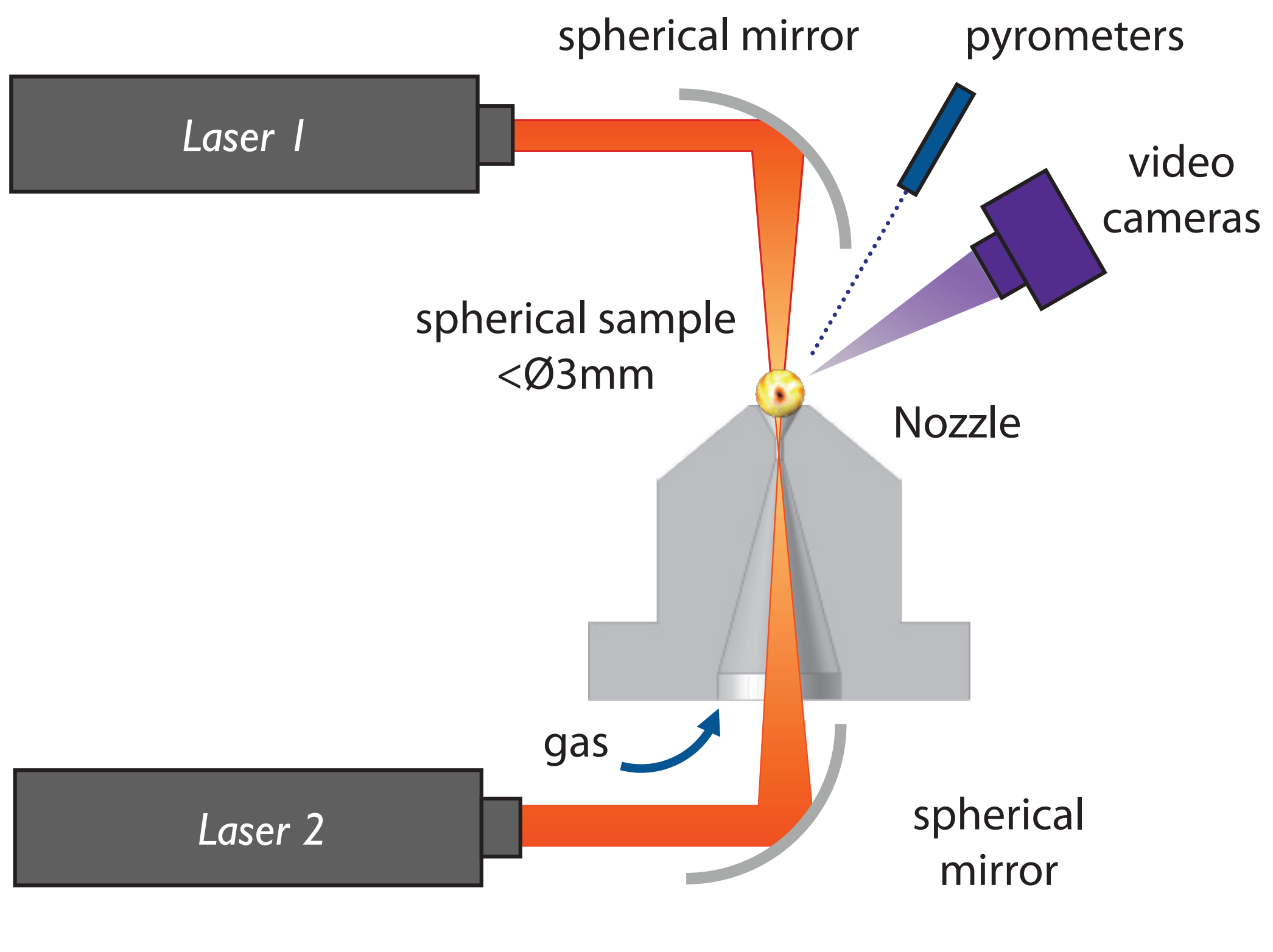
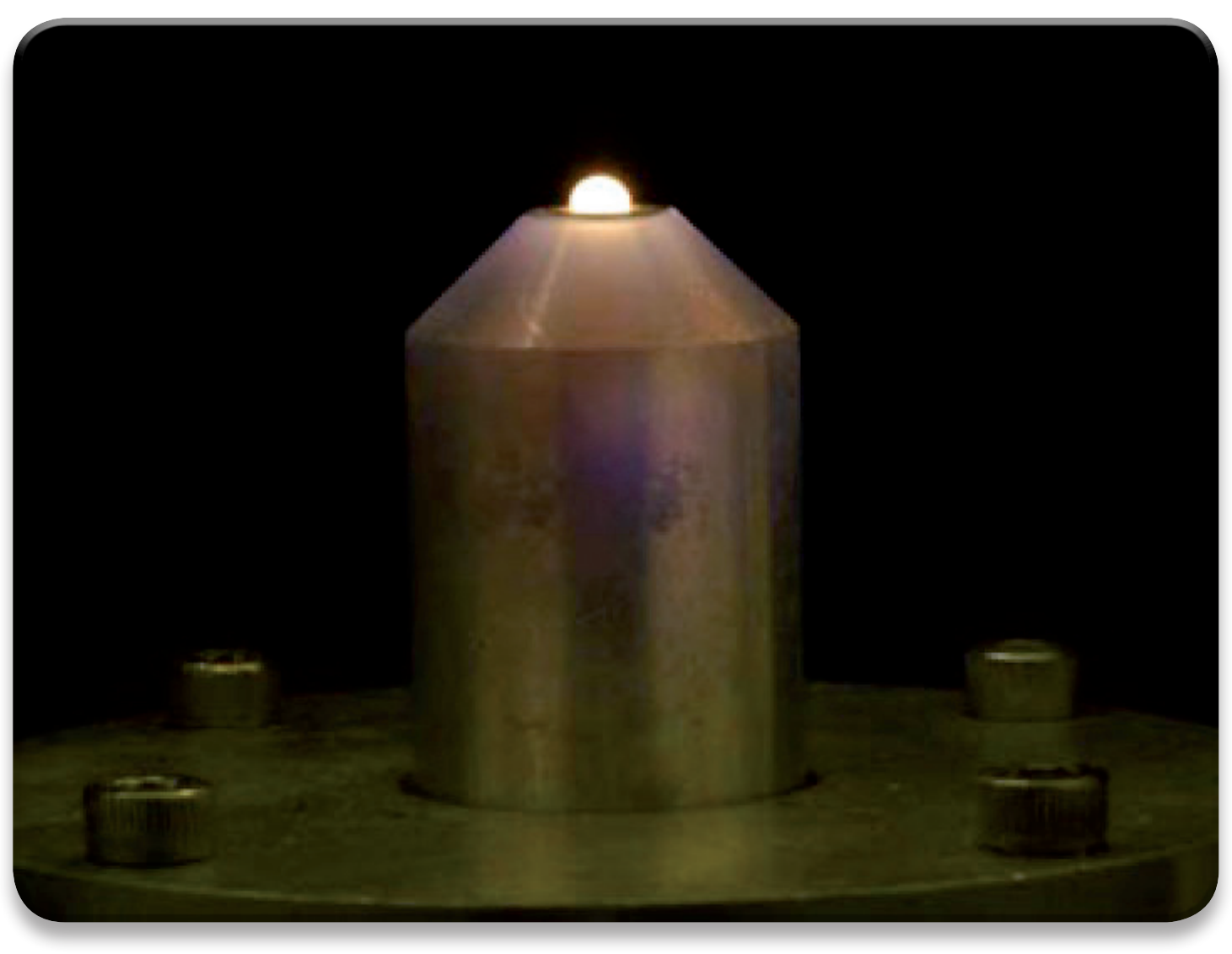


standard aerodynamic levitation setup

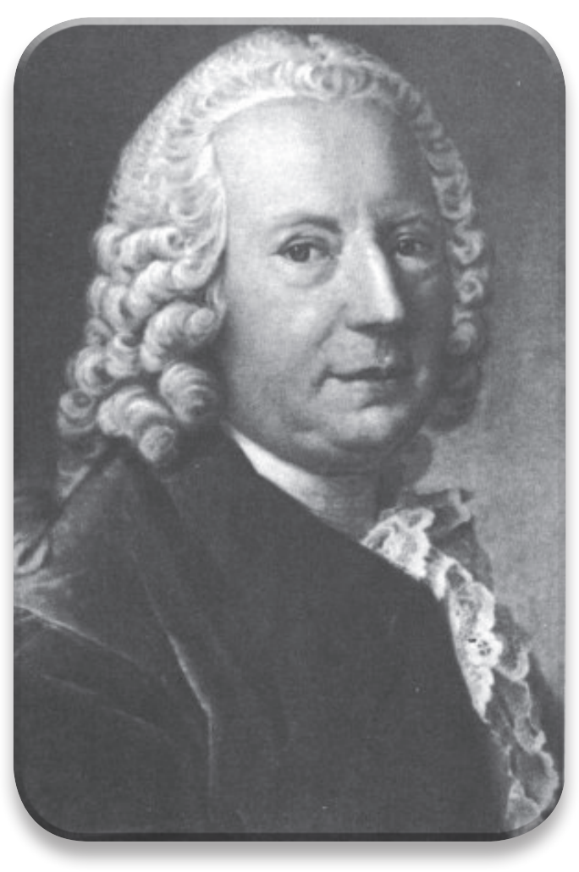
Motivated by the results of recent experiments performed in a furnace exploiting the aerodynamic levitation technique, we have investigated the possibility to levitate the samples well above the nozzle.



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.

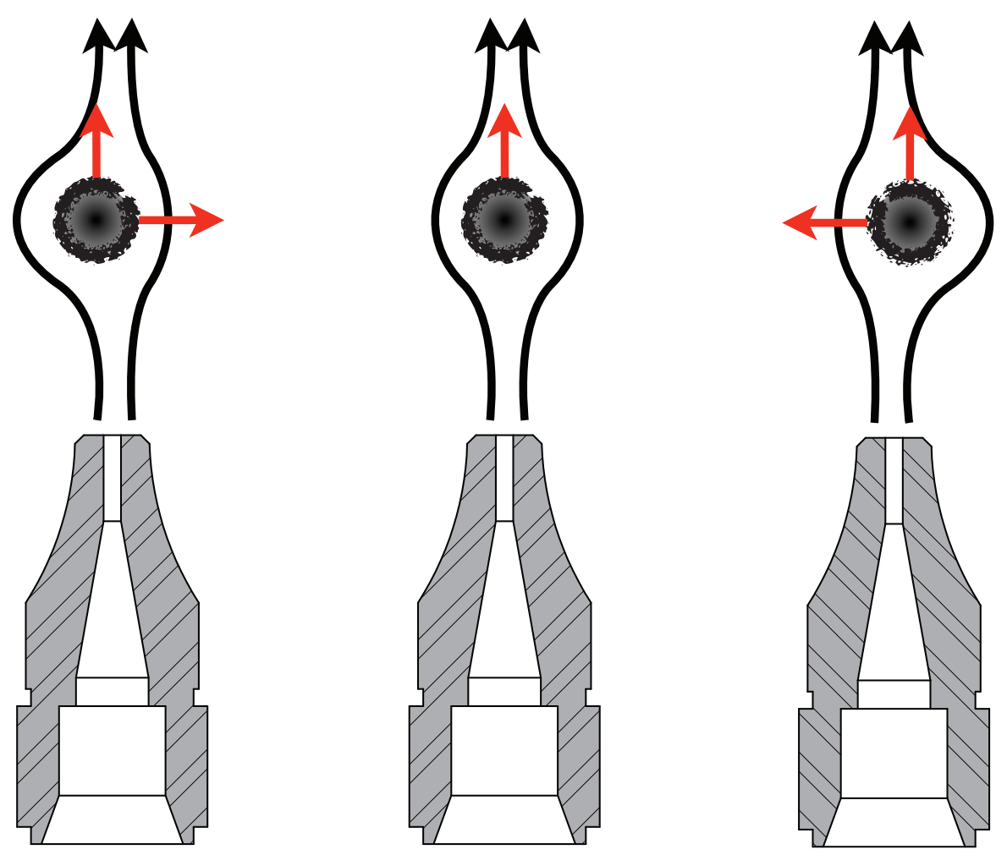
If we increase the gas flow, we can take advantage of the Coandă effect: the jet is drawn to the left and right surfaces and curves around, diverting the flow above the sample. Owing to the Bernouilli's principle, an increase in the speed of the fluid occurs simultaneously with a decrease in pressure or a decrease in the fluid's potential energy.



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

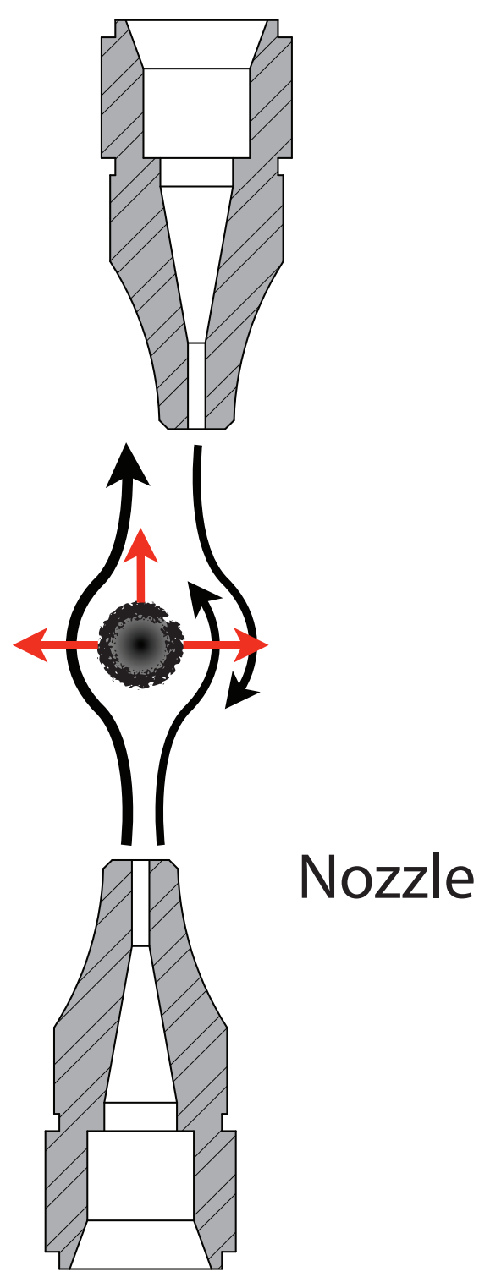
v	is the fluid flow speed at a point on a streamline,
g	is the acceleration due to gravity,
z	is the elevation of the point above a reference plane,
p	is the pressure at the point,
ρ	is the density of the fluid at all points in the fluid.

Bernouilli's equation

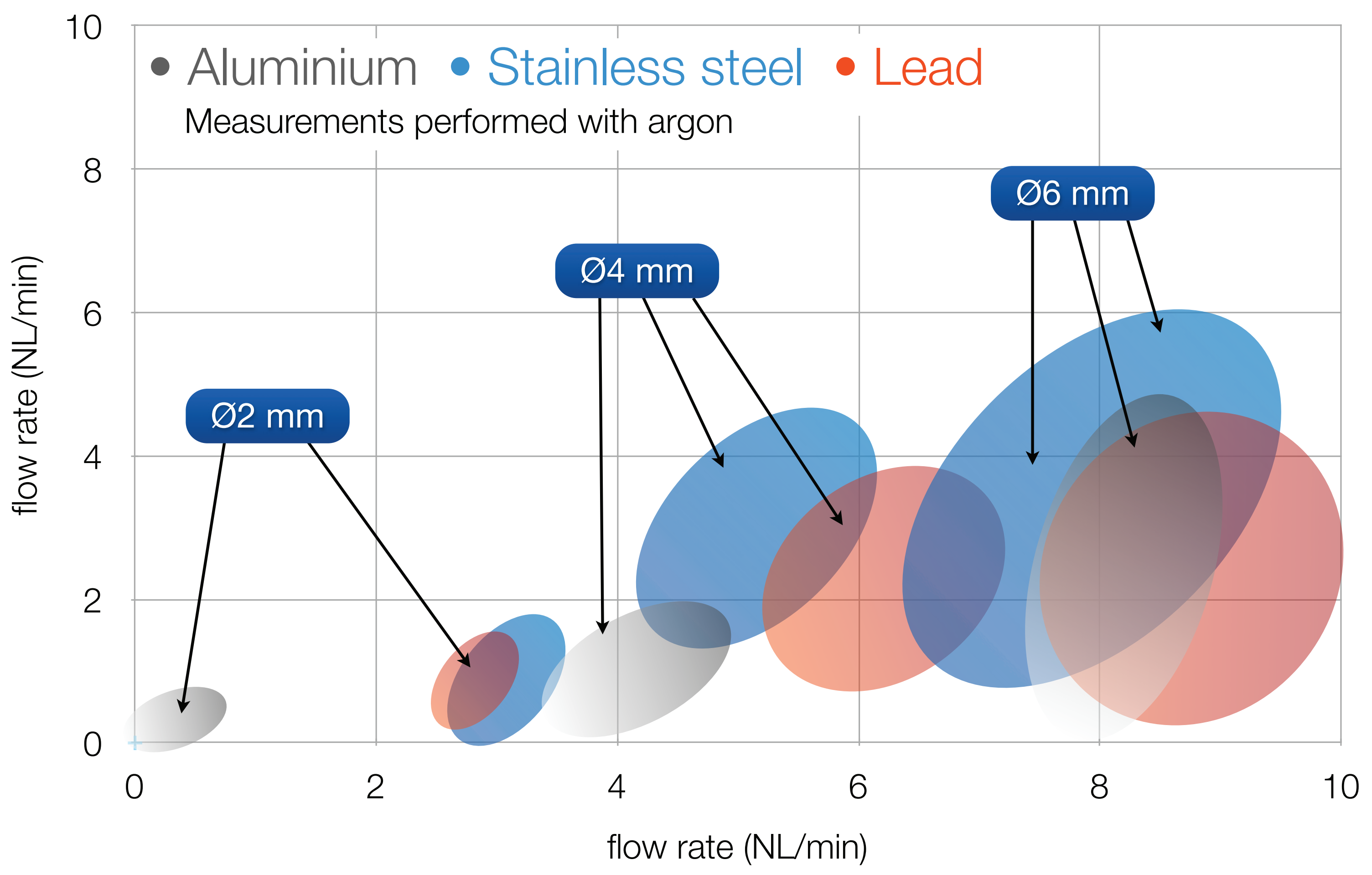


This change in the momentum of the gas flow is reacted out in the reduced pressure on the top surface of the sample, this suction being sufficient to overcome partly the weight. When the sample moves horizontally, the pressure difference resulting from the variation of the speed of the gas flowing on 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 real life, the flow is not laminar and the equilibrium is 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 these secondary jets.

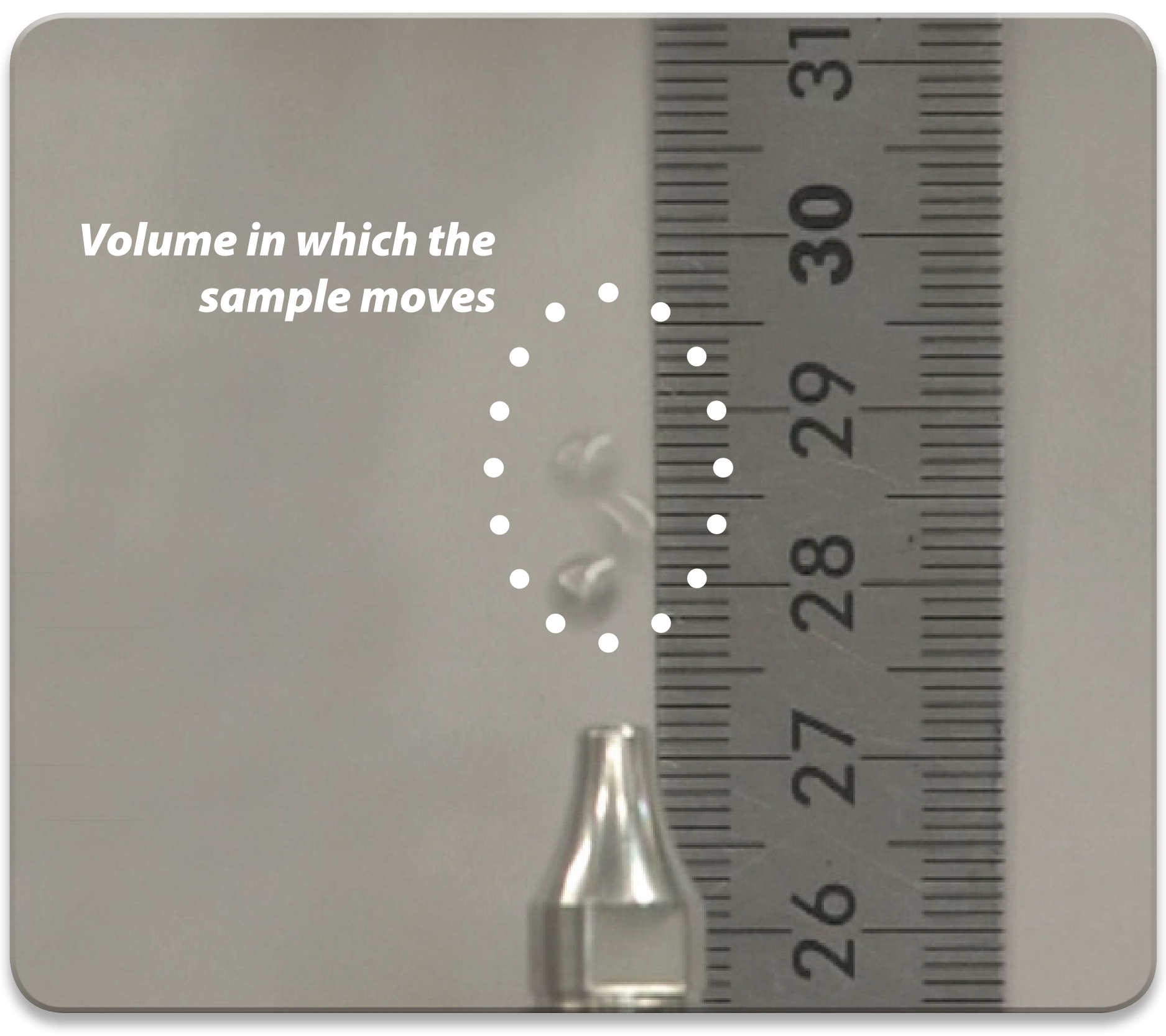


optimum flow rates applied to different samples

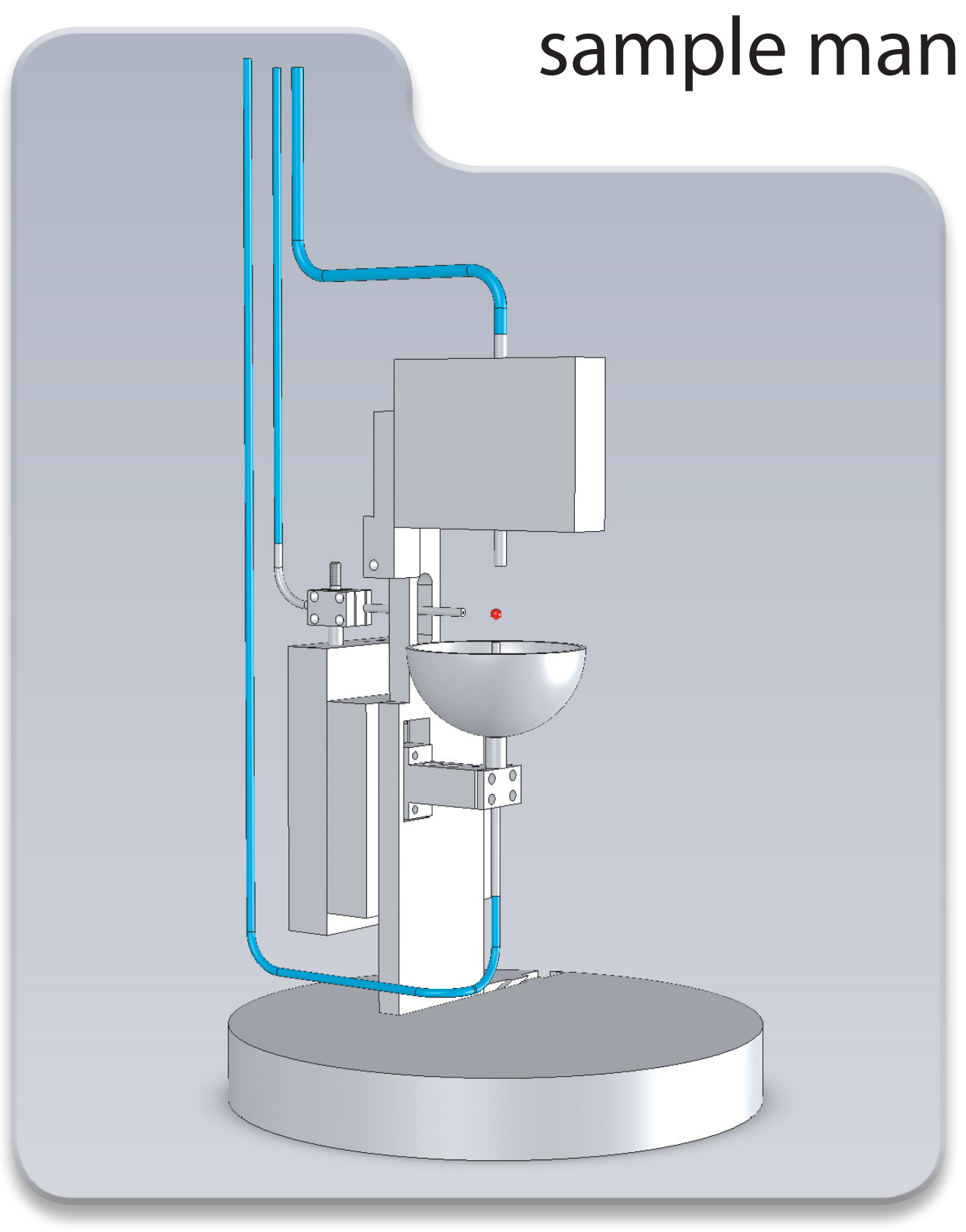
We have extensively tested this innovative technique with samples of different sizes and densities, different geometries of nozzles and several gases. We summarise in the graph the optimum argon flow rates for Ø2, Ø4 and Ø6 mm samples made from aluminium, stainless steel and lead. The horizontal and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

This multi-nozzle technique is very efficient and allows the levitation of light and heavy samples over long times, especially when using 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.

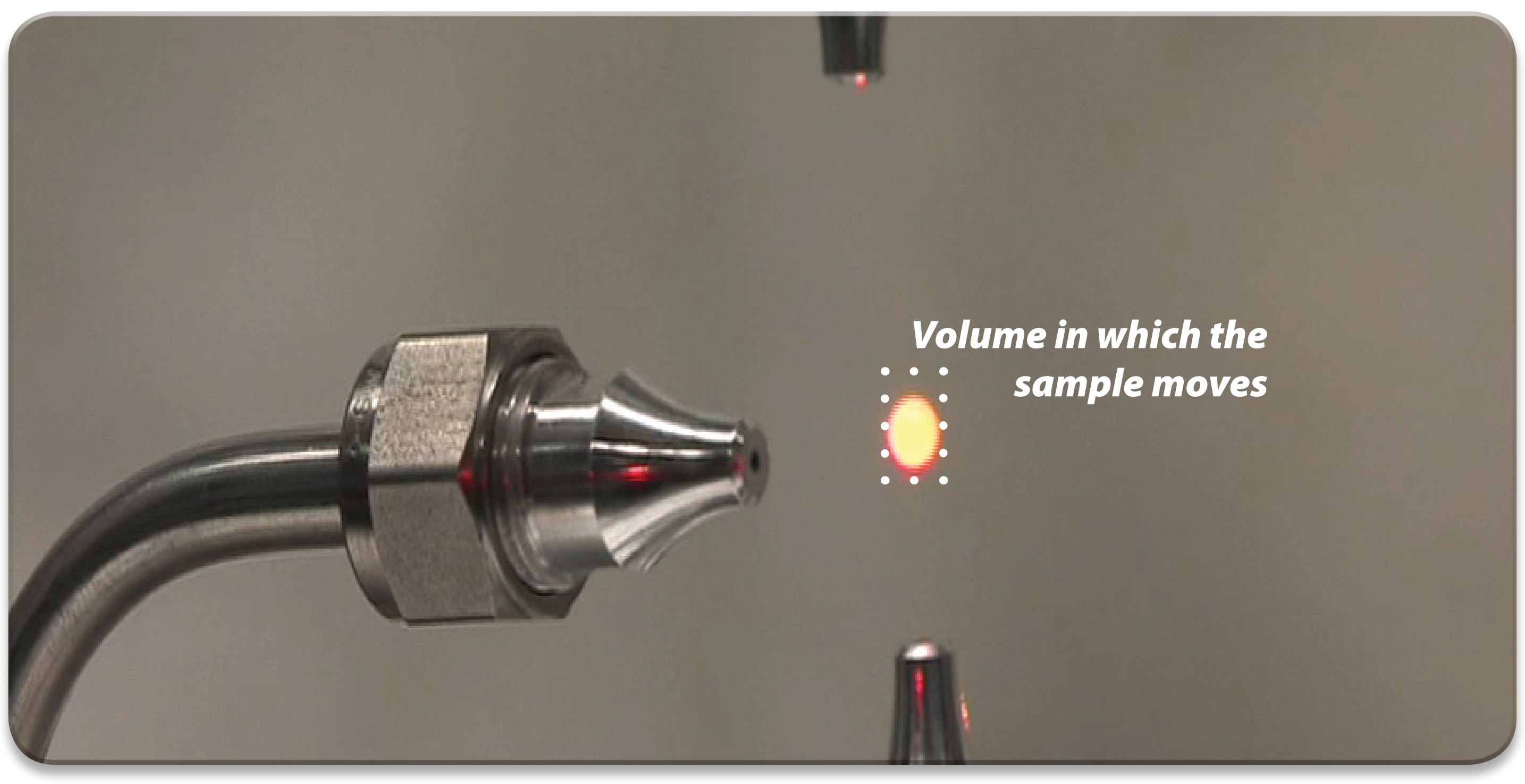
With a 125W 10 µm pulsed CO$_2$ laser, we have verified successfuly the possibility to levitate melted samples. Of course, the maximum temperature is determined by the reduction of the surface tension of the melt. A containerless furnace is now under construction. It will feature up to 4 motorized nozzles, a pyrometer, a camera and a sample manipulator.



highly unstable levitation with one jet



overview of the levitator



stable levitation with three jets while heating

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L. Hennet et al., *Appl. Phys. Lett.* **83** (2003) p. 3305

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

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