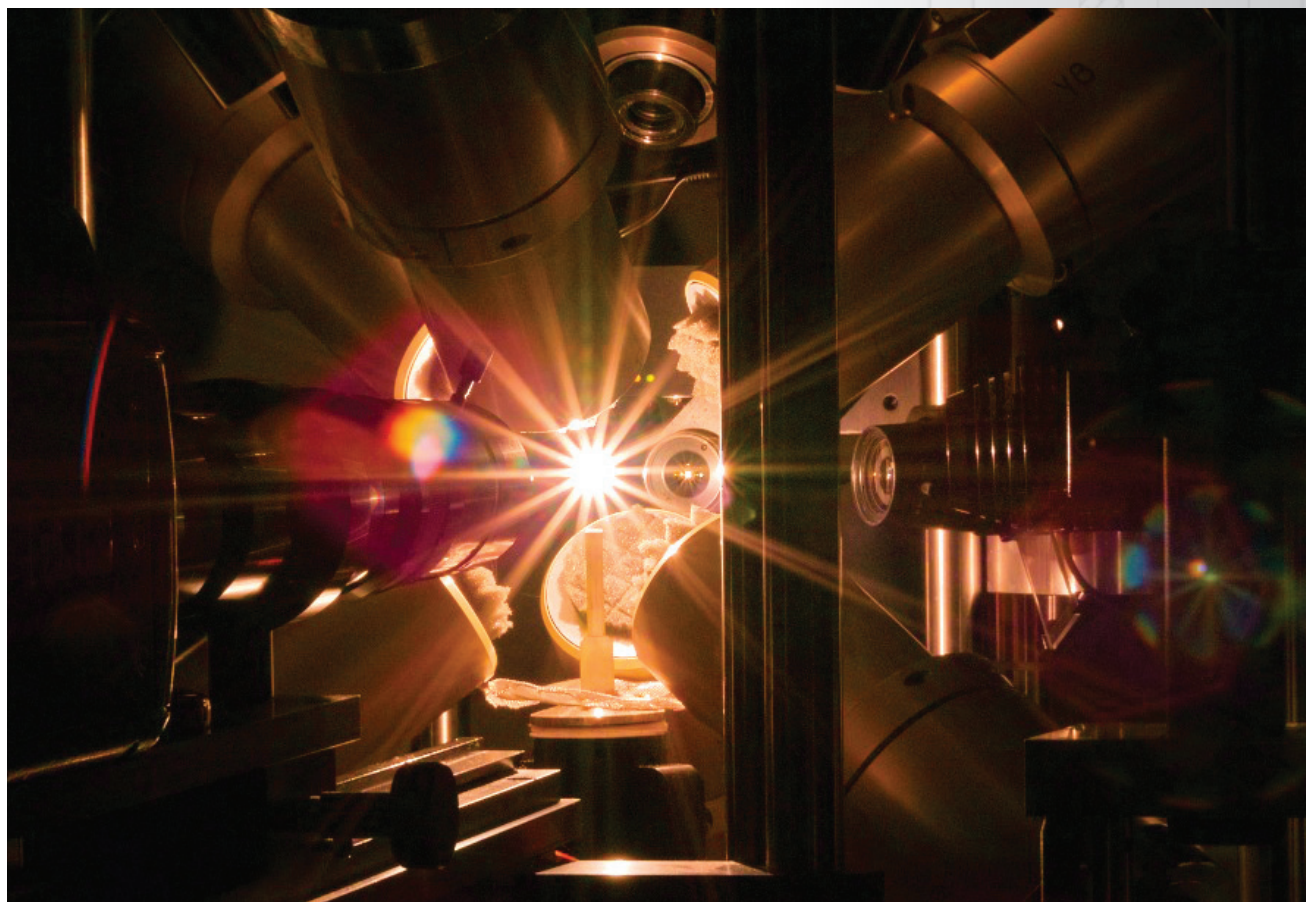


Product Description

Aero-Acoustic Levitator

For investigation and processing of solids and liquids
at very high temperatures, $>3000^{\circ}\text{C}$.



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Aero-Acoustic Levitator - Background and Applications

Liquids at very high temperatures occur in critical environments: aluminum fueled rocket exhaust, nuclear reactor accidents, volcanic eruptions, and in basic scientific investigations into the properties of materials. Temperatures in excess of 3000° Celsius can be of interest where no suitable containers are available. In fact, the discovery of inert containers for work at even lower temperatures is often the principal and most difficult problem to solve in experimental high temperature science. The Aero-Acoustic Levitator^{1,2} (AAL) provides containerless conditions for high temperature research. It enables well-controlled, contamination-free investigation of liquid and solid materials at extreme temperatures.

Containerless conditions achieved with the AAL allow study of deeply undercooled melts³⁻⁹ at temperatures far below the melting point. Novel glasses¹⁰⁻¹³ can be formed from melts that would otherwise crystallize upon cooling. Phase transitions under extreme conditions that may otherwise be missed are found by direct visual observation¹⁴⁻¹⁷. Well-controlled investigations of oxidation/reduction reactions¹⁸⁻²⁰ and phase diagrams²⁰ are possible. There are further possibilities for novel advances, such as surface tension and viscosity measurements by drop oscillation experiments²¹⁻²³, liquidus and melting point measurements that would otherwise be influenced by contaminants, optical property and emissivity measurements^{20,24-29} on liquids, synthesis of ultra-pure³⁰ and potentially single crystalline materials. Together, such investigations will advance scientific understanding of the liquid state of matter and gain a deeper understanding of material properties under technologically-important conditions.

In AAL, levitation is by the aerodynamic force of an upward flowing gas jet stabilized by acoustic forces subject to feedback control from an optical position-sensing system. In combination with laser beam heating, stable and well-controlled levitation of solid and molten materials is obtained at temperatures limited only by material volatility. Extensive applications to oxide materials have been made³¹. The AAL can be installed in a glove box for application to air sensitive materials.



Aero-Acoustic Levitator - Features and Specifications

Features of the basic system are given below. AAL systems are built to order following discussion of special needs for the applications of interest.

- Laser beam heating and melting of levitated samples with fast optical pyrometry for temperature measurements.
- Operation with any involatile solid or liquid material sample is stabilized; typically 0.25 to 0.35 cm diameter, and density up to at least 12 g/cc.
- Gas jet levitation in a three-axis acoustic system operated at 22 kHz.
- Electrically-heated aerodynamic levitation nozzle for use with air, oxygen, inert- or active-process gases. The gas is heated to stabilize laminar flow.
- Position sensing and sample velocity feedback controls acoustic standing waves to enhance sample stability.
- Acoustic forces control shape, spin, and can induce resonant oscillation of liquid drops.
- Video imaging provides well-resolved viewing of the levitated material under extreme radiance conditions.
- A fast video camera records sample rotation, oscillation, shape, crystallization events, etc. at kHz rates.
- The standard system has components integrated in a stand-alone frame. It can be configured for glove box operation.

Instrument Dimensions

Levitator structure	Base	0.6 x 0.6 m (24" x 24")
	Height	0.9 m (36")
System structure	Base	1.4 x 1.6 m (55" x 62")
	Height	2.0 m (78")
Total weight		500 kg (1100 lb)

Utility Requirements

Electrical (includes laser power)	6 circuits, 240V, 30A
Cooling water for each of 2 lasers	1000 liter/hour (4 gal/min)
Gases for levitation	up to 10 liter/min (21 ft ³ /hour)

Dimensions and utility requirements are approximate. Other supply voltages and line frequencies are available.



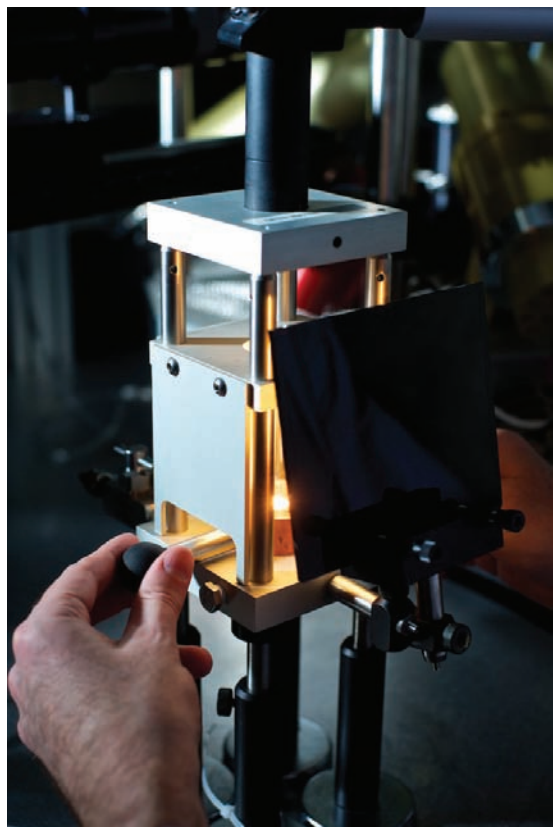


Photograph of the Aero-Acoustic Levitator system showing table-top levitator, CO₂ laser beam heating, rack-mounted electronics, Vision Research fast camera.

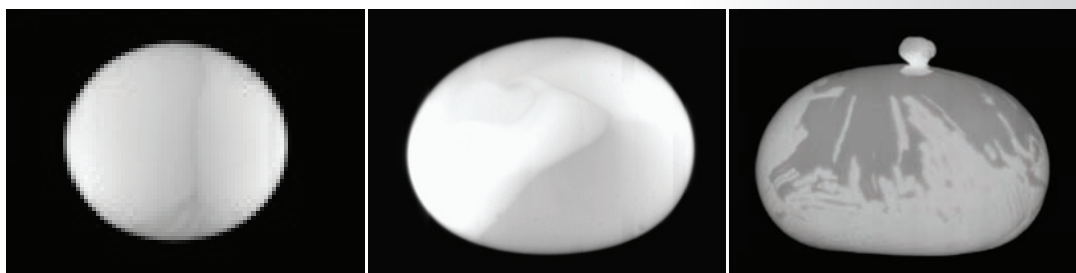




From the left: Dennis Merkley (acoustics, project management), Paul Nordine (PPM President), Jeff Sickel (software) during AAL delivery in Germany. Other team members not pictured here are James Rix (mechanical design) and John DeVos (electronics).



Laser Hearth melter³² used for sample preparation



Photographs of levitated samples

Left – liquid Al_2O_3 , $T_a = 3200^\circ\text{C}$; **Center** - liquid HfO_2 , density $\approx 9.6 \text{ g/cc}$ $T_a = 2910^\circ\text{C}$;

Right – Solid Y_2O_3 phase transition, $T_a = 2270^\circ\text{C}$.

Please contact PPM for discussion of your interest and needs.
Additional information, including video of AAL experiments is at
www.ppmeasurements.com



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