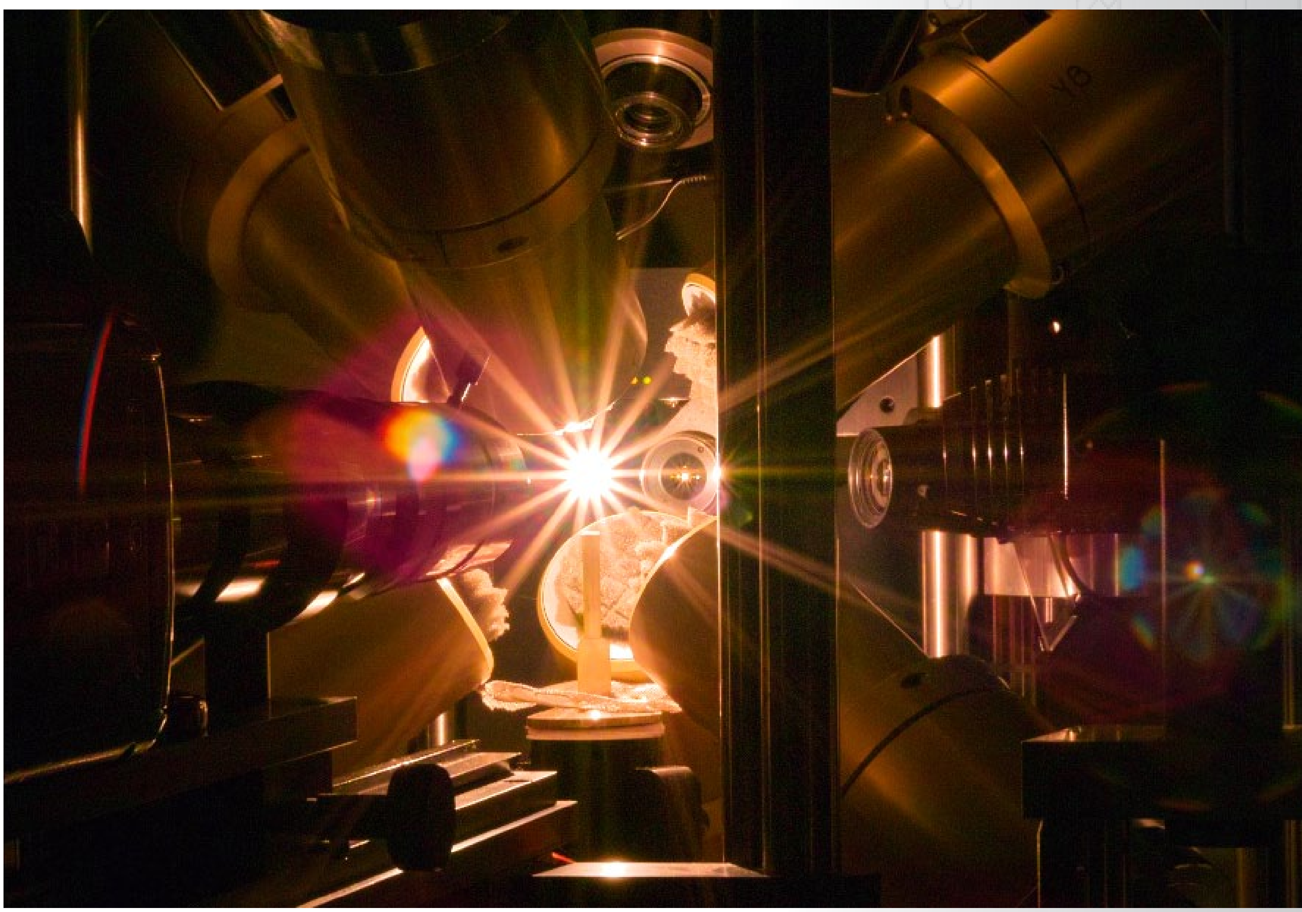
Product Description

Aero-Acoustic Levitator

Model 4.1

For investigation and processing of solids and liquids
at very high temperatures, >3000°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 melts[3-9] at temperatures far below the melting point. Novel glasses[10-13] 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 observation[14-17]. Well-controlled investigations of oxidation/reduction reactions[18-20] and phase diagrams[20] are possible. There are further possibilities for novel advances, such as surface tension and viscosity measurements by drop oscillation experiments[21,22], liquidus and melting point measurements[16] that would otherwise be influenced by contaminants, optical property and emissivity measurements on liquids[20,23-28], synthesis of ultra-pure[29] and potentially single crystalline materials, and calorimetric measurements of thermodynamic properties. 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 an 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 made. The AAL can be equipped with an inert shield gas flow or 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, 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, and crystallization events, at kHz rates.
- The standard system has components integrated in a stand-alone frame. It can be configured for glove box operation.

Added features of the Model 4.1 AAL System

- Motor-operated axial positioning of three acoustic transducers. The phase difference of opposed transducers is kept at 180 to maintain coincident nodes from the direct and reflected outputs of the acoustic transducers.
- Increased temperature capability in the gas jet heater to obtain laminar jet flow at increased flow rates for operation with high density materials.
- Inert shield gas flow apparatus for work on air-sensitive materials.
- Motor-driven stinger for melting point measurements. For melting/liquidus studies by observing stinger-induced crystallization of liquids below, but not above the melting/liquidus temperature.
- Oscillating drop measurements for surface tension and viscosity measurements. Diode laser source, detector, and electronics, with data acquisition and operating software.

Instrument Dimensions

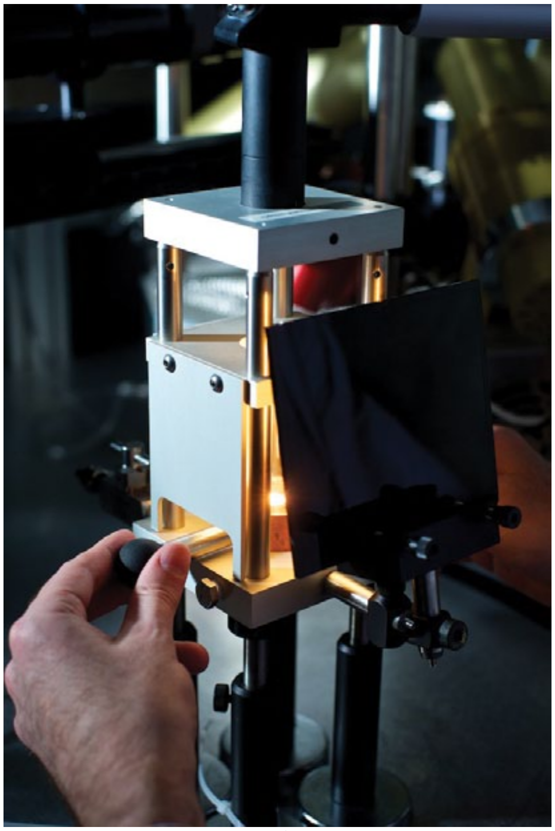
Levitator structure	Base	0.6 x 0.6 m (24″x 24″)
	Height	0.9 m (36″)
System structure	Base	1.4 x 1.6 m (55″ x 62″)
	Height	2.0 m (78″)
Total weight		500 kg (1100 lb)

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 Model 3.1 Aero-Acoustic Levitator system showing table-top levitator, CO_2 laser beam heating, rack-mounted electronics, and Vision Research fast camera.

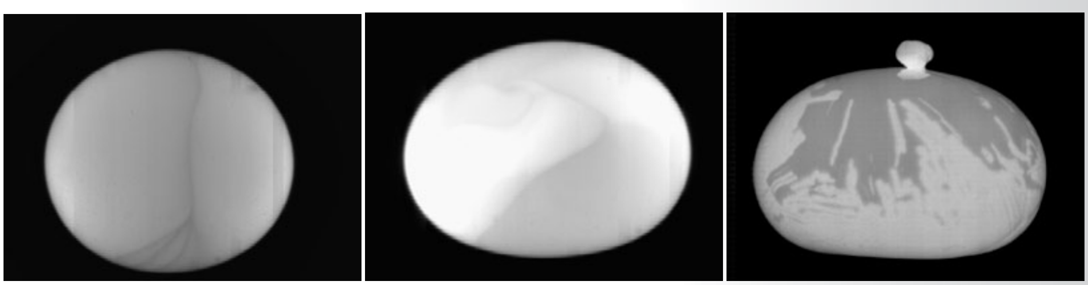


Laser Hearth melter[30] used for sample preparation

From the left:

Dennis Merkley (acoustics, project management),
Paul Nordine (PPM President),
Jeff Sickel (software)

during AAL delivery in Germany[32].
Other team members not pictured here are James Rix (mechanical design) and John DeVos (electronics).



Photographs of levitated samples

Left – liquid Al_2O_3, Ta = 3200°C; **Center** - liquid HfO_2, density ≈9.6 g/cc Ta = 2910°C;
Right – Solid Y_2O_3 phase transition, Ta = 2270°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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