

## International Journal of Innovative Research in Science, Engineering and Technology

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# Convergence of Many Body Expansion for Helium and Oxygen

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**ABSTRACT:** The practical utility of liquid gases is of great importance. The origin of extremely low temperatures, which are attainable by liquid air, liquid hydrogen and liquid helium, has opened a new and vast branch of scientific research. This fact has shown the need that every modern laboratory must have at least one liquid-air instrument. Liquid air bottles are now available at relatively low prices and easily.

### Obtaining oxygen and rare gases from liquid air

The fractional distillation method of air is the main method of obtaining oxygen industrially. Since the boiling point of nitrogen is  $-195\text{ }^{\circ}\text{C}$ . and Oxygen  $-183\text{ }^{\circ}\text{C}$ , so the part that comes first in vapor form is predominant in Nitrogen. Oxygen is predominant in what eventually comes in the vapor form, so a few fractional distillations will completely separate the two major parts of the air.

Rare gases (helium, neon, argon) have also been obtained by this method. Liquid air can be divided into two parts: the first more volatile (helium, hydrogen, neon) and the second less volatile (oxygen, argon, carbon dioxide, krypton, xenon). On cooling the first part with liquid hydrogen, gases other than hydrogen (helium and neon) will be obtained in the separate part. Similarly helium and neon can be obtained from air.

### calorimetry -

Dewar used calorimeters of liquid air, liquid oxygen, liquid hydrogen for the research of specific heat at low temperatures of objects. The calorimeter of liquid hydrogen can measure the calorific value of a liquid up to 0.003 calories.

### Achievement of high vacuum

This can be done through the use of liquid gases. For example, if a vessel containing a gas less volatile than air (such as sulfuric acid or water vapor) is surrounded by liquid air, all the gas inside will turn into a solid and thus create a high vacuum. Will go

### Study of the upper atmosphere

In the laboratory we can obtain lower temperatures with the help of liquid gases, which would be similar to the conditions in the upper atmosphere. In this way the upper atmosphere can also be studied sitting in the laboratory.

**KEYWORDS:** helium, oxygen, expansion, many, body, liquefaction, liquid, calorific, industrial

## I. INTRODUCTION

Although liquefaction devices based on the Joule-Thomson effect are of particular use, they cannot be called completely satisfactory, as their efficiency is about 15%. The method based on the principles of adiabatic diffusion of gases (the expansion of a gas in which heat is neither allowed to come in from outside nor from inside to outside) proved to be definite and effective.

Although Pictet had previously liquefied oxygen by "cascade method", but by adiabatic diffusion method, Calaret did the liquefaction of oxygen in 1877 AD.[1,2]

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The adiabatic variance method was not a continuous method. Therefore, this method was not used on an industrial scale until Claude and Heylandt developed a new method for liquefaction of air. The biggest difficulty was which lubricants to use in the moving parts of the machine, as all ordinary lubricants would turn into a solid at the respective temperatures. Claude overcame this difficulty by using petroleum ether, which was at  $-160^{\circ}\text{C}$ . Stays sticky.

The compressed gas is sent through a pipe into the device of the clod, which further splits into two branches at a point. Some amount of gas acting on the expansion cylinder pushes it up and cools itself. Now this cold gas moves from bottom to top, due to which the gas coming down in the tube of liquefaction becomes cold. When this gas from the tube comes out at the micro-exit, it expands and cools down and becomes liquefied. The amount of gas that is left over from liquefaction goes back to the compression pump and thus the whole process is repeated over and over again.

In 1934, Kapitza liquefied helium and hydrogen by the Claud method. In 1947 AD, by the Capizza method of Collins, he prepared the helium-liquid-machine in industrial form.[3,4]

## II. DISCUSSION

Adiabatic demagnetization method is especially important in the direction of achieving absolute zero temperature. Before the development of this method, the lowest attainable temperatures were that of liquid helium and solid helium, which were obtained respectively. In 1926 AD, Peter Debye made it clear on theoretical grounds that even lower temperatures can be achieved by adiabatic demagnetization of paramagnetic salts. In the process of imparting magnetic force to an object, its temperature increases somewhat. Therefore, on the contrary, if a magnetic object is demagnetized, it cools down.

The above theoretical prediction was proved by Simon and Kurti, Giauque and McDougall in 1934 AD. Paramagnetic (having magnetic properties in a magnetic field and losing magnetic properties after the magnetic field is removed) object B (gadolinium sulphate) is placed in an ellipsoid or sphere-shaped glass tube A, which is filled with dewar bottles c, d and f. is surrounded. They consist of liquid helium, liquid hydrogen and liquid air respectively. This whole group is placed between the north-south ends of the electromagnet.[5,6]

Magnetic force is imparted to object B within a magnetic field of 10,000 Gauss. The heat generated in the magnetization process is carried out by the flow of hydrogen gas. Meanwhile, the experimental object comes to the temperature of liquid helium. Then the magnetic field is broken, due to which object B becomes adiabatic demagnetization. The temperature of the experimental object falls further and it becomes liquefied. The interesting thing is that De Haas got the temperature up to 0.002 degree Kelvin by method in 1944 AD.

The principles of this method are based on the Joule-Thomson Effect and Regenerative Cooling. The use of the "Joule-Thomson effect" over the "cascade method" has two distinct advantages:

(1) It is sufficient to cool the gas up to the inversion temperature, while the "cascade method" has to be cooled down to the critical temperature which is far below the reversal temperature.

2. Much less prefreezing is required than the "cascade method". Then the amount of cooling achieved by the "Joule-Thomson effect" is increased by "regenerative cooling". The Principle of Regeneration was first used in this direction by Linde, Hampson and many others.

Linde (1895 AD) first used this method for the liquefaction of air. Dewar liquefied hydrogen by this method in 1898 AD and Camerling Onnes (1908 AD) liquefied helium .[7,8]

In Linde's apparatus, the compressed air at 200 "atmospheres" is sent through a water-cooled pipe, where the heat generated by the shrinkage is released. The compressed air is then sent through an annular tube with a small opening at the end. When the air comes out of the subtle outflow, it expands and its temperature drops. This cooled air now moves upwards and again goes into the "compression pump". This cooling air is almost at the same external pressure and

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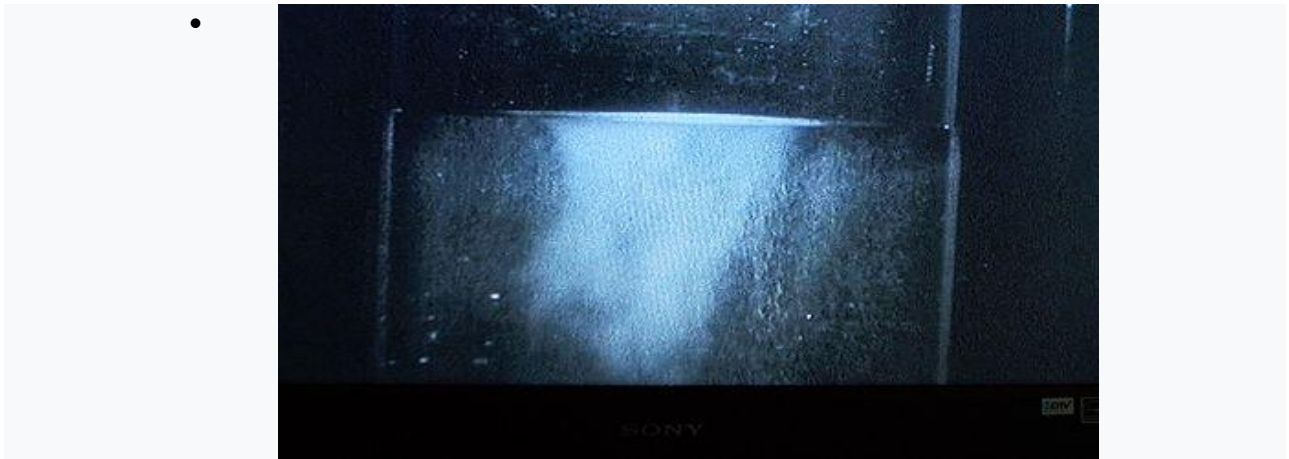
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cools the air inside the annular tube along the way. Due to repeated contraction and expansion, that temperature is attained which is sufficient for the liquefaction of air.

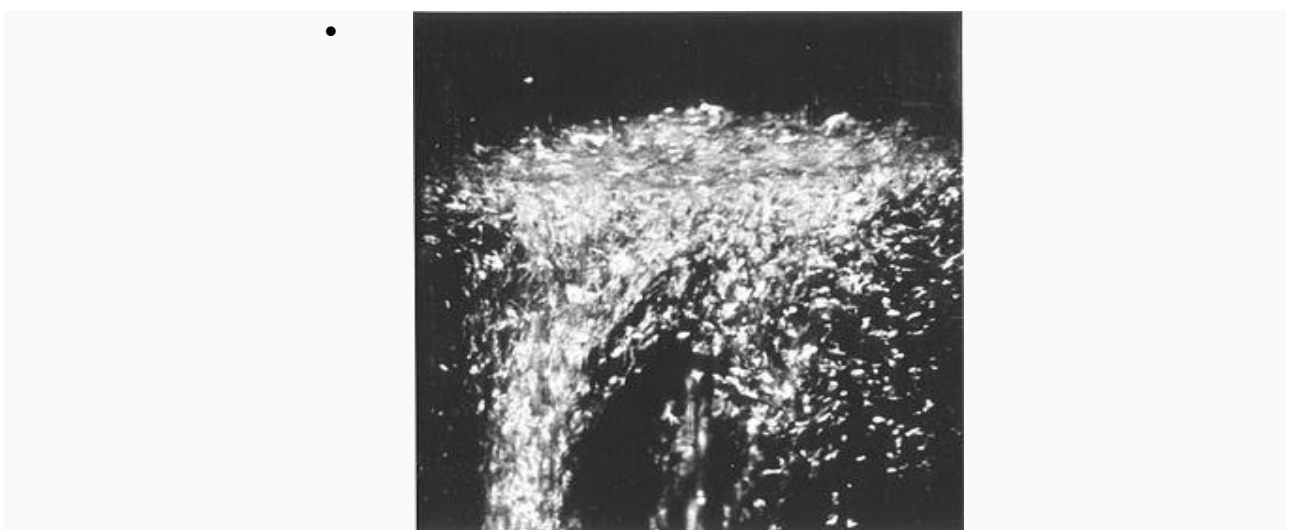
Linde's device was powered by a three-horsepower device and supplied one liter of liquid air per hour.

**Liquid helium** is a physical state of helium at very low temperatures at standard atmospheric pressures. Liquid helium may show superfluidity.[9,10]

At standard pressure, the chemical element helium exists in a liquid form only at the extremely low temperature of  $-269\text{ }^{\circ}\text{C}$  ( $-452.20\text{ }^{\circ}\text{F}$ ;  $4.15\text{ K}$ ). Its boiling point and critical point depend on which isotope of helium is present: the common isotope helium-4 or the rare isotope helium-3. These are the only two stable isotopes of helium. See the table below for the values of these physical quantities. The density of liquid helium-4 at its boiling point and a pressure of one atmosphere (101.3 kilopascals) is about  $125\text{ g/L}$  ( $0.125\text{ g/ml}$ ), or about one-eighth the density of liquid water.



Liquid helium (in a vacuum bottle) at  $4.2\text{ K}$  ( $-268.95\text{ }^{\circ}\text{C}$ ) and  $1\text{ bar}$  ( $15\text{ psi}$ ) boiling slowly.



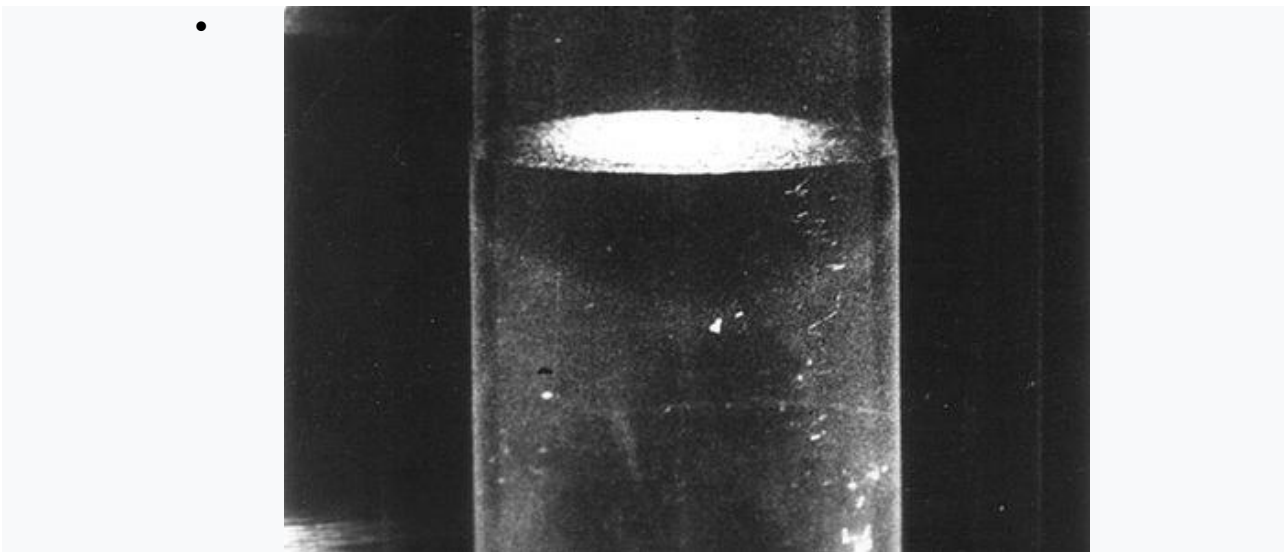
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Lambda point transition: as the liquid is cooled down through 2.17 K ( $-270.98^{\circ}\text{C}$ ), the boiling suddenly becomes violent for a moment.



Superfluid phase at temperature below 2.17 K ( $-270.98^{\circ}\text{C}$ ). In this state, the thermal conductivity is extremely high. This causes heat in the body of the liquid to be transferred to its surface so quickly that vaporization takes place only at the free surface of the liquid. Thus, there are no gas bubbles in the body of the liquid.

### III. RESULTS

The **expansion ratio** of a liquefied and cryogenic substance is the volume of a given amount of that substance in liquid form compared to the volume of the same amount of substance in gaseous form, at room temperature and normal atmospheric pressure.<sup>[1]</sup>

If a sufficient amount of liquid is vaporized within a closed container, it produces pressures that can rupture the pressure vessel. Hence the use of pressure relief valves and vent valves are important.<sup>[2]</sup>

The expansion ratio of liquefied and cryogenic from the boiling point to ambient is:

nitrogen 1 to 696

liquid helium 1 to 757

argon 1 to 847

liquid hydrogen 1 to 851

liquid oxygen 1 to 860[11,12]

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**Thermal expansion** is the tendency of matter to change its shape, area, volume, and density in response to a change in temperature, usually not including phase transitions.<sup>[1]</sup>

Temperature is a monotonic function of the average molecular kinetic energy of a substance. When a substance is heated, molecules begin to vibrate and move more, usually creating more distance between themselves. Substances which contract with increasing temperature are unusual, and only occur within limited temperature ranges (see examples below). The relative expansion (also called strain) divided by the change in temperature is called the material's **coefficient of linear thermal expansion** and generally varies with temperature. As energy in particles increases, they start moving faster and faster weakening the intermolecular forces between them, therefore expanding the substance.

Unlike gases or liquids, solid materials tend to keep their shape when undergoing thermal expansion.

Thermal expansion generally decreases with increasing bond energy, which also has an effect on the melting point of solids, so, high melting point materials are more likely to have lower thermal expansion. In general, liquids expand slightly more than solids. The thermal expansion of glasses is slightly higher compared to that of crystals. At the glass transition temperature, rearrangements that occur in an amorphous material lead to characteristic discontinuities of coefficient of thermal expansion and specific heat. These discontinuities allow detection of the glass transition temperature where a supercooled liquid transforms to a glass. An interesting "cooling-by-heating" effect occurs when a glass-forming liquid is heated from the outside, resulting in a temperature drop deep inside the liquid.

Absorption or desorption of water (or other solvents) can change the size of many common materials; many organic materials change size much more due to this effect than due to thermal expansion. Common plastics exposed to water can, in the long term, expand by many percent

The **coefficient of thermal expansion** describes how the size of an object changes with a change in temperature. Specifically, it measures the fractional change in size per degree change in temperature at a constant pressure, such that lower coefficients describe lower propensity for change in size. Several types of coefficients have been developed: volumetric, area, and linear. The choice of coefficient depends on the particular application and which dimensions are considered important. For solids, one might only be concerned with the change along a length, or over some area.

The volumetric thermal expansion coefficient is the most basic thermal expansion coefficient, and the most relevant for fluids. In general, substances expand or contract when their temperature changes, with expansion or contraction occurring in all directions. Substances that expand at the same rate in every direction are called isotropic. For isotropic materials, the area and volumetric thermal expansion coefficient are, respectively, approximately twice and three times larger than the linear thermal expansion coefficient.

Liquid oxygen has a pale blue color and is strongly paramagnetic: it can be suspended between the poles of a powerful horseshoe magnet. Liquid oxygen has a density of 1.141 kg/L (1.141 g/ml), slightly denser than liquid water, and is cryogenic with a freezing point of 54.36 K (−218.79 °C; −361.82 °F) and a boiling point of 90.19 K (−182.96 °C; −297.33 °F) at 1 bar (15 psi). Liquid oxygen has an expansion ratio of 1:861 under 1 standard atmosphere (100 kPa) and 20 °C (68 °F), and because of this, it is used in some commercial and military aircraft as a transportable source of breathing oxygen.[13,14]

Because of its cryogenic nature, liquid oxygen can cause the materials it touches to become extremely brittle. Liquid oxygen is also a very powerful oxidizing agent: organic materials will burn rapidly and energetically in liquid oxygen. Further, if soaked in liquid oxygen, some materials such as coal briquettes, carbon black, etc., can detonate unpredictably from sources of ignition such as flames, sparks or impact from light blows. Petrochemicals, including asphalt, often exhibit this behavior.

The tetraoxygen molecule (O<sub>4</sub>) was first predicted in 1924 by Gilbert N. Lewis, who proposed it to explain why liquid oxygen defied Curie's law. Modern computer simulations indicate that, although there are no stable O<sub>4</sub> molecules in liquid oxygen, O<sub>2</sub> molecules do tend to associate in pairs with antiparallel spins, forming transient O<sub>4</sub> units.



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Liquid oxygen (pale blue liquid) in a beaker.



When liquid oxygen is poured from a beaker into a strong magnet, the oxygen is temporarily suspended between the magnet poles, owing to its paramagnetism.

## IV. CONCLUSION



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## Oxygen plant expansion engine

The expansion of liquids is usually measured in a container. When a liquid expands in a vessel, the vessel expands along with the liquid. Hence the observed increase in volume (as measured by the liquid level) is not the actual increase in its volume. The expansion of the liquid relative to the container is called its apparent expansion, while the actual expansion of the liquid is called real expansion or absolute expansion. The ratio of apparent increase in volume of the liquid per unit rise of temperature to the original volume is called its coefficient of apparent expansion. The absolute expansion can be measured by a variety of techniques, including ultrasonic methods.

Historically, this phenomenon complicated the experimental determination of thermal expansion coefficients of liquids, since a direct measurement of the change in height of a liquid column generated by thermal expansion is a measurement of the apparent expansion of the liquid. Thus the experiment simultaneously measures two coefficients of expansion and measurement of the expansion of a liquid must account for the expansion of the container as well. For example, when a flask with a long narrow stem, containing enough liquid to partially fill the stem itself, is placed in a heat bath, the height of the liquid column in the stem will initially drop, followed immediately by a rise of that height until the whole system of flask, liquid and heat bath has warmed through. The initial drop in the height of the liquid column is not due to an initial contraction of the liquid, but rather to the expansion of the flask as it contacts the heat bath first. Soon after, the liquid in the flask is heated by the flask itself and begins to expand. Since liquids typically have a greater percent expansion than solids for the same temperature change, the expansion of the liquid in the flask eventually exceeds that of the flask, causing the level of liquid in the flask to rise. For small and equal rises in temperature, the increase in volume (real expansion) of a liquid is equal to the sum of the apparent increase in volume (apparent expansion) of the liquid and the increase in volume of the containing vessel. The absolute expansion of the liquid is the apparent expansion corrected for the expansion of the containing vessel[15]

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