Bubbles

In soap, in science, in physics, in insulation and in construction

Bubbles

Pears' Soap most famous advertisement, the painting was purchased by Thomas Barratt in August 1890

Bubbles

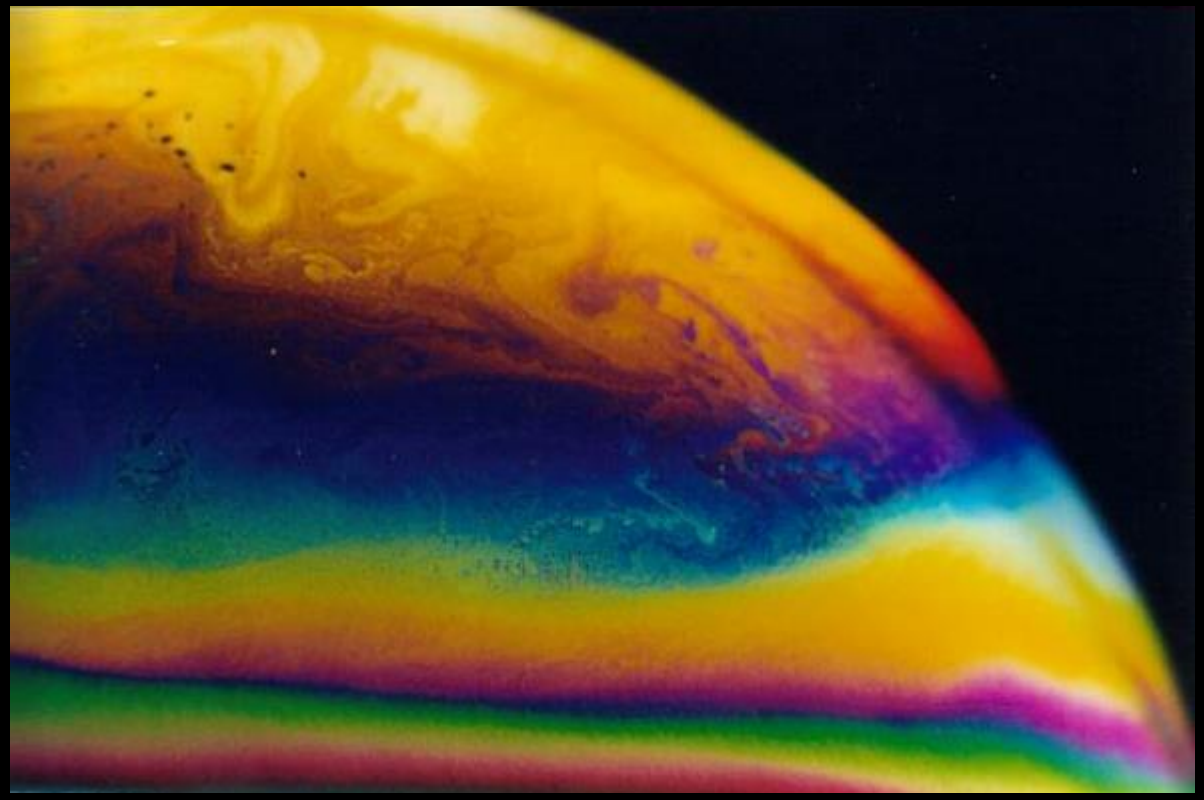
Bubbles

Bubbles are only visible because they have a different refractive index from the surrounding substance.

Bubbles of water vapour in boiling water can only be seen because the refractive index of the water is different from that of the water vapour inside the bubble

Soap Bubbles

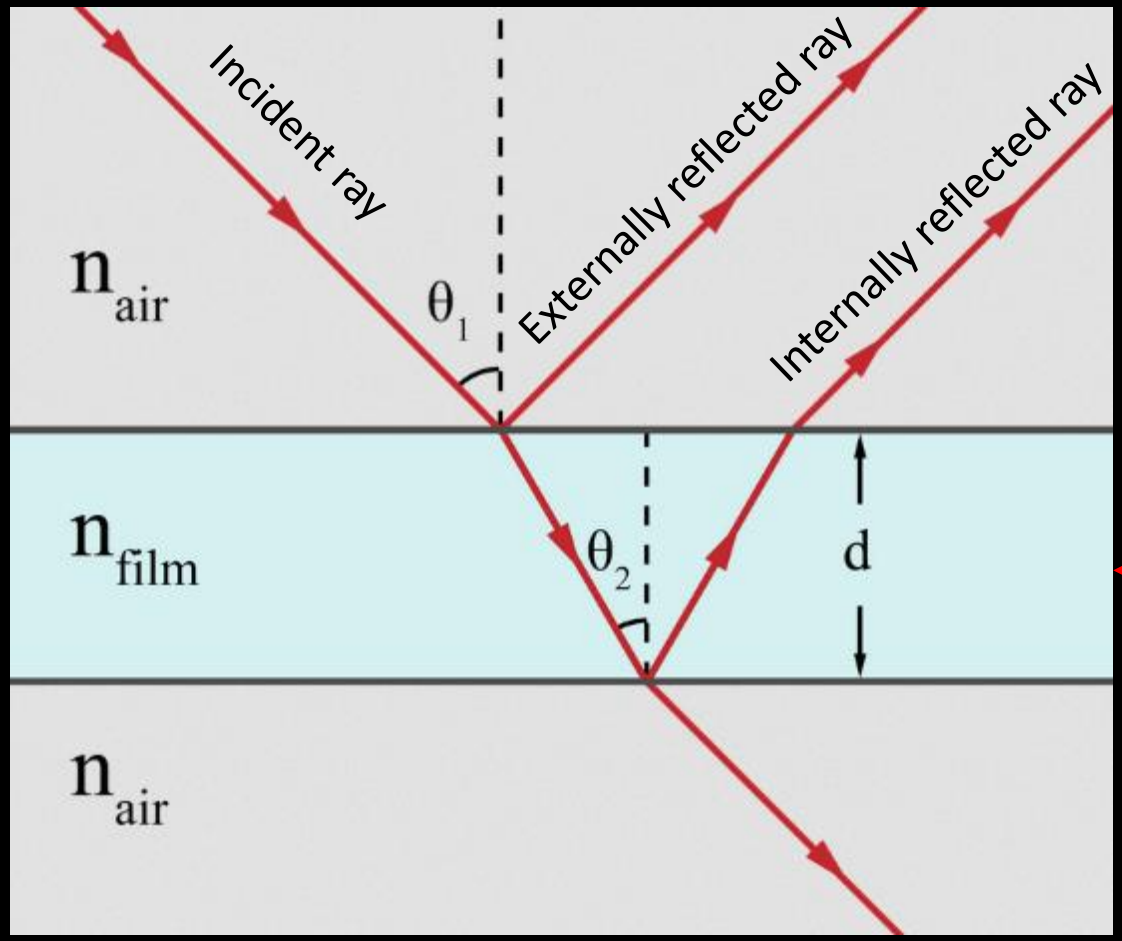
Soap bubbles are very thin indeed – at their thinnest they are just a molecule thick



Thin film maths - I

The colours you can see in a soap bubble are due to interference between the incident and reflected light. Light is an electromagnetic wave. When light bounces off the OUTSIDE face of the bubble it reverses phase. But because the refractive index of the bubble is greater than that of the air, no phase reversal happens at the INSIDE "back" face. So a vanishingly thin bubble will look black, because the incident and reflected light exactly cancel each other.

Thin film maths - II



The thin film (bubble)

Thin film maths - III

$$2n_{\text{film}}\, d \cos(\theta_2) = \left(m - \frac{1}{2}\right)\lambda$$ for constructive interference of reflected light

$$2n_{\text{film}}\, d \cos\left(\theta_2\right) = m\lambda$$ for destructive interference of reflected light

Where:
d is the film thickness
ϑ_2 is the internally reflected angle
λ is the wavelength of light
n is the refractive index
m is an integer

Nucleation

Small discontinuities in a vessel provide the nucleation sites for the birth of bubbles.

Once a bubble is born it tries to reduce to a lower energy level – which means it grows in diameter and the internal pressure drops.

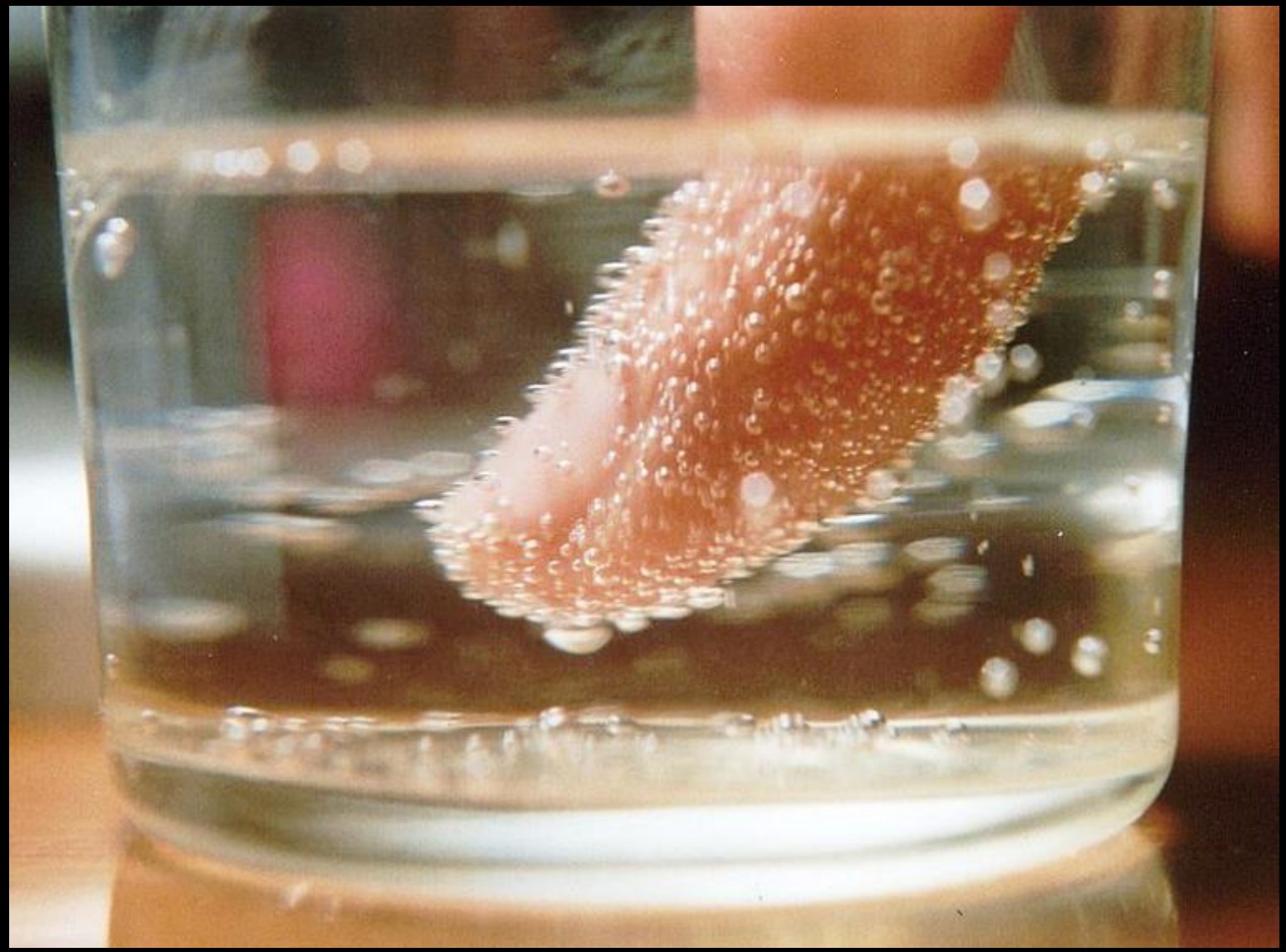
But the bubble displaces more liquid, so the upward force (good old Archimedes) increases and it detaches from the container wall and rises to the surface.

Nucleation

If a vessel is squeaky clean, the number of nucleation sites can fall dramatically and the liquid may become superheated before the phase change to vapour (a bubble) happens.

This is called boiling with bumping

Nucleation



What happens if you place a finger in your champagne

Nucleation

Or a slice of lemon in a gin and tonic

Nucleation

Or pop a sugar lump into a bottle of Coke!

Cavitation

The violent collapse of bubbles near solid surfaces

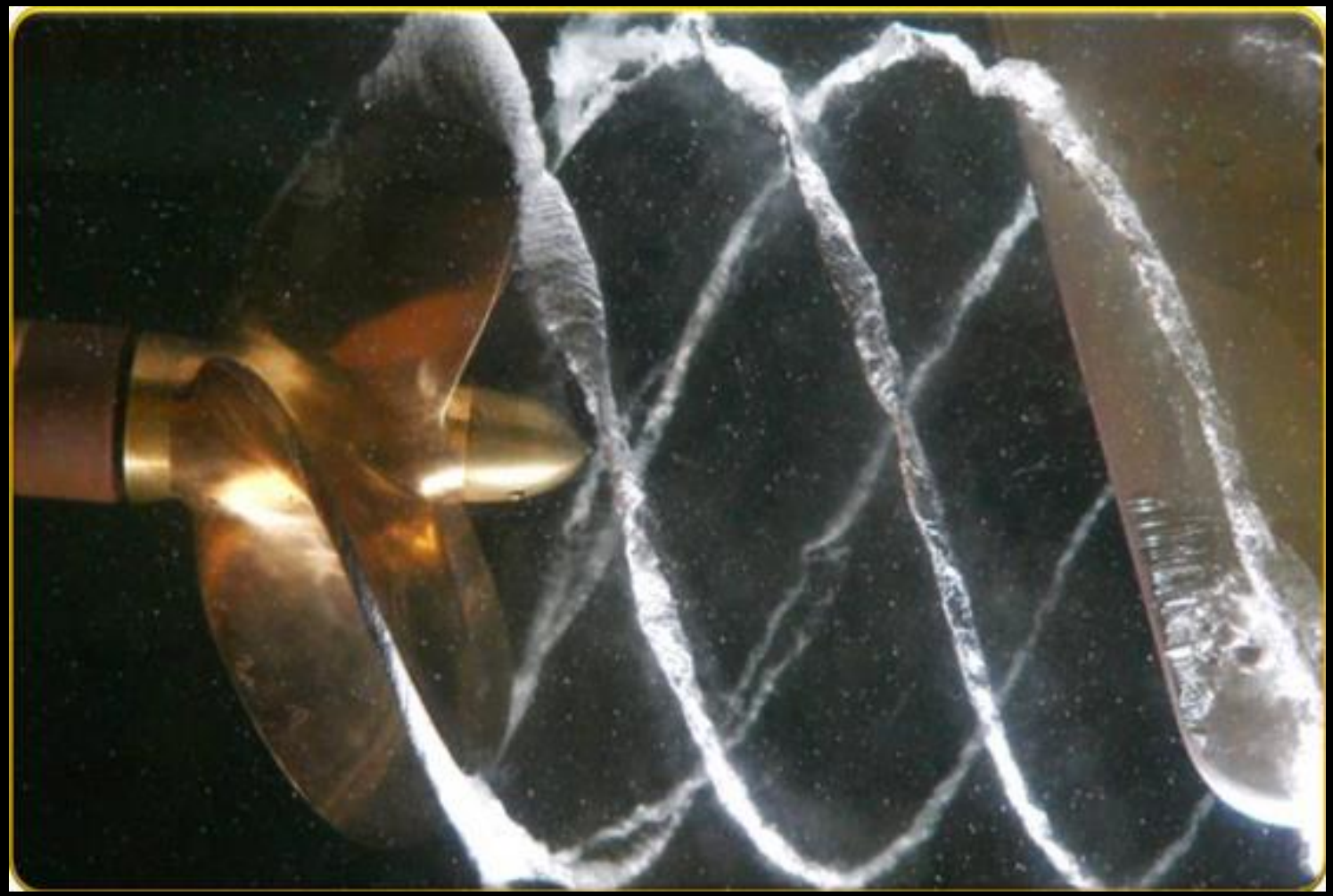
Wikipedia: **Cavitation** is the formation of vapour cavities in a liquid, small liquid-free zones ("bubbles" or "voids"), that are the consequence of forces acting upon the liquid. It usually occurs when a liquid is subjected to rapid changes of pressure that cause the formation of cavities in the liquid where the pressure is relatively low. When subjected to higher pressure, the voids implode and can generate an intense shock wave.

Cavitation damage

Caused by the boat propeller rotating too fast.

You can hear the damage being caused by cavitation

Cavitation damage



Caused by the boat propeller rotating too fast.

You can hear the damage being caused by cavitation

Useful Cavitation

Ultrasonic cleaning

Frequencies above the range of hearing are used.
Typically 20-400kHz

The cleaning liquid is literally torn apart to create millions of cavitation bubbles

The high pressures and temperatures instantaneously created within the microscopic bubbles perform cleaning

The cloud chamber

Predecessor to the bubble chamber

Not about bubbles, but….

Bubble chamber

Use in particle physics

Successor to the *Cloud Chamber*

A vessel filled with (e.g.) liquid hydrogen used to identify the tracks of particles emitted during radioactive decay

Invented in 1952. Possibly inspired by a glass of beer?

Bubble chamber

Ionising radiations

The tracks of elementary charged particles passing through the chamber momentarily produce bubbles of gas as they lose some kinetic energy.

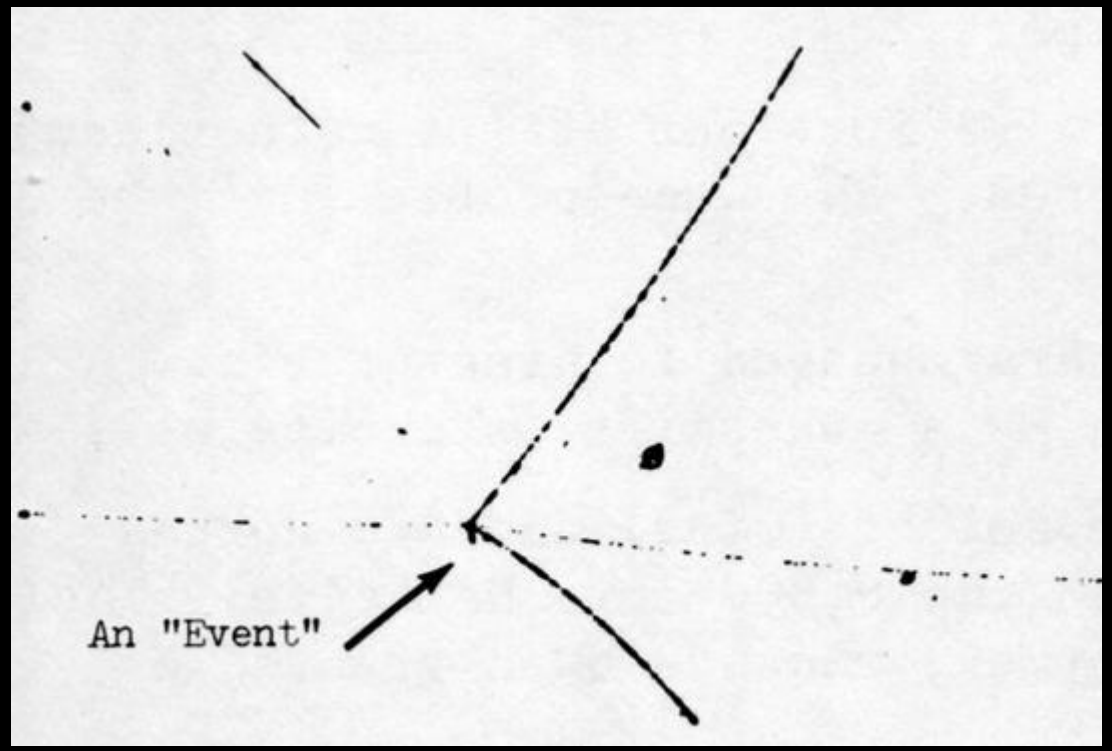
Bubble chamber

First examples of tracks in John Woods' tiny 40mm bubble chamber

Bubble chamber

A very large bubble chamber. This is the disused equipment now kept as a sculpture at Fermilab

Bubble chamber

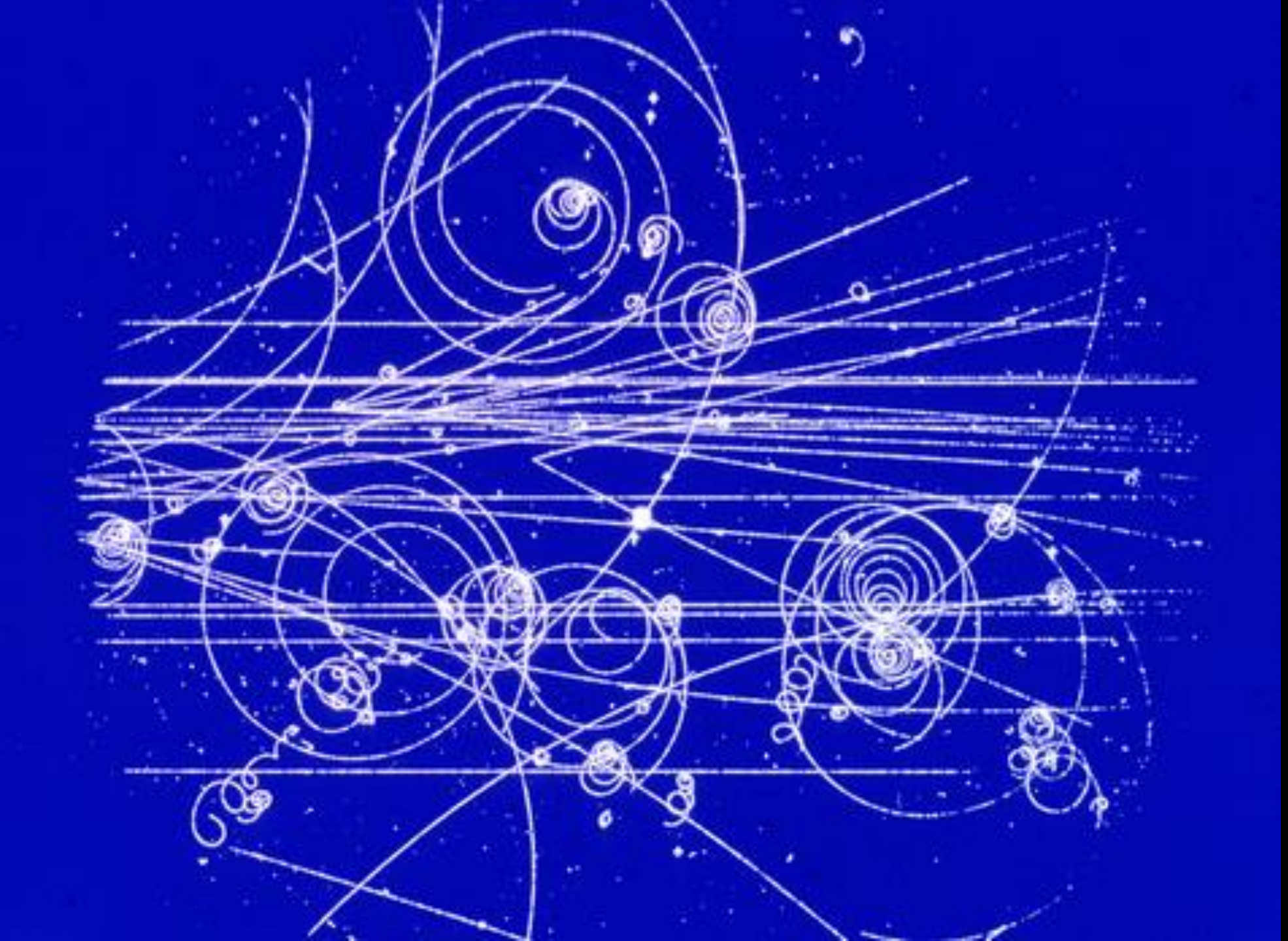


Historic photo of a particle event in a bubble chamber

Bubble chamber

Pictures from CERN

The high energy particle accelerator known as the Large Hadron Collider produces a mass of results, and was responsible for confirming the existence of the Higgs Boson.



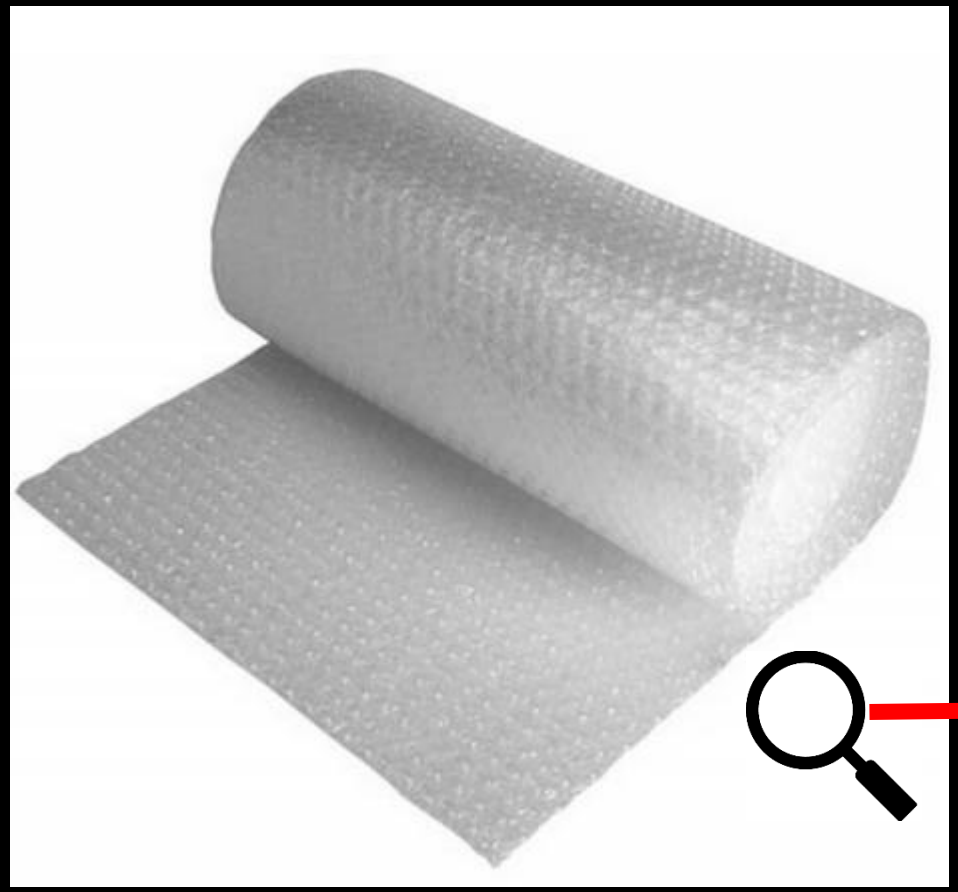
Bubbles in packaging

Bubblewrap

The most difficult material for recycling. Made from low density polyethylene. Cannot be recycled and ends up in landfill.

Solution: Melt and burn rather than burying

Bubbles in packaging



Bubbles in insulation

DIY insulation for windows or greenhouses

An interesting use for redundant bubblewrap packaging

Bubbles in insulation

Celotex

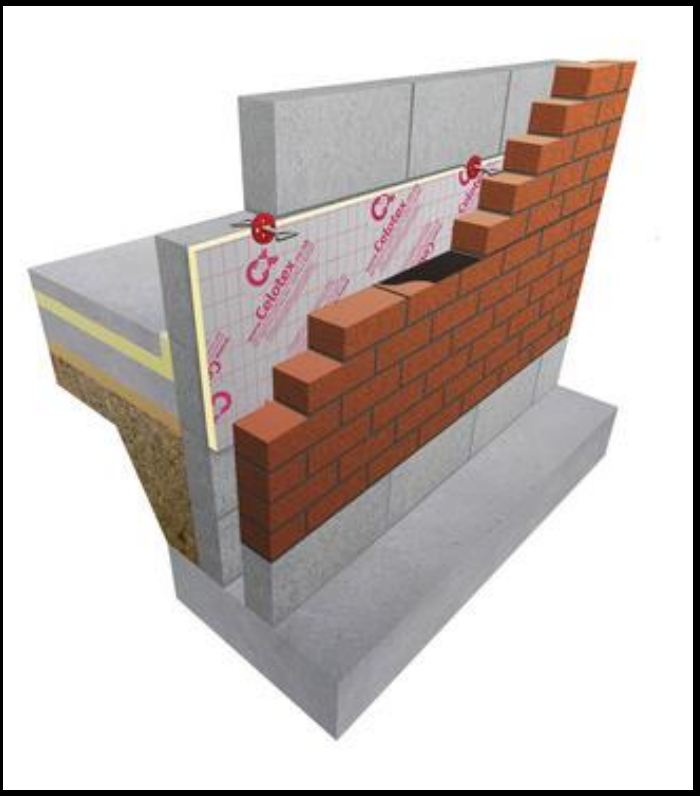
Used throughout the construction industry. A structural foam core in an aluminium foil sandwich. Can be used in wall cavities; as roof insulation and also underfloor insulation

Notoriety achieved in the Grenfell fire

Comes in various grades and thicknesses

Bubbles in insulation

Celotex



Structural foam mouldings

Structural Foam is a term commonly used to describe thermoplastic injection moulding components made by the injection moulding process which have a cellular core.

A cellular plastic is one in which the outer surface is denser than the inner layers. The core of the moulding is of a honeycomb nature and less dense than the outer surface. The combination results in a moulding of a high stiffness ratio compared with non-structural foam (compact) mouldings.

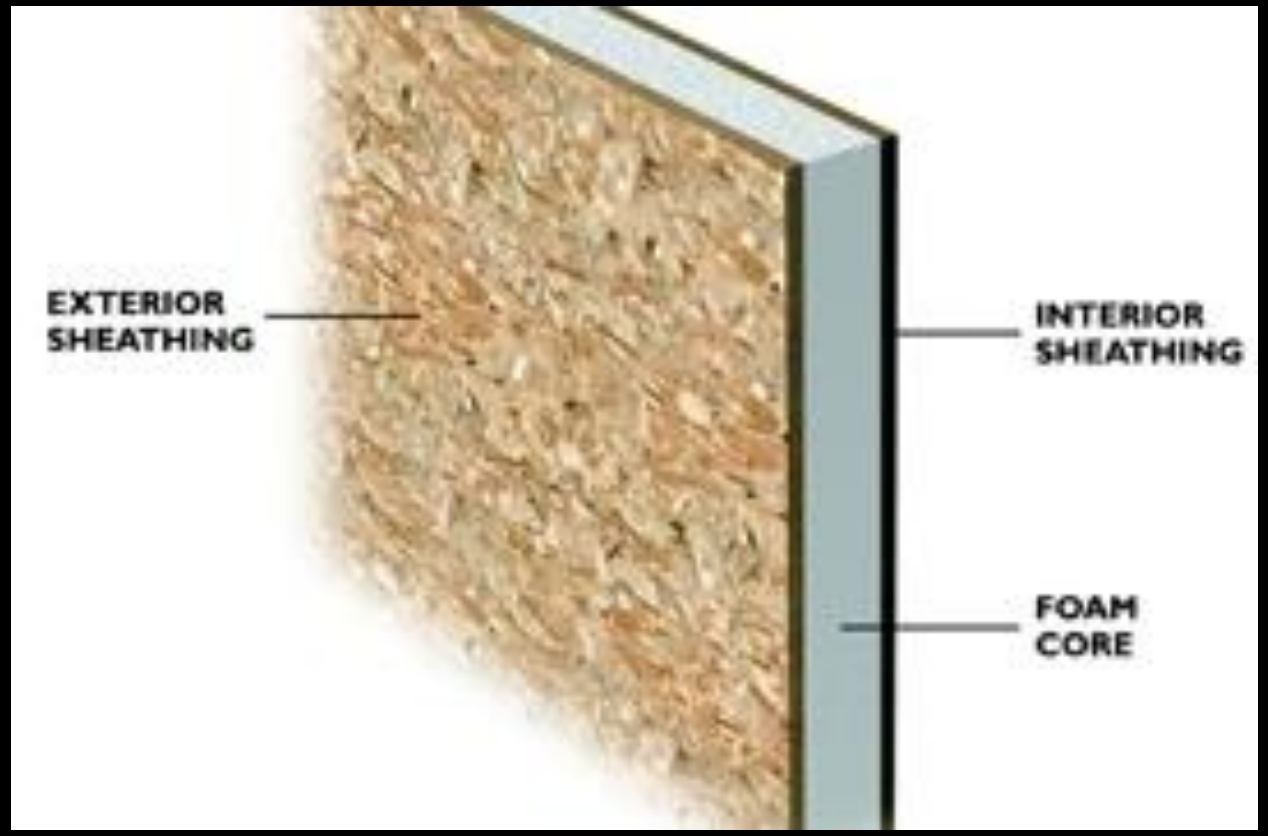
Structural foam panels

SIPS or Structural Insulated Panels

21st Century building material. Forget bricks, sand and cement!

A building needs a solid concrete foundation (incorporating CELOTEX of course!). But once the services – electricity; gas; water; drainage and telecoms are installed – the house can be built very largely from SIPS units.

Structural foam panels



SIPS or Structural Insulated Panels

The panels consist of an insulating foam core sandwiched between two structural facings, typically of stranded wood board

Ecohaus - SIPS delivered

Ecohaus under construction

Completed Ecohaus

Ecohaus in Guernsey

Complex heat exchange area!

The house is controlled throughout the year to give an internal temperature of 22° C by a combination of electrical and solar heating

A lot more to Bubbles…