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The magic of the microwave oven

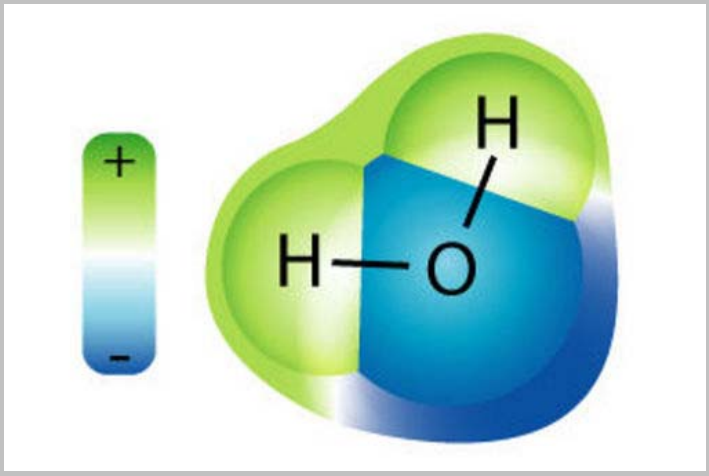
During the First World War, British Government was trying to develop a ‘death ray’ machine, to destroy the enemy by high power electromagnetic waves. They did not get far, but the research effort led to many useful applications of radio waves, says S.Ananthanarayanan.

An important benefit in the last decade was the use of electromagnetic waves of much higher frequency to actually boil and cook.

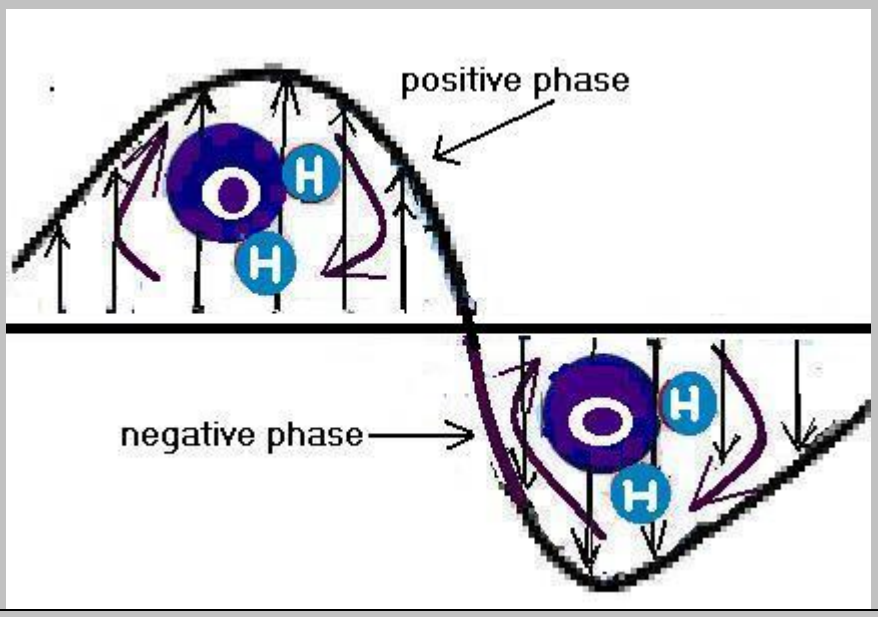
How does the microwave oven work?

Microwaves act on the water content of anything in the oven and heat up the water by spinning the water molecules round, creating friction between molecule and molecule! It is something like swinging a bar magnet over a compass needle. If we get the correct rhythm, we could make the compass needle spin!

An electromagnetic wave is able to do this because the water molecule is not a symmetric molecule, but is what is known as a ‘polar’ molecule. This means the charged particles it consists of are so placed that there is plus charge on one side and minus charge on the other. Rather like a tricycle, with the negative oxygen atom at the front wheel and the positive hydrogen atoms at the two rear wheels.



Now, if an electromagnetic field that is vibrating fast enough is applied, the water molecules in liquid water get affected so that they begin to spin. And like what would happen if you started to spin in a crowded street, they strike their neighbours, which are also spinning, and the energy in the liquid rises very fast.



As all organic things, of which food is made, contain water, even if they are ‘dry’, microwave ovens heat them up in a jiffy!

The oven

So the micro oven is a container with an arrangement to generate electromagnetic waves of very high frequency, which matches the speed of rotation of a water molecule. There are of course, electromagnetic waves all around us, but these waves hardly affect water molecules, as the frequencies do not match. The waves are also feeble. But the micro oven has the electronics to hit the right frequency, and intensity, and there we are.

How about ice?

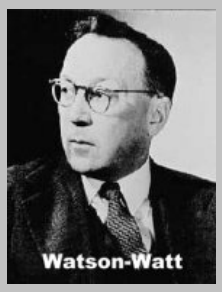
When water freezes to form ice, the molecules are ‘bound’ and not free like when liquid. Hence, in the electromagnetic field, they do not spin. No spinning, no friction, no heating!

This is why a piece of ice is not affected in the microwave oven. Even food that has been frozen contains ice crystals and the food has to be thawed before being warmed in the micro. Else, the ice portions remain cold and the warming is not uniform.

And the containers of the food?

The food containers used in microwave ovens are made of non-organic materials, like glass or ceramic. These contain no free polar molecules to pirouette and cause heating. Hence they stay cool.

But metals, or ‘conductors’, placed in fluctuating magnetic fields develop electric currents within themselves, behaving like the cores of ‘electric transformers’. At the high frequencies found in microwave ovens, very high voltages develop. This causes ‘arcing’ or flashes of electric discharge, which can lead to damage and fires.



In thepopular fiction of the day, a weapon called "death ray" was frequently used to kill air crews and disable aircraft. The director of Scientific Research for the Air Ministry, H.E.Wimperis, felt it was only right to investigate whether such a weapon could actually be built. In 1935, he asked Robert Watson-Watt, a radio expert at the National Physical Laboratories in Slough, if the death ray stories had validity. Watson-Watt believed that building such a ray was impossible, but did find a way using the echo of radio waves for aircraft detection, not destruction