NEWS

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Collapsing bubbles have hot plasma core

Mark Peplow

Find could boost hopes for bubble-driven desktop fusion.

They call it a star in a jar: when sound waves crush bubbles of gas in a liquid, energy is released in a dramatic burst of heat and light.

This cloud of collapsing bubbles are lit up by their own sonoluminescence.

© D. Flannigan and K.S. Suslick, University of Illinois at Urbana-Champaign

Now the first detailed measurements of the phenomenon have shown that the molecules in the gas really do create a pinpoint of plasma, the energetic soup of ions and electrons found in every star.

The research raises hopes that the effect, called sonoluminescence, might one day be used as an almost limitless source of energy.

Ken Suslick and David Flannigan, chemists from the University of Illinois at Urbana-Champaign, say they have recorded the most intense flashes of light ever seen from these bubbles, visible to the naked eye, which has allowed them to probe what happens inside.

"Nobody has been able to measure the temperature inside a single collapsing bubble before," says Suslick. The bubbles reached more than 15,000°C he says, which is four times hotter than the surface of the Sun.

Plasma promise

In 2002, a group of researchers led by Rusi Taleyarkhan, a physicist then based at Oak Ridge National Laboratory, Tennessee, controversially claimed they had seen similar bubbles triggering fusion[1], the process that is the source of the Sun's energy.

But Suslick, along with almost every other researcher in the field, says that 'bubble fusion' has yet to be proved.

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>
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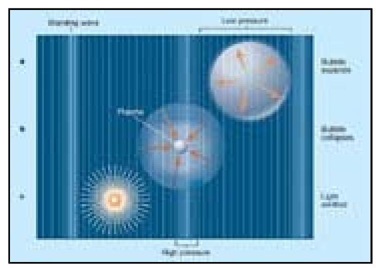
"Our results can neither confirm or deny Taleyarkhan's claims to fusion," he says. But he adds that any confined fusion reaction requires a plasma. "Our paper shows for the first time, and definitively, that there can be a plasma formed during this process." The research is published this week in *Nature*[2].

Swell and squeeze

The researchers used sound waves between 20 and 40 kHz, above the range of human hearing, on a sample of concentrated sulphuric acid that contained traces of argon gas.

The sound waves produce areas of high and low density within the liquid, making pressure at any one point oscillate between two extremes. Bubbles of gas in the liquid swell rapidly at lower pressures before being squeezed tight by the high pressure that follows.

The change in pressure is so fast that the bubble effectively implodes with enough force to generate tremendous heat, in a process called acoustic cavitation. "Compress a gas and you heat it, just like pumping up a bicycle tyre," explains Suslick. The heat separates electrons from their atoms, and as they snap back into position the energy they acquired is released as a burst of light.



Sound waves make bubbles swell before crushing them. Click here to see this image enlarged.

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Proof of the plasma comes from the presence of an ionic oxygen molecule (O_2^+). Some process must remove an electron from the molecule without breaking the chemical bond holding the two atoms together.

Heating alone would break the molecule in two, so Suslick and Flannigan argue that the molecule was ionized after it collided with high-energy electrons or other ions in a hot plasma core.

Argon tactic

Previous measurements of acoustic cavitation have looked at bubbles in water, and were always stymied by the fact that most of the sonoluminescent energy is absorbed by molecules of water vapour in the bubble.

But sulphuric acid is much less volatile than water, so Suslick's bubbles contained very few sulphuric acid molecules, consisting almost entirely of argon. And because argon is an atom rather than a molecule, it contains no chemical bonds to vibrate or break, so there is less opportunity for energy to be absorbed.

The collapsing bubbles released about 2,700 times more light than the equivalent bubbles in water, making it significantly easier to measure the temperature accurately, says Suslick.

"Flannigan and Suslick's experiments are a milestone, as they constitute the first direct measurement of the temperature and the state of matter in a single bubble at collapse," comments Detlef Lohse, a physicist at the University of Twente in Enschede, the Netherlands.

Suslick's team is already using acoustic cavitation to drive chemical reactions, and he hopes to increase the amounts of energy released by the bubbles of plasma using different mixtures of gases and liquids.

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References

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