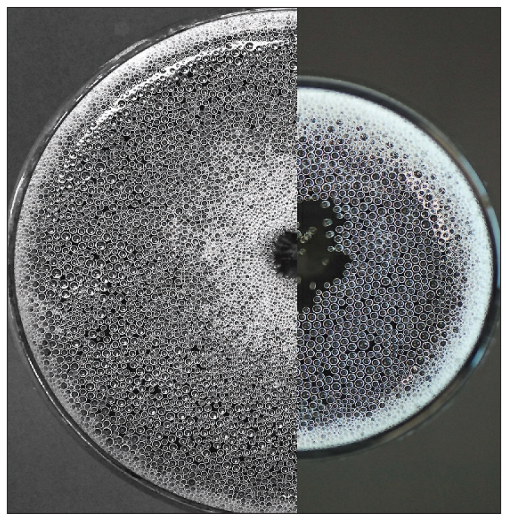
Where bubbly gets its fizz

Tracing the sparkle in a champagne glass is heady fare, says
s ananthanarayanan



MICRO-PHOTOGRAPHS of rising bubbles brighten the latest work of Gérard Liger-Belair, Professor of Physics at the Laboratory of Oenology at the University of Rheims, in France's Champagne district. The piece, *The Physics behind the Fizz in Champagne and Sparkling Wines*, in the current issue of the *European Physical Journal*, follows *Uncorked*, his 2004 book, which won the award for "Best Professional/Scholarly Book in Physics and Astronomy" of the Association of American Publishers and also the 2005 Gourmand World Cookbook Award for "Best Book on European Wine".

Liger-Belair uses physics, chemistry and high-speed photography to study the science behind the picturesque bubbles that rise as champagne is poured. The science of champagne itself, as of wines in general, is well understood but the mystery of the geometric, floral and even night-sky patterns formed by the bubbles that rise — now quickly, now slowly — in a freshly poured glass has remained unclear. The "oenology and applied chemistry" lab at Rheims, right within France's champagne-producing districts, has been working to understand the mechanics of the champagne bubble, the discovery of which could have uses in other fields.

All wines are the juice of grapes, whose sugar content has been converted into alcohol by the action of yeast. Different strains of yeast produce different families of alcohols and other "co-generation" to yield characteristic flavours. The yeasts are native to the grape that grows in different districts and, hence, the character of wines that are named by the place of origin. But champagne and other sparkling wines have an added load of carbon dioxide, which gives them an extra tang and also the visual effects as the gas leaves the wine in streams of bubbles.

The wine in Champagne in carbonated through a process attributed to Dom Perignon, a 17th century monk and cellar-master in the abbey at Hautvilliers, a village in north-east France. In the production of wine, a colony of yeast is first added to fresh grape juice, which has about 12 per cent of sugar content. As the yeast attacks the sugar to form alcohol and carbon dioxide, it takes the help of dissolved oxygen in the juice to multiply some millionfold. As soon as there is a good population of yeast, the juice is closed to fresh access to oxygen through an air lock, which lets out the CO_2, and the yeast devotes itself to sugar-conversion till all the sugar is used up.

And along the way, the exhausted yeast, as well as fresh yeast, settles to the bottom of the container and the clear wine is decanted. This is important, as leaving the yeast in the wine creates unpleasant flavours and visually disturbs the clarity of the wine.

In the case of champagne, dead yeast would be a double disaster as the debris, or "lees", would rise and cloud the wine as soon as the carbonated bottle is opened. Again, as some yeast cells get created in the next process of making sparkling wine, these need special treatment. The next process, which is after the sugar has fermented and the clear wine drawn into bottles, is that another charge of sugar is added to the wine and the bottle is corked. As there is some yeast, this new sugar also ferments, with the difference that the bottle is corked and the CO_2 stays and carbonates the wine. But the trouble is that this second fermentation again produces dead yeast cells and "lees", which need to be gotten rid of. In the process discovered by Dom Perignon, this is managed by keeping the bottles with the corks downwards, during the second fermentation.

The lees thus collect in the neck of the bottle, at the cork. When the fermentation is over, the wine at the neck is frozen solid, so that the cork can be removed without the wine or the gas escaping. The lees are then cleaned, topping up the loss with some fresh wine and the bottle is corked again. The wine is now clear of dead yeast and is also carbonated!

The fizz

The level of alcohol in the wine and the extent of the second fermentation are controlled so that there is around five litres of CO_2 dissolved in a 0.75-litre bottle of champagne. This is the gas that is released, some 20 million bubbles, when the cork is opened. The bubbles stay in solution when the cork is there, because of the pressure. This, again, is the reason that champagne bottles are sturdy, to withstand pressure. When the pressure is released, the gas bubbles out, like in the case of boiling. But just like boiling, the bubbles need to form first as very small bubbles before they rise and burst at the surface. But very small bubbles have to form at very high pressure and in the case of pure water, which is protected from particles of dust, boiling may not set in at a temperature well above its boiling point.

In the case of champagne that has been popped, too, there is the need for tiny "points of nucleation", which may be imperfections in the glass or specks of lint or dust that allow the first bubbles to form. And then, research shows, the nature of the bubble release depends on factors like the alcohol and carbonation levels, temperature, salts, carbohydrates, minerals and other components of the wine. Gérard Liger-Belair took high-speed micro-photographs of bubbles to stretch out the stages of their short lifespan to analyse the forces at work. "Fibres entrap a tiny air pocket when champagne is poured," he says.

"Then, this tiny air pocket literally sucks the carbon dioxide" from the surrounding wine so that the bubble grows till it lets go the fibre to rise to the surface. As it rises, it draws in more CO_2 and also swells with reducing depth, and bubbles race apart. The speed of bubble growth falls with the level of carbonation, which again changes the distance between bubbles. And the bubbling creates currents within the wine and bubbles may swerve and spiral or merge and deflect!"

Apart from their fleeting rise from the point of arising to the surface, the bubbles again express themselves when they burst. When they burst, they spray liquid jets that break up into micro-droplets of wine and create a mist of aromatic substances that are released into the bubbles at the bubble-wine interface. Close observation reveals that the bubbles form at the surface as a raft in a hexagonal pattern, with bubbles moving and jostling to take the place of one that has burst Gérard Liger-Belair's work into the detailed study of the mechanics of sparkling could help create better wines, as the connoisseur view is that smaller bubbles make for a better quality of champagne. "Today, it is not yet possible to control the bubble size," says Liger-Belair, "except by diminishing CO_2 content, which is obviously not legal." But the study may help vineyards get there.

In the words of Professor Richard N Zare of Stanford, who reviewed the book *Uncorked* in the journal *Nature* and conducted trials on Californian wines, "Our thirst for knowledge is still not satisfied".

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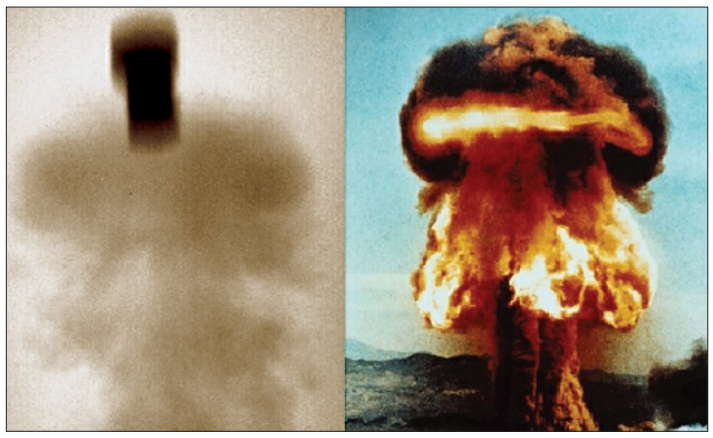


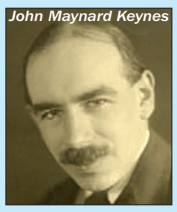
The popping of a champagne cork compared with an atomic blast at Nevada.

Witticisms inspired by champagne

WINSTON Churchill: "Meeting Franklin Roosevelt was like opening your first bottle of champagne; knowing him was like drinking it."

Winston Churchill

John Maynard Keynes



Deathbed commentary of John Maynard Keynes: "My only regret in life is that I didn't drink enough champagne."

Dorothy Parker

Dorothy Parker: "Three be the things I shall never attain: envy, content and sufficient champagne."