The making of Stars ‘R’ Us!

Journal Item

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The motivation behind our exhibit was to highlight the role of spectroscopy and chemistry in unravelling astronomical wonders. We aimed to show how the new discipline of astrochemistry is combining the clues gleaned from telescopes with sophisticated laboratory experiments and computer modelling to understand the evolution of chemical complexity to the verge of life itself. With the next generation of telescopes now being designed to specifically seek out the molecular markers of life, the importance of molecules, as markers and progenitors for star and planet formation, is paramount. The new science of astrochemistry combines the astronomers’ need to understand the chemical evolution of the universe with the chemists’ desire to investigate chemical reactions in the extreme environments found in the atmospheres of stars and in the cold, dark depths of the interstellar medium.

The idea for the ‘Stars ‘R’ Us!’ exhibit was originally developed by Martin McCoustra, who then enlisted the help of the rest of the team to create what proved to be a highly successful exhibit. The exhibit combined the frontier research of astronomers, chemists and physicists from Nottingham, University College London, the Open University and Leiden, with the public understanding of science expertise of the Royal Observatory, Greenwich. The material in the exhibit had to be accessible to a wide audience: schoolchildren, the general public, leaders from industry and the government as well as Fellows of the Royal Society and their guests all visited the exhibition at various times during the week. This fact was brought home to all of us very clearly during the exhibition itself – at one time we might be explaining the exhibit to a retired couple with only a minimal knowledge of science, while the next minute we found ourselves faced with a PhD student in astrophysics.

When designing our exhibit, the main aim was to make a contribution to widening general scientific literacy and supporting lifelong learning. However, at events such as the Royal Society Summer Exhibition, the public also has the rare opportunity to show to the public how such science is performed, in an exhibit called ‘Stars ‘R’ Us!’ In this article we set out how we approached the challenge of making our science as interesting to members of the public as it is to us.

Say “astrochemistry” and many people imagine something remote, irrelevant and, well, pretty dull. Yet to someone working in the field this is exciting science that delves into the origins of life itself. Astronomical observations have already identified more than 120 different molecules in space. Chemists and astronomers are now working together to understand how these molecules are formed. But how can we probe reactions occurring light years from our labs? This is where astronomy, chemistry and physics come together to generate exciting and cutting-edge science that helps us understand the evolution of the cosmos. At the 2004 Royal Society Summer Exhibition, the leading annual showcase for fundamental science in the UK, we won the opportunity to show to the public how such science is performed, in an exhibit called ‘Stars ‘R’ Us!’ In this article we set out how we approached the challenge of making our science as interesting to members of the public as it is to us.

The structure of the exhibit

It was decided that the best way to make this science accessible to as wide an audience as possible was to show how important it is for astronomy. Astronomy has great public appeal, from the beauty of the night sky to the awe-inspiring scale of the cosmos; we hoped that by putting our work in this context, people would appreciate what we are trying to find out.

We decided that our exhibit (see figure 1) should be eye-catching and should combine scientific information with hands-on experience. We designed a series of posters that told the story behind the exhibit in a manner accessible to a non-specialist. We also accompanied the posters with a video, telling the story of how chemistry and astronomy are coming together to give a better understanding of how stars form.

The main parts of our exhibit were four hands-on experiments that gave visitors a chance to see for themselves how some of the science worked. The first exhibit, Seeing Stars, illustrated how visible spectroscopy allows us to detect atoms and molecules in stars. We made a series of glass “stars”, containing He, Ne and Ar, to be viewed through a hand-held spectroscopy viewer to see the distinct emission from the different atoms in the plasma.

Our second hands-on exhibit, Seeing the Unseen, compared images of a model interstellar cloud in the visible and in the infrared. It allowed us to demonstrate how using the infrared allows us to see inside star-forming regions that appear opaque to the human eye. To achieve this effect we used a simple Sony digital camcorder, equipped with a NightShot mode that converts the camera into a near-infrared camera. Our astronomical object, Barnard 68, was printed onto an acetate film, behind which was located a printed circuit board onto which the logos of our universities were etched. This was then illuminated from behind by an array of near-infrared light-emitting diodes. Light from the diodes, transmitted through the logos and the image of Barnard 68, was only visible with the camera in Nighthost mode. Switching between the normal operating mode of the camera and its Nighthost mode thus allowed us to illustrate the principle of using infrared astronomy to see the unseen.

Reproducing Space was our third exhibit and consisted of a simple, static ultra-high vacuum chamber illustrating the type of experimental apparatus used in our laboratory surface science studies. Although this exhibit was simple, it was highly effective as people were able
to see the lengths to which it is necessary to go in order to achieve the very low temperatures and pressures that are present in the interstellar medium. The chamber itself was cut away and we filled it with sweets. Needless to say, this move was very successful – and not only with our younger visitors.

Our final hands-on exhibit was Life in a Bottle. This was the exhibit most modified from our original intention. We had planned to develop this as a working Urey–Miller experiment with online infrared spectroscopy to probe the evolving liquid phase. However, considerations of electrical and chemical safety led us to simplify this idea considerably. A straightforward experimental format was designed in which a water-based reaction mixture was excited by a spark from a high-voltage discharge circuit. The chemical evolution of the mixture in the reaction cell was monitored in advance of the exhibition and we presented these observations on materials supporting the exhibit. Although the discharge operated during the exhibition, the effect was illustrative rather than real.

The science behind the exhibit

In summary, we told a story that focused on the star cycle and the chemistry that controls this process. The first part of the story described how stars form from vast clouds of gas and dust and how the cosmos evolves through a continuous cycle of star birth, life and death. In particular, our story stressed how chemistry plays a crucial role in controlling the star cycle.

We underlined how the cosmos formed from the simplest atom, H, along with small amounts of He and Li. Early stars took these elements and began the process of nuclear synthesis to form heavier and heavier atoms: in the first hands-on exhibit, Seeing Stars, we described how one can see this process occurring in the Sun by studying how atoms absorb and emit light that is characteristic of their structure. The spectra of stars become more complex as the star gets older and, in the infrared, we can even see evidence for the formation of molecules in some stellar atmospheres. In the Seeing the Unseen exhibit we showed how infrared spectroscopy allows us to see objects not observable in the visible spectrum.
The next part of our story explained that in certain areas of the space between the stars, we find dense clouds that are rich in molecules and also in dust particles. Our visitors were surprised to hear that more than 120 different molecules have been identified in space so far. This fact then led us on to how chemistry is important in the star formation process: the conditions in these dense clouds are extremely harsh with very low temperatures and extremely low pressures, meaning that many chemical reactions are not possible. Although some gas-phase reactions do occur, for some molecules they cannot account for the observed abundances and chemical reactions on the surface of dust grains must occur. This fact forms the basis of the research of several of the members of our team. The chemists and physicists in our consortium are involved in investigating the rates of formation of molecules on surfaces and in ices and their release into the gas phase. We explained how we use special equipment to simulate the low temperature and pressure conditions of the interstellar medium and were able to show the visitors the apparatus that is used in the Reproducing Space exhibit.

The final part of our story focused on the origins of life itself. We explained the different theories about how life began on Earth and our Life in a Bottle exhibit illustrated one of these theories about how life began on Earth and our visitors were surprised to hear that more than 120 different molecules have been identified in space so far. This fact forms the basis of the research of several of the members of our team. The chemists and physicists in our consortium are involved in investigating the rates of formation of molecules on surfaces and in ices and their release into the gas phase. We explained how we use special equipment to simulate the low temperature and pressure conditions of the interstellar medium and were able to show the visitors the apparatus that is used in the Reproducing Space exhibit.

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