

Final Report - Stars 'r' Us!; The Cosmic Chemistry Connection

Dr Wendy Brown (UCL), Dr Helen Fraser (University of Strathclyde),
Prof. Martin McCoustra (University of Nottingham (now at Heriot-Watt))

Stars 'r' Us! is a collaborative project between Heriot-Watt university (Prof. Martin McCoustra) and the universities of Strathclyde (Dr. Helen Fraser), OU (Prof. Nigel Mason), Nottingham (Dr. June McCombie), UCL (Dr. Wendy Brown and Dr. Serena Viti) and Dr. Robert Massey (Science and Policy Advisor at the Royal Astronomical Society, formerly of the National Maritime Museum, Royal Greenwich Observatory). Our exhibit illustrates the relationship between astronomy, molecular physics and chemistry, and how they are fusing to make a new interdisciplinary science - Astrochemistry. Further information can be found at

<http://www.chem.ucl.ac.uk/cosmicdust/starsrus.html>

BACKGROUND

We are all made of star stuff! Atoms inside us were forged in the nuclear furnaces of ancient stars, and subsequently scattered into deep space as these stars eventually explode and die. In the cold dark regions of space between the stars, gas and dust gather together in the stellar nurseries and chemical cauldrons of our galaxy. Reactions between atoms in these clouds form increasingly more complex molecules. Astronomers use these molecules to do some detective work – trying to establish how star formation and planet formation occur. Like forensic experts, they cannot actually be there when the event happens, and so they use spectroscopic techniques combined with imaging telescopes to 'see' into deep space. Looking there, we find over 220 different molecules in space. Some are simple like hydrogen gas, and some are more complex – like glycine – the simplest amino acid. Since all of the gas and dust in space eventually forms new stars and planets, we can use chemical evolution as a tracer of the star forming process. Observational evidence shows that new solar-systems are being formed constantly in our galaxy. "Stars 'r' Us!" follows this story, from star birth to death and back again. The story is told many ways, *via* posters, a video and interactive exhibits which allow the public to get hands-on experience with ideas such as spectroscopy.

STARS 'R' US in Glasgow



Figure 1: The revamped "Stars 'r' Us!" exhibit. The video can be seen playing on the left-hand plasma-display, and the posters on the back display board. The hands-on exhibits are visible in the foreground, with white handout leaflets attached; the left-hand exhibit with a large 'telescope' on the floor was developed with a grant from the IoPiS. Postcards are on the tables, with images taken from the display and video materials on the front, and the academic's contact details on the back.

When it was announced that the Royal Society Summer Exhibition 2006 would also travel to Glasgow, we exploited a unique opportunity to bring the "Stars 'r' Us!" exhibit to a new audience in Scotland and to update the exhibit to incorporate many of the recent advances in Astrochemistry, in particular the latest results from the laboratories of the grant holders, and the discoveries made by the SPITZER space telescope¹. At a time when studies in physical sciences are falling, a project such as "Stars 'r' Us!" is key, as it utilises the very visual science of Astronomy to illustrate simple Chemistry and Physics, and re-ignite, or even initiate, interest in these scientific disciplines. Around £20,000 was raised to support this activity this time, through a PPE grant from the EPSRC, and awards / sponsorship from PPARC, RSC, IoPiS, Herriot Watt University, the EPSRC Astrosurf Network (supporting postgrad and postdoctoral students to attend) the Thin Films and Surfaces group of the IoP, Astrophysical Chemistry group of the RSC, and our industrial sponsors; Lesker Ltd, Thermo Scientific, VTS Ltd, VAT Valves, Leybold Vacuum, Bruker, VG, Hiden, Adixen, and Elliot Scientific.

The key aim of the "Stars 'r' Us!" exhibit is to bring the science of Astrochemistry to the wider public, and in doing so, to encourage particularly the 16-18 year old age group to appreciate the diversity of areas where science and technology are keenly applied in both research and our everyday lives. By featuring at the Royal Society Summer

Exhibition in Glasgow, we were able to find a platform from which to achieve this aim, through personal contact with a young and dynamic team of scientists, communicating our exhibit of hands-on demonstrations and easy-to grasp explanations. The “Stars ‘r’ Us!” team strongly believe that the key to improving uptake of science and engineering careers amongst young people is to make science exciting and relevant to them without patronising anyone.

An overview of the new exhibit is shown in Figure 1. The newly refurbished exhibit had the desired effect, in that those of us who had worked on the stand previously found it much easier to deliver our explanations and hold the attention of the public/school children audiences (see Fig.2). Handouts and posters were fully updated and drawing on our previous experience of manning and displaying the exhibit, pictures and wording in the posters were changed accordingly. Information was also provided on contact details for the academic team, leading to subsequent requests for schools talks and visits. As the sponsors notice – the end panels of the exhibition stand contained all their logos – as well as those of the major investors from 2004 when the project originated. These logos were also included on our video, which was distributed on a CD ROM to teachers requesting the information. PDF versions of these materials were also made available for download from the website. We also gained permission from the RSC to reproduce a bundle of 3 articles in full-colour format, previously published in Education in Chemistry, one of which was authored by this team². These were handed out in person to teachers, and over 100 were distributed during the exhibition. Finally the exhibit was also featured in the officially produced DVD of the Exhibition – available from the Royal Society.

The team who worked on the display during the exhibition week included 8 academics, two staff members from Nottingham University and the ROE with extensive outreach experience as the main function of their job, 3 PDRAs (from UCL and Heriot-Watt), 6 PhD students plus 3 additional students about to embark on their PhD studies (from UCL, Heriot-Watt and Strathclyde), and 3 local (Strathclyde/Edinburgh) undergraduate students, who were undertaking summer projects in Astrochemistry. All of these staff attended a one-day meeting in Strathclyde to learn how to assemble and use the exhibit. They also received training in communication with the public and gave a 5-minute talk about the exhibit on which they received feedback, especially from Dr Robert Massey (now aof the Royal Astronomical Society), an expert with significant experience in outreach, communication and media work. This was key training for the team members, who acted not only as ambassadors for their universities, but also for science and its public image as a whole. It was reassuring to see as the week progressed, students clearly learnt more communication skills by watching each other, and as such improved their own communication skills. We certainly benefited from having run the training day, and will undertake similar training before other major events in the future.

Fig 2. Collage of outputs from Stars ‘r’ Us! exhibit. Clockwise from top left; A PhD student explaining the new exhibit, ‘Eye to the Telescope’. 2nd photo – a PhD student being interviewed for the Royal Society DVD of the event. 3rd photo – the UHV ‘sweets’ chamber. 4th – photo – the new telescope, part of the new hands-on display produced for this exhibition. 5th photo - Members of the team at work during the exhibition. Final photo – the ‘seeing stars’ exhibit was a big draw to visitors of all ages.



	Daytime and Tuesday evening				Private events	TOTAL
	Media	Students	Public	Subtotal	Evening	
Tuesday	0	279	112	391	n/a	391
Wednesday	0	384	99	483	174 (teachers)	657
Thursday	0	358	137	495	207 (science & policy)	702
TOTAL 2006	0	1021	348	1369	381	1750
London	50	1342	1886	3246	1313	4609

Table 1. Statistics on visitors to the event, and comparison with London 2006 (data from Royal Society)

The demographics of the audience reached were provided by the Royal Society (see Table 1). 30% (104 / 348) of all public visitors completed a brief registration form on arrival, 11% (38) of whom also completed a feedback questionnaire. Replies showed that 54% of public visitors were aged under 40, 39% of public visitors were female, 26% of public visitors were students (University degree or PhD), 37% of public visitors were in full time employment. 95% of those who returned the feedback questionnaire rated the Exhibition 1 or 2, on a scale where 1 is very interesting and

5 is not at all interesting. 92% of those who returned the feedback questionnaire rated the explanations given by exhibitors as 1 or 2, on a scale where 1 is very clear and understandable and 5 is not at all clear or understandable. 90% of visitors who returned the feedback questionnaire said that their interest in science had increased as a result of visiting the exhibition. The team found members of the public very interested in our stand, and we were assisted in catching attention by being positioned opposite the entrance doors of the main exhibit hall, where we were therefore the first thing people saw as they entered. 31 school groups attended the event, of which 97% came from the non-independent sector. 44% of teachers at the schools visits and soiree event combined said it had given them inspiration for future activities. 23% of schools were from at least 50 miles outside Glasgow, including Aberdeen, Inverness, East Lothian and Dumfriesshire, and 59% of school children visiting were female.

EVALUATION & IMPACT

The Royal Society Summer Exhibition in Glasgow was an ideal platform from which to expose the public and opinion formers to our research, and we would like to thank our sponsors / grant awarders for their support – without you we would not have been able to produce such an excellent exhibit or finance the team to attend the event. Overall we consider that our participation in the RSSEG was a success, and that we were able to get key concepts from Chemistry and Physics across to our audience, illustrating the emerging science of Astrochemistry.

- **Stimulating Public Interest** – “Stars ‘r’ Us!” was designed with the specific intention of bringing basic Physics and Chemistry to the public through the exciting science of Astrochemistry. This is achieved through direct discussion between the team manning the exhibit and members of the public attending the exhibition. Posters and a video, which the public could watch independently, and a series of hand-outs, postcards and leaflets were also available. The leaflets were associated with 4 interactive exhibits; ‘Seeing Stars’, which demonstrates basic electronic spectroscopy (see Figure 2), ‘Recreating Space’, a sweet-filled UHV chamber which demonstrates the experimental techniques used by Brown, Fraser and McCoustra in laboratory astrophysics, ‘Eye to the Telescope or Seeing the Unseen’, which illustrates the difference between the infrared sky and visible stars, and ‘Chemistry to Life’, a mock up of the Urey-Miller classic experiment showing how a few chemicals, water and lightning can produce the ingredients for life. The latter did not feature in this exhibition as space in the exhibit hall was limited.
- **Public debate between scientists and public** – the opportunity for teachers, educators, policy makers, the general public and school children to meet numerous scientists at one time, face-to-face and talk to them, is a key objective of the RSSE. To feature successfully at such events it is imperative that the whole team engage with the visiting public and children. Our training day was vital in ensuring that all of the team, from academics to undergraduates, had the skills required to approach the visitors, and to tell a coherent, scientifically accurate story on a level they could understand. Many visitors ask questions, have visited our website or sought additional information from the academic team *via* the email contact details on our postcards.
- **Inspiring the future generation in SET** – the “Stars ‘R’ Us!” team applied to exhibit in Glasgow specifically because we wanted to bring our science to the audience in Scotland. With two members of the team now working in Scottish universities, it was crucial to establish good links with local schools, and to engage students in SET activities, through material less dry than their school studies. The figures given previously clearly showed that at least 50 % of our audience was of school age, and anecdotally our stand was continually one of the busiest – perhaps initially because of the lure of free sweets, but we used this as a ploy to start them talking and questioning the science on the stand! On more than one occasion teachers would come and drag children away for lunch or to catch the bus – such enthusiasm is exactly what we are aiming to stimulate with “Stars ‘r’ Us!” In addition, we found the revised and revamped materials very effective in communicating our story of chemistry in star formation.
- **Build and sustain a community of researchers in SET** – Clearly, “Stars ‘r’ Us!” has been operating for a much longer period than the lifetime of this PPE grant. The outcomes and future activities of “Stars ‘r’ Us!” are detailed in the next section. We have utilised the exhibit on a regular basis over the past two years, and with our participation in the RSSEG, have had the opportunity to update the exhibit and to train a new generation of PDRA’s and students to assist with future events. Only 1 PDRA from the Glasgow team had previously participated in “Stars ‘r’ Us!”, so our team training was a clear building block for the future. Many of the team, from academics to undergraduates, have gone on to apply the skills learnt during this grant to other related PUS activities.

HISTORY & FUTURE DISSEMINATION ACTIVITIES

The “Stars ‘r’ Us!” exhibit was developed in 2004, having been selected for the Royal Society Summer Exhibition (RSSE) in London that year¹. For that exhibition we raised over £25,000 to fund the construction and running costs of the exhibit. Sponsorship came originally from an award from the PPARC small awards scheme, EPSRC sponsorship, contributions from the Universities of Nottingham, UCL, and the OU, major sponsorship from the RSC and RAS, and minor sponsorship from subject groups of the RSC/RAS/IOP and various industrial companies with whom we usually do business. With the appointment of Dr H.J. Fraser to a permanent position in Strathclyde in 2005, and the move of Prof. M.R.S. McCoustra to Heriot-Watt University in August 2006, these universities also invested in the project. Since 2004, the exhibit has been used at University open days by all of the partners in the project. The university concerned has covered specific costs for such events, usually amounting to transporting the exhibit from its storage at the University of Nottingham. Due to institutional changes the posters and written material, as well as list of sponsors, have

been reprinted four times since the original event (once in French), funded each time by a different source. However, no major revamp of the exhibits themselves was undertaken and no major monies for repairs were sought since the inception of this project. In addition to the 2004 RSSE, the exhibit has been shown successfully at the following national and international events, with costs covered either by us or by the named event organiser:

- London - National Science Week RGO/NMM, Greenwich March 2005 and 2006.
- Athens – Einstein Year, June 2005, (invited by British Council, Athens).
- Chelmsford - International Scout Jamboree, July 2005, (invited by Scout Association following a visit to the Royal Society Summer Exhibition 2004 by the organiser of the scout jamboree).
- Paris - Village des Science, October 2005, (invited by British Council, France).
- Newcastle, Manchester, Brighton, Nottingham - UK Chemistry Week Shopping Centre Tour, November 2005 (on behalf of the RSC).

“Stars ‘r’ Us!” is to feature again during the National Science Week activities at the Royal Greenwich Observatory / National Maritime Museum (March 2007), and possibly at the Edinburgh Science Festival (April 2007) and a science festival planned for the summer of 2007 in Milton Keynes. Additional discussions are underway to transport the exhibit to South Africa in 2008 as part of the outreach programme for the SALT telescope, and subsequently to visit local townships providing a very new audience with exposure to the field. Discussions are also underway for the exhibit to feature in the Dark Skies project (a major PPARC-funded outreach activity in Scotland), whereby astronomy, observing and the related scientific disciplines are taken throughout Scotland to schools and the public, especially in the remoter areas of the Highlands and Islands. In addition, the exhibit continues to be used on a regular basis by all of the partner collaborators for demonstrations at their University Open days. If you are interested in featuring Stars ‘R’ Us at your event please email Prof. Martin McCoustra (m.r.s.mccoustra@hw.ac.uk) initially – noting that the team usually require the organizers to meet costs of public liability, transport and team travel, accommodation and subsistence.

Schools and teachers showed significant interest in our exhibit and especially the associated materials we produced. A compendium of relevant articles on Astrochemistry appearing in the RSC Education in Chemistry journal was prepared (with the permission of the RSC). This included an article by some of the “Stars ‘r’ Us!” team². This proved very popular with over 100 copies being distributed. A CD of the display materials and handouts was also made available to teachers, for which around 10 requests were received during the Glasgow exhibition. These disks have now been distributed.

The “Stars ‘r’ Us!” website is being constantly maintained and updated, with details of the background science on the exhibit, details of the exhibit itself, and pictures from events at which the exhibit features. A 1st year UCL Chemistry PhD student, who helped with the exhibit for the first time in Glasgow, is now maintaining this website.

Schools visits resulting from direct contact between the “Stars ‘R’ Us!” team and local teachers during the Glasgow Exhibition have led to Dr. Fraser and Prof. McCoustra making new and vital contacts with schools within Scotland. Visits have ranged from discussing Astrochemistry across a wide range of year-groups, to more focused work on curriculum related science in the Standard and Higher grade syllabi on stars, planets and solar systems. Two of the UCL researchers who were involved in the Glasgow Exhibition have subsequently used their experience to become schools ambassadors, regularly giving talks associated with Astrochemistry and the science behind the “Stars ‘R’ Us!” exhibit at London schools. One Glasgow student has also gone on to work on the Dark Skies Project, building on the skills she developed as part of this programme.

A **legal agreement** has been drawn up between the interested parties in this collaborative project, detailing future bookings, ownership, storage, payment and use of the “Stars ‘r’ Us!” exhibit.

References

¹S. Viti, et al, "The making of Stars R Us!", *Astronomy and Geophysics*, **45** (2004) 6.22–6.24.

²M. R. S. McCoustra, et al, "To infinity and beyond", *Education in Chemistry* **42** (2005) 153-154

ONCE AGAIN THANKYOU TO OUR SPONSORS