Profile: Paul Crowther

Paul Crowther, Professor of Astrophysics at the University of Sheffield, talks about massive stars, communication and the importance of getting the facts right on funding.

I was a bit of a geek as a kid, although not to the extent of having a telescope in the backyard. In common with many of my peers, Carl Sagan's *Cosmos* hooked me on astronomy when I was 12 and I knew right away that this was for me. Science overall – and a fair bit of science fiction – kept me going through O-levels. My maths was pretty strong too, so I took a degree in maths and astronomy rather than the more conventional physics. I was offered an applied maths PhD in fluid dynamics, but astronomy drew me in again and I started research at University College London with the topic that has stayed with me throughout my career: high-mass stars.

Picture the universe without high-mass stars: no core-collapse supernovae or gamma-ray bursts, no exotic stellar remnants – black holes and neutron stars – and we would be without many of the tools we take for granted in studying high-redshift galaxies. Huge areas of astrophysics would be unavailable – and we would probably not be here to witness such a universe. Low-mass stars make oxygen, but they're poor recyclers. It is high-mass stars that send oxygen out into space through supernovae explosions from which new stellar generations are born; without them there would probably have been so little oxygen on Earth that life may have taken a quite different path, if it started at all.

Observing time

I started my PhD in numerical astrophysics, but soon realized that, while the models we used were constantly becoming outdated, excellent observations would better stand the test of time. Allan Willis, my supervisor at UCL, and Linda Smith, were instrumental in propelling me through my PhD. I had plenty of scope for hands-on observing, which is one big difference between then and now. My favourite was the 2.3 m telescope at Siding Spring Observatory in Australia, which I had to operate on my own, so if there were any problems I had to think on my feet to solve them – and quickly! Students now tend not to go observing in that way so often; it's fantastic that students have access to high-quality data from 8–10 m telescopes, but if everything is predetermined, you lose out on real-time decision-making. The scarcity of good small research telescopes is a problem for PhD students, although they can benefit from teaching telescopes, as they do here at Sheffield.

Since moving to Sheffield in 2003, my main research activity has been at the boundary between massive stars and supernovae. The understanding of the various types of supernovae and that different mechanisms make them happen has really benefited from enhanced observations. Type Ia supernovae explode when a white dwarf is tipped over the Chandrasekhar limit, while core-collapse supernovae explode once they form iron in their cores. The most common, Type II, supernovae involve hydrogen-rich red supergiant progenitors, and weigh in at around 10 solar masses, but there are also hydrogen-poor examples, known as Type Ib or Ic. I'm interested in finding out which stars die in such explosions. Are they extremely massive stars whose powerful winds peel away the hydrogen, or is it stripped away within lower-mass binaries? I've been surveying nearby galaxies using VLT and Gemini, mapping out the location of very-high-mass stars. When a new Type Ib or Ic supernova is found in that galaxy, we can see whether the progenitor could have been a high-mass star. So far, progenitors have not been found for these relatively rare flavours of supernovae. Still, this sort of work – picking out time-variable behaviour – is exciting because we can now study the transient universe visually with survey telescopes such as Pan-STARRS, in gamma rays with Swift and at radio wavelengths with LOFAR, simultaneously.

Such multiwavelength approaches have been characteristic of UK astronomy over the past decade. Dual-hemisphere, space-based and ground-based astronomy has provided a big advantage for the UK over our immediate competitors; the loss of major observatories such as Gemini, while our European competitors keep access to comparable northern hemisphere facilities, is going to eat away at that advantage. Most research doesn't use a telescope or observatory in isolation. UK astronomers are leading many of the large Herschel surveys, but the ground-breaking research that will result will doubtless need ground-based follow-up; UK astronomers may ultimately have to defer leadership to others if we do not have competitive instrumentation in both hemispheres.

> **"I intended the website to be short-lived, but events have unfolded and it has continued"**

STFC website

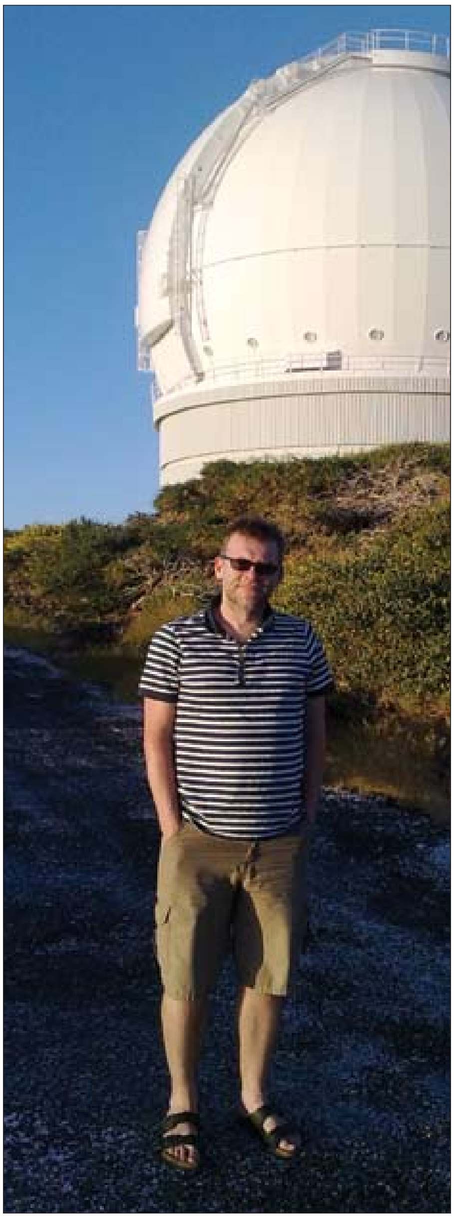
I started my STFC website (http://pacrowther.staff.shef.ac.uk/stfc.hml) in 2007 to keep track of what was happening to the funding of astronomy at that time. I had been chairing the UK Gemini National Time Allocation Committee and we had just completed the latest half-yearly peer review when, overnight it seemed, the UK was thrown out of the Gemini partnership. I wanted to try to set out the facts, together with opinions from senior people, in order to provide context so that the UK astronomy community could keep track of events. As I saw it, at that time there was a huge communication problem. The research councils were putting out good news stories, yet everything on the ground was bad news; in between there was a void. And, as always when you have a vacuum, rumours ran riot. I tried to update the website regularly so that it allowed members of the community to look back and track down reliable information when rumours spread. For example, there was a feeling at one stage that astronomy had been growing at a disproportionate rate, which would perhaps have explained the cuts suffered by STFC in the previous spending round. I was able to check the facts; it turned out that growth in UK academic astronomy had taken place at the same rate as physics departments and higher education in general. Any feeling that funding for this subject needed to be squeezed was entirely misplaced.

There certainly has been growth in UK astrophysics over the past decade, largely because we're very successful. Astronomy is the most accessible science and the UK has many world-leading research scientists. It is no surprise that astronomers have been Presidents of the Institute of Physics and the Royal Society in recent years. Many people, at all levels, are involved with outreach, through National Science Week, for example. I enjoy giving school talks – and it's especially satisfying when you can inspire students who may not think they can go into science, to realize that it is possible. The government rightly wants more people trained in physics to go into teaching, yet we're only going to get the right people becoming physics teachers if they are motivated to study science in the first place, and stick with it. Astronomy is a way to reach out to a lot of them.

And they are interested, judging by the popularity of Brian Cox's *Wonders…* series, and *Stargazing Live*. Stories that the media pick up on are often fairly speculative, but the publicity they attract might also make someone consider a career in science. Last summer I led the team involved with discovering the "biggest stars" – actually the most massive – that attracted media interest. During discussions with reporters I tried to feed in interesting ideas about star formation, big explosions and even Population III stars. People see physics and astronomy as useful, as well. A former UCL colleague, Nic Walton, now in Cambridge, has recently applied his astronomical software to cancer screening, for example. Universities have seen a healthy growth in physics and astronomy students over the past five years, a welcome upturn that coincided with the introduction of fees and perhaps the rationale: "If I'm paying for my degree, I'd better do something tangible, something that makes me more employable."

Better communication

I had intended the website to be short-lived, but events have unfolded and it has continued; it is only now that there seems to be some stability in funding. Big positive changes have included greatly improved two-way communication with STFC and closer dialogue with politicians. In addition, we now have the Astronomy Forum – senior representatives from each UK institute – to provide an authoritative perspective on policy independent of the RAS Council, which appears to be functioning well. Compared to astronomers, particle physicists present a much more unified voice, because they know they have to work together if they are to tackle their projects at all. Astronomers are a lot more individualistic, so opinions are a lot more varied. The Astronomy Forum is proving an effective way to harness the collective views and engage with the research councils.



Paul in front of the dome of the William Herschel Telescope, La Palma.

Those individual voices exist because astronomy is one of the few sciences where an individual or a small group can have a great idea and run with it. In astronomy you can have complete ownership of a question, and a dataset, and see it through from the start to fruition. This is not the case in many other areas of science where, of necessity, the science takes place in large consortia, without such well-defined individual roles. It would be a shame for UK astronomy to go down that route, concentrating on a few big projects. There is a role for the individual, provided the facilities and funding are there.

UK astronomy is among the best in the world, second only to the US. I hope we can hold on to that strength during the economic downturn. Despite coming out of the government spending round at the high end of expectations, the volume of research grants is still just half of the recent high level and, while research student numbers remain high, they are going overseas once they finish their PhDs. It's a very healthy thing for young researchers to go and experience different countries and cultures, but it's only healthy in the long run for UK science if there's two-way traffic. If our next generation of researchers develop their careers in other countries, and find buoyant research communities there, then they will be inclined to stay there rather than return to the UK. People are by far the most important part of research. We have been lucky in the UK in that we've had a large enough community, in which observers, theorists and instrumentation people are close enough to talk and drive new developments together. Now we're looking at a rapidly declining postdoctoral cohort, with numbers a long way down even from a decade ago. I hope that we can hang on to key people, although the capabilities we have lost and are still at risk of losing make it more likely that we will fall behind. I worry that the pressure on funding may result in our addressing just a few problems, putting all our eggs in one or two baskets. That would undoubtedly dissuade many people from staying in UK astrophysics.

Expect the unexpected

That route also runs the risk of losing the unexpected. It is often the case that an instrument with a specific purpose does not only what it was expected to do, but brings in lots more, serendipitous, science. With versatile instrumentation you can go well beyond the expected outcomes. This sort of discovery – and there's a lot to discover in astronomy – is not linear and it's not predictable. A little over ten years ago, for example, there were only theoretical predictions connecting gamma-ray bursters and supernovae. Now this is well established observationally, thanks to technological advances that allowed the sky to be surveyed systematically across the electromagnetic spectrum.

Excellent observational data will bring more advances. Within a decade we should know what dark matter is. And I hope we'll have come closer to understanding dark energy. At the moment we are in the awkward position, scientifically, of being comfortable with what makes up a few percent of the universe, and very uncomfortable with the other 94% or so. And I'd hope we would by then be well beyond merely finding Earth-like planets, and have much more evidence-led theories on planet formation, planetary systems and how our solar system fits in. ●

Further information

http://pacrowther.staff.shef.ac.uk