members of the audience!

Ralph Spencer (Manchester) discussed the extensive radio data on Cygnus X-3, a well-studied X-ray binary system at a distance of about 10 kpc. It has a 4.8 hour X-ray and IR period, but lies on the Galactic plane and is not visible in the optical bands. Cyg X-3 is famous for its dramatic outbursts (10 Jy at cm wavelengths) and MERLIN and VLA images show that these outbursts are accompanied by the symmetric ejection of radio-emitting clouds at 0.3c. At much higher resolution, VLBA snapshot images taken at intervals of around 20 minutes during a minor 0.3 Jy flare, show that the source appears to expand and contract during the flares at rates suggesting initial apparent velocities of ~6c. Ejection at a Lorentz factor of around 3 at about 30° to the line of sight could explain the apparent expansion and increase in flux, but the "contracting" phase is most likely to be due to the source fading rapidly after expansion, revealing quiescent emission in a compact centre.

Peter Scheuer (Cambridge) stood back from the observational fray and summarized what he thought we had learnt in almost 20 years of studying superluminal motion. He broadly accepted the relativistic jet model underlying "unified schemes" of AGN, but pointed out a few worrying anomalies and inconsistencies. In particular, if the central engine in radio galaxies is obscured by a dusty torus, where does the reprocessed energy appear? Current data do not suggest that radio galaxies are preferentially infrared luminous as might be expected. He also pointed out that the speeds inferred in radio jets may not be the "true" speeds, but could be the pattern velocity of shocks in the jet or slower-moving shear layers at the jet periphery. He favoured such surface shear-layer models for large-scale jets.

Scheuer finally brought the discussion full circle by referring to the major problem of interpreting the large day-to-day variations in radio flux density in some high redshift sources. The implied brightness temperatures exceed 10^{20} K which is hard to explain away with Doppler-boosted synchrotron radiation in the manner suggested by Rees 30 years ago. Could this instead be a signature of coherent radiation in AGN?

Comet Hale-Bopp: April fool joke or comet of the century?

Iwan Williams, Martin Cartwright and Alan Fitzsimmons wonder how wonderful comet Hale-Bopp will become as it nears the Sun.

Most new comets are discovered within a magnitude range of about 11 to 14, for the obvious reason that if they are brighter they would have been discovered earlier, and if fainter they are not noticed. There are exceptions, two recent examples being C/1996 Q1 (Tabur) discovered at around magnitude 6, and C/1996 N2 (Elst-Pizaro) discovered at magnitude 19.

Comet Hale-Bopp, C/1995 O1, was not remarkable in its brightness, being discovered in July 1995 at a magnitude of about 11. What was remarkable and very soon led to the label "the comet of the century", was its distance from the Sun – over 7 astronomical units at the time of discovery. To put this into context, comet P/1 Halley had a magnitude of 22.8 when at a similar heliocentric distance during its last apparition around 1985. But more important than entertaining the public was the unprecedented opportunity to follow the evolution of a large and active comet from beyond Jupiter to perihelion and back again.

When discovered, Hale-Bopp was already an active comet with a visible coma. Over the past few years, there have been a number of examples where some ejection from the cometary nucleus has taken place at large heliocentric distances. Two of the best-known examples were comet Halley in January 1989, where a significant outburst was observed with the comet at a heliocentric distance of 10 AU, and 2060 Chiron between 1986 and 1988 while at a slightly greater distance of 11 AU. In both cases, however, the integrated magnitude after the outburst was at least five magnitudes fainter than the observed magnitude of comet Hale-Bopp. In both, the coma was faint and contributed only a little to the overall brightness. In the case of Hale-Bopp, unless the nucleus really is comparable to a large asteroid, the coma must be the dominant contributor.

By imaging alone, it is sometimes very difficult to determine whether we are observing a bare nucleus or a body with a coma, because seeing smears out the point of light that is the nucleus into an image that can look very similar to a coma. This prolonged the debate as to whether a comet was a single snowball as claimed by Whipple, or the loose collection of grains favoured by Lyttleton.

Paradoxically, as more and more comets are found to have an attendant dust cloud at large distances, the probability that both were correct increases. Dust grains do not of their own volition leap off a cometary surface, and current thinking is that the outbursts at large heliocentric distances are driven by a similar mechanism to that which generates the normal coma and tail, through volatiles sublimating: the resulting outflow of gas drags with it small solid grains. For a normal coma, this is mainly driven by the sublimation of water which becomes possible at 3–4 AU from the Sun. In more distant outbursts, ices such as CO or CO_2 sublimate. For the large coma required to explain the brightness, the nucleus of Hale-Bopp must be large, rich in ices and active over a large fraction of its surface.

In August 1995, Alan Fitzsimmons and Martin Cartwright carried out spectrophotometry using the William Herschel telescope on la Palma. They clearly established the presence of CN (a daughter product of HCN) and showed that Hale-Bopp was outgassing at 10 times the rate that Halley was when at 4.5 AU (about 50% nearer the Sun than Hale-Bopp). In September 1995 a number of observers detected CO emission, with the comet still at around 7 AU from the Sun, indicating that this indeed was the source of the coma. If Hale-Bopp behaved like Halley for the remainder of the apparition, then a spectacular comet was indeed on the way. Measurements of the water production rate in late 1996 by Jacques Crovisier and colleagues at the *Observatoire du Medon*, Paris, suggest that it is already more active than comet Halley at its maximum.

In August 1996 the authors obtained CCD images of the comet each night for two weeks (one of which is shown below). These images showed that the comet had six jets, which stayed remarkably constant throughout the observation period.

Perihelion date is 1 April: if the comet turns out to be a flop, like several others, astronomers can perhaps claim that it was an elaborate April fool joke! At that time the comet will be 1.3 AU away from the Earth, but it should still be a very impressive object in the northern hemisphere. Though the large distance from the Earth reduces its brightness, we will have a good, near-orthogonal view of the tail. Estimates for brightness vary between +3 and –3, with perhaps the more realistic values around 0. Even if the pessimistic estimates turn out to be correct, it should be a very clear naked-eye object for a considerable period.

But even the most optimistic forecasts of brightness do not really make it the comet of the century. For our money, that remains the great January comet of 1910.