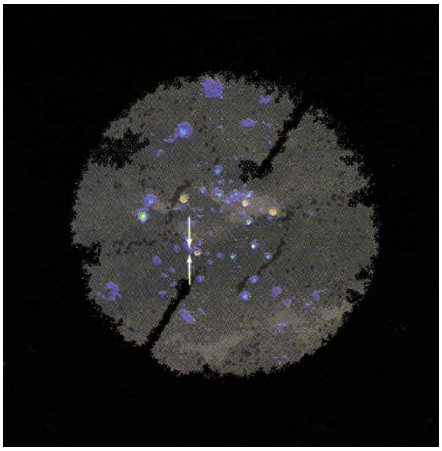

ROSAT/PSPC

Figure 1 **X-ray image of the Rho Ophiuchi star-forming region, obtained with the Rosat Position Sensitive Proportional Counter (PSPC) in 1991. The angular diameter of the image is about 2 degrees, so the region is about 18 light years across. Most of these sources are young, optically visible stars; YLW15 (arrowed), which has produced an unprecedentedly brilliant X-ray flare, is even younger, and still embedded in a dusty nebula.**

ambiguities in source identification. Second, the intrinsic X-ray luminosity or power of the outburst is much higher than has been seen from anything in our Galaxy other than compact objects (neutron stars, white dwarfs and black-hole candidates). After correcting for the effects of dust absorption, the inferred X-ray luminosity is about 10^{34}–10^{36} erg s^{-1}. The spread in values is mainly due to an imprecise knowledge of the amount of absorbing dust. But even the low end of this luminosity range would mean that YLW15 is about ten million times brighter in X-rays than the Sun, and about ten times brighter than the most luminous Galactic stellar X-ray sources, compact objects excluded.

Could the same physical processes that produce X-ray flares on the Sun (and by inference on other Sun-like stars) be responsible for the huge X-ray output of YLW15? Grosso *et al.* think not, arguing that solar mechanisms are too inefficient and that the inferred size of the X-ray-emitting region of YLW15 is much larger than the protostar itself. Although the energy release mechanism in solar X-ray flares is still controversial, evidence is gathering[7,8] that it is a process called magnetic reconnection. In this picture the magnetic field rapidly drops to a lower energy state as the result of a localized rearrangement of magnetic field lines (for further discussion see ref. 9).

Some of the field energy released in this process goes into heating the plasma near the reconnection site, which then cools rapidly by emitting thermal X-rays. In the Sun, the magnetic structures that reconnect are confined to the vicinity of the solar surface. Grosso *et al.* argue that, in contrast, the X-ray emission from YLW15 may originate when magnetic field lines anchored to the protostar reconnect with an external structure such as a circumstellar disk or perhaps a protostellar companion. That would increase the length scale of the participating magnetic structures to tens of stellar radii or more, as deduced from models of the X-ray outburst.

Several new questions are raised by this brilliant flare. If the energy release does involve magnetic processes, then how are the magnetic fields produced in such a young object? Are they internally generated, or are we perhaps witnessing the venting of primordial magnetic energy that the protostar inherited from its parent molecular cloud? And what sort of external structure might the protostellar magnetic field be interacting with? Any answer must be considered speculative, but one of the most enticing possibilities is that we are seeing a magnetic interaction between the two components of a close protostellar binary system — the birth of twins. Some indirect evidence in support of this idea comes from the fact that YLW15 is one of the strongest radio sources in Rho Ophiuchi, and at least one study suggests that the frequency of binary systems in this star-forming region may be higher among radio emitters[10].

Finally, if our own Sun once experienced such convulsive releases of X-ray energy, what would have been the implications for the chemistry, thermal structure and evolution of the inner nebular disk where the terrestrial planets formed? Current models of nebula evolution[11] do not consider the cumulative effects of energy input from intense X-ray flares, but such refinements may now be necessary. ☐

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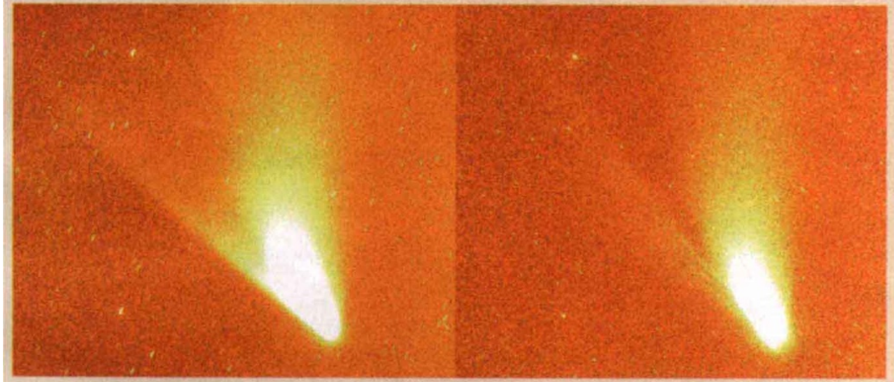
1. Haisch, B. & Schmitt, J. H. M. M. *Publ. Astron. Soc. Pacif.* **108,** 113–129 (1996).
2. Rosner, R., Golub, L. & Vaiana, G. S. *Annu. Rev. Astron. Astrophys.* **23,** 413–452 (1985).
3. Charles, P. A. & Seward, F. D. *Exploring the X-ray Universe* (Cambridge Univ. Press, 1995).
4. Acton, L. *et al. Science* **258,** 618–625 (1992).
5. Grosso, N. *et al. Nature* **387,** 56–58 (1997).
6. Wilking, B. A., Lada, C. J. & Young, E. T. *Astrophys. J.* **340,** 823–852 (1989).
7. Masuda, S., Kosugi, T., Hara, H., Tsuneta, S. & Ogawara, Y. *Nature* **371,** 495–497 (1994).
8. Innes, D. E., Inhester, B., Axford, W. I. & Wilhelm, K. *Nature* **386,** 811–813 (1997).
9. Klimchuk, J. *Nature* **386,** 760–761 (1997).
10. Strom, K. M., Kepner, J. & Strom, S. E. *Astrophys. J.* **438,** 813–829 (1995).
11. Cassen, P. in *Chondrules and the Protoplanetary Disk* (eds Hewins, R. H. *et al.*) 21–28 (Cambridge Univ. Press, 1996).

Comets

Hale-Bopp's atomic tail



Hale–Bopp is fading, but on its way out it has sprung a surprise. It has got a third tail, a tail made of sodium — something never before seen.

A team using the Isaac Newton Telescope on La Palma looked for emission from sodium atoms using a spectral filter. With the filter on, they took the picture on the left: the sodium tail is shown, clearly much straighter and narrower than the wide, bright, curving dust tail to its right.

Without the filter (right) the ion tail is visible as a faint, fan-like structure. The charged ion tail is driven by the solar wind, but that should have no effect on neutral sodium atoms. So what forms the sodium tail? It may be that, like the dust in the dust tail, the sodium atoms are accelerated by light pressure. But instead of reflecting the Sun's light like the dust, they absorb it, and so are accelerated by fluorescence (G. Cremonese, H. Rauer & A. Fitzsimmons *IAU Circ. No.* 6634; 1997).

Unfortunately, the new tail is too faint to see with the naked eye, but its colour should be familiar. It is the same yellowish colour — a pair of spectral lines at 589 nanometres — produced by low-pressure sodium street lamps, which have become widespread in many countries as a source of ugly lighting. But sodium lights are dimmer than their tungsten or mercury-vapour predecessors, so contribute less to light pollution. Those of us who live in large cities owe the visibility of Hale–Bopp, in some slight part, to sodium.

Stephen Battersby