frequencies with the rise from minimum to maximum being only a factor of 10^2–10^4. This is in contrast to a normal classical nova in which the rise from minimum to maximum can exceed factors of 10^6. In an X-ray nova the optical brightness may rise only 10^2 while the rise at X-ray frequencies can exceed factors of 10^4. Interestingly, V394 Corona Astrina, V745 Sco and V404 Cyg had all been catalogued as classical novae with small-amplitude optical outbursts. It was not until they were found in outburst again that it was realized that they are unusual objects. It now seems clear that if even fragmentary data on an existing outburst indicate a small-amplitude rise, the system should be analysed and monitored for another outburst.

The spectroscopic observations of both recurrent and X-ray novae show remarkable similarities and, in addition, there was also a strong similarity between the optical spectra of V404 Cyg at maximum, of the X-ray nova A06200-00 about 2–3 weeks after maximum, and of the extraordinary object SS433. These systems all showed strong emission lines from hydrogen and neutral helium. In some of these outbursts emission lines from ionized helium can become very strong and, in some cases, this indicates non-solar abundance ratios of hydrogen to helium in the ejected material[3,4].

This similarity is not so surprising, because the objects have the same basic structure: a binary-star system with one large star, the secondary, that fills its 'Roche' lobe (inside which its gravity dominates gas orbits) and the other star a compact object that can be either a white dwarf, neutron star or black hole. Where the Roche lobes of the two stars touch (at the 'inner lagrangian point'), material can overflow from the secondary and reach the surface of the compact object via an accretion disk. In recurrent and classical novae, the compact star appears always to be a white dwarf, whereas in X-ray novae it is either a black hole or neutron star[5].

The binaries' orbital periods indicate that for some recurrent novae the larger star must be close in size to a main sequence star, whereas others have much longer periods and the secondary must be much bigger in size and so must have evolved to fill its Roche lobe. T Corona Borealis and RS Ophiuchi, which have very long orbital periods, are probably recurrent novae with giant secondaries. Observations show that V745 Sco also has a giant secondary (IAU Circs 4844, 4885) and it should turn out to have a very long orbital period. In contrast, U Scorpii and V394 CrA are probably recurrent novae with evolved, but small, secondaries, because B. Schaefer (NASA/Goddard Space Flight Center) reported at the meeting that he had found orbital periods of 1.25 days for U Sco and 0.76 days for V394 CrA. X-ray novae all seem to have short periods (A06200-00 has a period of 7.3 hours and Cen X-4 has a period of 15.1 hours) and, although the period of V404 Cyg has yet to be determined, we predict that it will also be found to be short.

There are currently two competing models for the cause of the outbursts in recurrent nova systems. The first is an adaptation (by one of us, S.S., and colleagues[6,7]) of the thermonuclear runaway theory that was originally developed for the classical nova outburst. This assumes that a layer of hydrogen-rich material is transferred from the secondary onto the white dwarf. When enough material has been accreted, the bottom of the layer reaches thermonuclear burning temperatures and an explosion results.

The second theory is that an episode of increased mass-transfer or accretion-disk instability occurs that causes a period of enhanced mass transfer onto the compact object[8]. The system then becomes bright as a result of radiated accretion energy. It is not currently possible to distinguish observationally between these two hypotheses for a particular recurrent nova. However, X-ray nova outbursts must arise from either a mass-transfer or accretion-disk instability because there is no other way of depositing the necessarily large amount of accreted material onto the neutron star to produce an outburst that lasts for months. This is also true for those systems that have black holes as the compact component.

Comparisons at the meeting of the X-ray, optical and radio data obtained at short notice during the outburst of V404 Cyg, demonstrated the importance of fast response and coordinated multiwavelength observations to our continuing understanding of both X-ray and recurrent novae. Advanced space-borne and ground-based observatories, soon to operate across the entire electromagnetic spectrum and linked by a worldwide network of computers for realtime communication, may well provide the crucial observations necessary to test models of recurrent and X-ray novae, and other astrophysical phenomena as well. □

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DAEDALUS

Falling metal

SNOW, says Daedalus, is one of the most interesting of solids. Its open, branched, crystalline structure gives it a very low density; it absorbs sound and insulates heat extremely well, and can be compacted into a strong structural material. In principle, any solid can be formed into a snow by mixing its vapour with air or some other inert gas, and cooling the mixture below the freezing point of the solid. The supersaturated vapour will then precipitate directly as crystals without going through the liquid phase. A growing gas-suspended crystal has great difficulty in disposing of its latent heat of condensation, and takes up an open, feathery, dendritic snowflake structure. Daedalus is now trying the process with metals.

The metal with the highest vapour pressure at its freezing point, and therefore the easiest snow former, appears to be thulium. DREADCO meteorologists are cooling mixtures of thulium vapour and argon in a pilot hot-precipitation column, and studying the resulting thulium snow under a microscope. When the process is fully understood, they will be ready to apply it to more traditional engineering metals.

Daedalus's metallic snow will be a light, fluffy, dead-black powder — maybe the blackest solid known, thanks to its micro-labyrinthine structure. Like mono-crystalline metallic whiskers, its individual 'snowflakes' will be immensely strong. It should make a wonderful reinforcing agent for plastics and ceramics. And passing a current through the powder, spot welding the crystals together at their innumerable points of contact, should give a uniquely light and strong 'expanded metal'. DREADCO's 'Snometal' should revolutionize engineering.

For a start, it will absorb energy wonderfully. Snometal bumpers, traffic barriers, crash hats and safety cages will soak up any amount of punishment by the micro-deformation and crushing of their open structure. By the same token, Snometal will lend itself to all sorts of extruding and rolling and forming and pressing operations. In particular, it could be pressed into car bodies that are far lighter than normal sheet-steel ones, yet more rigid and energy absorbing. Even better, Snometal car bodies could be 'filled' with a suitable polymer. The resulting light, rigid, colourful and totally rustproof structure would last forever. Even after a collision, it could be pressed back to its original shape in a way that is impossible for fully dense steel. The steady obsolescence of all road vehicles, a major contributor to the global waste of fuel and materials, would be splendidly checked. And the pointless ritual of polishing and washing would be over for millions of resentful motorists.

David Jones