for regulating gene expression. With advances in computational strategies for locating conserved RNA folds in sequence databases, high-throughput methods for monitoring alternative splicing and other steps in gene expression, and prior knowledge of the function of genes involved in small-molecule metabolism, finding other examples of such regulatory modules in eukaryotes seems possible. In any case, we can be almost certain that new forms of RNA-based regulation will continue to emerge and amaze. ■

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SUPERNOVAE

Answers and questions

David Branch and Ken'ichi Nomoto

Do we understand the violent and cosmologically significant stellar explosions known as type-Ia supernovae? Yes and no, as astronomers participating in a conference in California agreed.

In mid-March, more than 100 astronomers converged on the Kavli Institute for Theoretical Physics in Santa Barbara, California, for an international conference* on so-called type-Ia supernovae (SNe Ia). Understanding these stellar explosions has a high priority: measurements of their brightness in the late 1990s revealed the existence of a mysterious 'dark energy' permeating space and accelerating the Universe's expansion. This conference was not primarily about exploiting SNe Ia for cosmology, but about assessing our current state of knowledge of where they come from, what exactly their stellar progenitors are, how they work, and how they explode.

A good idea lasts

In 1960, Fred Hoyle and William Fowler[1] concluded that SNe Ia are the result of thermonuclear instability following the ignition of nuclear fuel in 'electron-degenerate' matter. Such matter is formed when a star contracts and the electrons of its matter are compressed to fill every energy level available to them by the quantum-mechanical Pauli exclusion principle. Since then, astronomers have fleshed out the idea. Unlike other supernovae — types Ib, Ic and II, collectively known as core-collapse supernovae and produced only by short-lived, massive stars — SNe Ia are seen in both young and old stellar populations. They are even found in elliptical galaxies, meaning that some of them are produced by long-lived, low-mass stars found in these galaxies.

Most low-mass stars end their lives as electron-degenerate carbon–oxygen white dwarfs, without exploding. A more dramatic fate comes if the white dwarf accretes non-degenerate matter from a companion in a binary system (the single-degenerate scenario) or merges with

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**Paths to Exploding Stars: Accretion and Explosion*, Santa Barbara, California, 19–23 March 2007; http://online.kitp.ucsb.edu/online/snovae_c07

HYDROLOGY

Flood of data

P. BATES

If you need more precise measurements of natural events on Earth's surface, get into space. Researchers studying glaciers and earthquakes have for some time followed this principle, exploiting the power of satellite interferometric imaging to map surface displacements down to the centimetre scale. Doug Alsdorf and his colleagues have taken the same approach in their investigations of the periodic floods that occur in the Amazon basin (D. Alsdorf *et al. Geophys. Res. Lett.* **34,** doi:10.1029/2007GL029447; 2007).

The Amazon river has an intimate relationship with its vast floodplain, with an estimated 25% of its average annual discharge flowing and ebbing across it. But very little is known about the behaviour of these floods: not least, gauges of water level are placed only along the main channels, and then only sparsely. There are technical difficulties in taking interferometric measurements of water surfaces with satellite-borne synthetic-aperture radar. But flooded vegetation (pictured) does reflect an adequate signal.

Using data provided by instruments aboard the Japanese Earth Resources Satellite, Alsdorf *et al.* have been able to map the spatial and temporal complexity of floodplain inundation. Their study of floods from three different years takes in an area of the central Amazon basin that includes flows from the Purus river, as well as the Amazon itself.

Water levels in the floods, it turns out, do not take on the pattern that might be expected from a simple correspondence with the levels in the main channel of the river. Rather, there is a complicated interplay in which flow paths and water levels are influenced not only by the main channel and floodplain topography, but also by local and far-reaching hydraulic factors created by the flood itself.

These are proof-of-principle findings, with a practical edge. Modelling of floods is bedevilled by a lack of relevant measurements to test them. Satellite data can help redress that lack, with the ultimate aim of guiding engineering or other solutions to the inundation of areas inhabited by human populations. Furthermore, periodic flooding, and the associated delivery of sediments and nutrients, is a natural feature of wetland ecosystems not only in the Amazon but throughout the world. Some wetlands are under threat and, in some, restoration projects are in hand. Clarification of the relevant networks of water flow in different circumstances would offer another approach to ensuring the long-term success of such projects.

Tim Lincoln

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another white dwarf (the double-degenerate scenario) to form a configuration that approaches or exceeds the limiting 'Chandrasekhar' mass for a white dwarf, which amounts to 1.4 solar masses. Then, ignition of nuclear fuel near the centre of the body, and the outward propagation of a nuclear burning front, can release enough energy to explode the star within a second, leaving nothing behind (except, in the single-degenerate scheme, a toasted companion star).

The theoretically calculated composition and density structure of such explosions are expected to be broadly consistent with the observed spectra and light curves (of brightness against time) of SNe Ia. Indeed, increasingly detailed calculations of spectra and light curves for suitably parametrized numerical models of exploding white dwarfs are providing impressive agreement with observations (D. Kasen, Johns Hopkins Univ.; S. Woosley, UCSC)[2]. A white dwarf that accretes matter until it explodes still seems to be the best idea going.

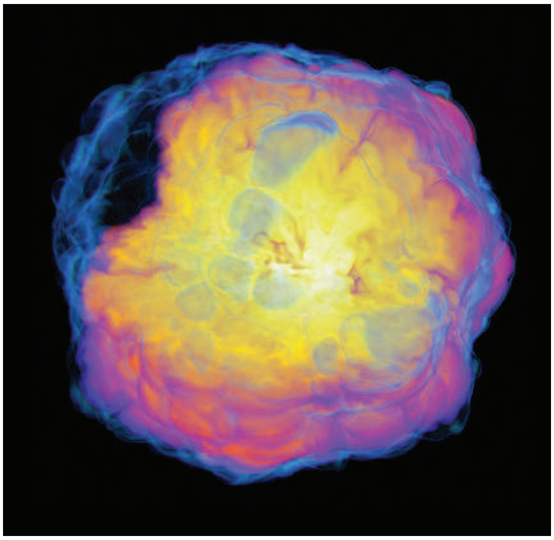

Figure 1 | Burn-out. A three-dimensional calculation of a pure deflagration explosion of a white dwarf. Blue areas represent high-velocity, low-density, unburnt carbon and oxygen; yellow represents low-velocity, high-density matter that has burnt to iron-group elements. In the central part of the image, the blue has been removed in order to make the interior yellow visible.

F. K. ROEPKE/W. HILLEBRANDT/MAX-PLANCK-INST. ASTROPHYS., GARCHING

Hunt for white dwarfs

A large galaxy such as ours produces SNe Ia about once a century. At any time, therefore, it should contain numerous accreting white dwarfs slowly approaching catastrophe. A few single-degenerate systems in which an accreting white dwarf seems to be near the Chandrasekar mass have been identified (I. Hachisu, Univ. Tokyo; J. Sokoloski, Columbia Univ.)[3,4], but in general these systems seem to be in short supply.

A favourite class of single-degenerate progenitor has been 'super-soft-X-ray sources', many of which are white dwarfs that accrete matter from non-degenerate companion stars. These white dwarfs gain mass by undergoing steady nuclear burning near their surfaces, thus emitting low-energy 'soft' X-rays. But recent surveys of such sources in nearby galaxies with NASA's Chandra X-ray Observatory have detected far too few of them to account for the observed rate of SNe Ia (R. Di Stefano, Harvard Univ.). It might be that recurrent, weaker nova eruptions and the absorption of X-rays by winds from the hot white dwarfs substantially reduce the observable duration of soft-X-ray emission.

Because white dwarfs are very dim, double-degenerate systems can be found only in a small, nearby volume of space. Most of the systems found so far have a total mass that is less than the Chandrasekhar limit, but one system whose total mass seems to be beyond it has been found (R. Napiwotzki, Univ. Hertfordshire)[5]. Double-degenerate systems might help to account for SNe Ia in very old populations such as elliptical galaxies. But whether the merging stars will really explode, rather than collapse to form neutron stars, is unclear (P. Podsiadlowski, Oxford Univ.). X-rays from the products formed by the merger, from before the supernova occurs, are not seen in sufficient numbers (R. Webbink, UIUC).

Mystery of exploding dwarfs

For decades we have known that, if nuclear ignition initially produces an outgoing detonation front that propagates supersonically, the entire white dwarf will be burnt to iron-group isotopes. This is inconsistent with the signatures of the intermediate-mass elements magnesium, silicon, sulphur and calcium in SNe Ia spectra. Instead, ignition must initially produce a 'deflagration', a form of combustion that propagates subsonically.

One-dimensional, spherically symmetrical calculations of nuclear hydrodynamics can produce the composition and density structures needed to match light curves and spectra. Computationally intensive calculations in three dimensions, however, reveal that pure deflagration explosions are relatively weak (W. Hillebrandt and F. Röpke, MPA Garching) (Fig. 1). A 'deflagration–detonation' transition similar to that which occurs in the cylinders of a car might provide more energy, but whether a nuclear equivalent could occur in the unconfined ejecta of a supernova is unclear (V. Gamezo, US Naval Research Lab.; L. Dursi, Univ. Toronto)[6,7].

Another possibility — gravitationally confined detonation — invokes a buoyant bubble of burnt fuel that bursts through the surface of the white dwarf and drives a 'flood' across the surface that converges at the antipode, causing a detonation (T. Plewa and D. Lamb, Univ. Chicago)[8,9]. This and all other explosion models involve thorny issues of nuclear-combustion physics; which of the scenarios are viable remains a subject of lively debate[10].

Saving grace

The consensus in Santa Barbara remained that SNe Ia are produced by accreting or merging white dwarfs. But as observational advances occur and more complex explosion models are calculated, the questions of where the progenitors are and how they explode seem to become only more perplexing. Beyond the issue of how nature makes the impressively homogeneous 'normal' SNe Ia, questions persist about what causes the moderate diversity among them, as well as what causes the minority that are strikingly peculiar in various ways (A. Filippenko, UC Berkeley). These include a homogeneous class of events of unusually low energy (M. Phillips, Las Campanas Observ.)[11–13], and one event the mass of whose ejecta seems to have been substantially above the Chandrasekhar limit (D. Howell, Univ. Toronto)[14].

In the face of these perplexing features, a saving grace is that the use of SNe Ia luminosity as empirical distance indicators for cosmology — the foundation on which the first observation of the Universe's accelerating expanion was built — still seems to be valid. Mild differences in the intrinsic luminosity of normal SNe Ia can, to a first-order approximation, continue to be allowed for through an observed relation between peak luminosity and light-curve width. Extreme outliers such as the 'super-Chandra' event[14] can be excluded from cosmological samples. Nevertheless, the use of SNe Ia for cosmology will be on firmer ground when our understanding of the phenomenon itself improves. Observations of SNe Ia, the search for their progenitors, and efforts to calculate properly the propagation of their nuclear flame are set to continue. ■

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