SUPERNOVA NEUTRINOS

Improved flavour

Neutrinos come in three flavours — electron neutrinos, muon neutrinos and tau neutrinos. When a massive star collapses in on itself and becomes a supernova (such as the one spotted by Chinese astronomers in AD 85 that left this remnant, pictured, RCW 86), a large fraction of its gravitational energy is released in an intense burst of neutrinos of all three flavours. The burst lasts just a few seconds, but the total energy of the neutrinos produced is equivalent to 10 per cent of the resulting neutron star's rest mass. Consequently, although

neutrinos interact only weakly with other particles in their environment, the sheer number of them produced means that these interactions can have notable impacts on a supernova's evolution. The nature of these interactions depends on the relative fraction of each neutrino flavour. But, John Cherry and colleagues suggest that there could be a problem with a key assumption that physicists use to calculate these fractions (*Phys. Rev. Lett.* in the press; preprint at <http://arxiv.org/abs/1203.1607>).

Most supernova neutrino-flavour calculations are based on the 'neutrino

bulb' model. This assumes that the distribution of flavours is determined exclusively by processes that occur within a sharply defined sphere around the core of a collapsing star, known as the neutrinosphere. To test the validity of this, Cherry *et al.* considered the contribution of flavour transformation caused by direction-changing scattering events involving neutrinos in the halo region beyond the neutrinosphere.

Their analysis suggests that, at late times in the course of a supernova, the density of neutrinos in the halo environment is small enough that scattered neutrinos make a negligible contribution to the potentials that govern the evolution of neutrino flavour. So at these times the neutrino-bulb model remains valid. But at early stages in the collapse of a star's core, the calculations suggest that scattered neutrinos can contribute between 14 and 90 per cent to the magnitude of these flavour-changing potentials.

The authors argue that the failure of the neutrino-bulb model to account for the contribution of halo neutrinos could have important consequences for our understanding of the dynamics of supernovae. In addition to carrying away most of the gravitational energy generated by a star's collapse, neutrinos are expected to be involved in other energy transport mechanisms and in the nucleosynthesis of heavy elements.

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HIGH-TEMPERATURE SUPERCONDUCTIVITY

Charting the pseudogap

Hole-doped cuprate superconductors exhibit an enigmatic state known as the pseudogap state. Mapping the distribution of this state as it evolves in real space with doping indicates that the moment the pseudogap fills the material is when superconductivity emerges — suggesting an intimate connection between the two.

Peter Wahl

In times past, before the continents of the world had been completely explored, maps often contained blank regions of white in the place of uncharted lands. Exploration by sea was invariably easier than exploration by land, and so the coastlines surrounding these

lands were usually known in much greater detail. A similar situation exists in the world of hole-doped cuprate superconductors. The map is a map of states of matter — a phase diagram¹ — with doping concentration on the east–west axis and temperature on the

north–south axis (Fig. 1). To the west lies an antiferromagnetic Mott insulator state; to the southeast, a curved peninsula of the superconducting state (better known as the 'superconducting dome') and to the northeast the badlands (or rather,