Can new particle physics solve astronomy's old problems?

IF CURRENT theories of physics are correct, the observable universe of atoms and molecules is merely froth floating on a sea of dimly perceived stuff called, for that very reason, dark matter and dark energy. Dark matter is perceived through its gravitational pull on the more familiar “normal” matter of stars and galaxies, while dark energy is perceived by the opposite effect—it pushes ordinary matter apart.

Until recently, physicists of both the subatomic and the astronomical persuasions thought that, gravity and the cosmological push aside, dark matter and dark energy tended to keep to themselves. Now some of them are not so sure. Particle physicists, in particular, are beginning to think that dark matter and dark energy may actually be responsible for the loudest bangs since the big one—and astronomers are not happy that the particle boys and girls are muscling in on their territory.

Late last year, Louis Clavelli, a particle physicist at the University of Alabama, went public with the astonishing idea that gamma-ray bursts, the brightest explosions in

the universe, are caused by the sudden conversion of vast quantities of normal matter into dark matter. The triggering mechanism for this catastrophe is, appropriately, dark energy.

To explain dark energy, particle physicists suggest that space exists in "phases" rather in the way that water can be solid, liquid or gaseous. The existence of dark energy shows that space does not reside in the lowest of these phases. Just as liquid water can freeze, so, in a sense, can space.

When this happens, normal matter becomes "supersymmetric". Supersymmetry is a theory devised by particle physicists to tidy up the rather arbitrary "standard model" of subatomic particles with which they now work. It invokes a shadowy world of partner particles to those of the standard model. These provide mathematical symmetry to the particle zoo (particle physicists love symmetry) and, coincidentally, provide a plausible explanation for dark matter. That is because supersymmetric particles are much heavier than their normal counterparts.

The circumstances necessary for the shift from normal to supersymmetric matter to take place involve extreme

density, but Dr Clavelli's calculations suggest that it is within the range of densities found in dead stars known as white dwarfs. These are about the same size as the Earth, but with a million times the mass. White dwarfs litter space in their trillions and, according to Dr Clavelli, any one of them could "freeze" at any time, turning its atoms into dark matter and releasing a powerful blast of gamma rays across the universe in a way analogous to water giving up its latent heat when it turns to ice.

It is a controversial idea. Astronomers have been studying gamma-ray bursts for more than 30 years, and have evolved a complex theory to explain them in terms of giant stars that become unstable and rip themselves to pieces. Dr Clavelli thinks that these efforts amount to beating a square peg into a round hole. The astronomers think the same about his theory.

Even if Dr Clavelli turns out to be wrong, the particle physicists are not done meddling in astronomy. The next shoot-out is likely to be over celestial objects called EGRET sources. Some 170 of these have been discovered. They are sources of gamma rays but, unlike gamma-ray bursts, they shine continuously. They were discovered by the *Compton* gamma-ray observatory,

launched in 1991 by NASA, America's space agency, and named after the Energetic Gamma Ray Experiment Telescope (EGRET) on *Compton* that found them. So far, they have defied attempts at explanation.

Argyro Tasitsiomi, of the University of Chicago, thinks there is a chance that EGRET sources are actually clumps of supersymmetric particles called neutralinos. She has calculated that when neutralinos collide, they should give out gamma rays. That means there should be a faint wash of gamma rays passing through space, with bright spots anywhere that clumps of dark matter have formed. She hopes that NASA's Gamma-ray Large Area Space Telescope (GLAST), which is due to be launched in 2007, will provide more detailed observations to test her ideas.

Some particle physicists also invoke dark matter as a possible explanation for so-called ultra-high-energy cosmic rays. Since the beginning of the 20th century, scientists have known that there is more radiation on Earth than can be accounted for by radioactive elements in the rocks. They traced the extra radiation to a perpetual sleet of particles coming from space. Although these particles appear to be made of “normal” matter,

some arrive at Earth with energies that defy traditional explanation. James Pinfold, of the University of Alberta, in Canada, thinks that dark matter may be responsible because some forms of it should decay spontaneously, spitting out an ultra-high-energy cosmic ray in the process.

Cosmic rays were among the first high-energy particles to be studied, before physicists worked out how to build the giant accelerators that they now use to make such particles. It would be a delicious irony if they turned out to hold the secret of supersymmetry—the subject's most persistent known unknown.