Quantum foam blows away naked singularity

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NAKED singularities and cosmic censorship may sound like lurid terms from the tabloids, but in fact these phrases lie at the heart of a troubling question for modern cosmology: what happens when our known laws of space and time break down, as happens in the final moments of a star collapsing to a point under its own gravity?

The answer, say a trio of cosmologists, lies in theories of quantum gravity, which attempt to unify the otherwise incompatible theories of quantum mechanics with Einstein's general relativity. According to Parampreet Singh of Pennsylvania State University at University Park and Rituparno Goswami and Pankaj Joshi of the Tata Institute of Fundamental Research in Mumbai, India, a theory called loop quantum gravity can explain those final moments and could also reveal a distinct, observable signal to look for.

The collapse of stars heavier than about 5 solar masses is particularly disconcerting for cosmologists. In many scenarios, Einstein's theory of general relativity predicts that the likely outcome is not a black hole, as is popularly assumed, but a naked singularity - an infinitely dense fireball in which the laws of physics break down. Unlike a black hole, it is potentially observable.

The known laws of physics would misbehave wildly at these singularities and cannot predict what astronomers studying such collapsing stars might see. To avoid such anarchy cosmologists Roger Penrose, Stephen Hawking and others hypothesised a "cosmic censorship principle" that would prevent such a situation by cloaking all singularities within black holes, so they could never be observed. But this hypothesis remains unproven.

For Singh and his colleagues, the answer lies instead in loop quantum gravity (LQG), which is one of the main contenders for a theory of quantum gravity. In LQG, space-time itself is composed of tiny packets, or quanta, bound together in a kind of foam. When the researchers used the theory to model the extreme events leading up to a naked singularity, they found that the singularity literally evaporated. The dying star ejected all its mass in a colossal burst of particles, preventing the singularity from forming.

The model, to appear in the journal *Physical Review Letters*, also shows that this burst has a distinct signature that astronomers could look for: the star dims briefly before its final violent outburst. "This provides us with a rare observational test for quantum gravity," says Singh. If the model is correct, the burst would include high-energy gamma rays, cosmic rays and neutrinos. Probes such as the European Space Agency's Extreme Universe Space Observatory, planned for launch in 2010, could test this prediction.

Lee Smolin of the Perimeter Institute in Waterloo, Canada, and one of the founders of LQG, cautiously welcomed the result. "These results provide strong evidence that LQG removes naked singularities," he says. "However, their models are greatly restricted, so it's hard to say if the singularities are removed in the full theory."

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