

# Hawking sees light at end of Black Hole

Later today (21<sup>st</sup> July), at a conference on Relativity and Gravitation at Dublin, Stephen Hawking will unveil his answer to the 'black hole paradox', says S.Ananthanarayanan

But what is the paradox about black holes and what did Stephen Hawking have to do with it?

## Black holes primer

A black hole is how a star that is more than about 1.3 times the mass of the sun will be at the end of its life. Stars set out as wispy clouds of hydrogen, millions of kilometers across, slowly closing in because of gravity. As the gas gets compressed, it heats up and keeps getting hotter, till it reaches millions of degrees C. When compressed and hot like that, the nuclei of hydrogen fuse into nuclei of helium. This is a reaction that gives off immense heat. This causes more 'fusions' and also makes the gas expand. The expansion progresses for millions of kilometers, till the gas cools because of expansion and the force of gravity takes over again. Again, compression causes warming and fusion of hydrogen nuclei, and so on.

When the hydrogen gets used up, greater compression and more energetic reactions result in fusion to create heavier elements. The process goes on till most elements are created and till the star has no more fusion reactions to generate heat to stem the compression by gravity. The force of compression will now get stronger as the star gets denser and in theory the star should reduce to a geometric point.

While this does not actually take place, for reasons that have to do with the quantum nature of very small things, a result of the great density of the star is immense force of gravity in its vicinity. This makes surrounding matter crash into the star and further increase its mass. In the larger stars, the density reaches a point when the force of gravity at its surface is so strong that even the light emitted by the star is not able to escape.

Hence the name 'Black', and as all matter that falls in becomes part of the star and disappears from view, the name 'Hole'.

## Hawking and the Black Hole

The Black Hole is bristling with relativistic effects. An entity falling in accelerates nearly to the speed of light. According to relativity, time now starts moving slower for the entity. As it gets nearly to the black hole, time should come to a standstill. The entity should then, in its time-frame, never reach the black hole!

In this fertile bed of research and conjecture, Stephen Hawking put in his oar with the discovery that for all its appetite to draw things in, black holes would also continuously radiate! The way Hawking worked this out was with a marvel of quantum physics - that every now and then, a pair, of an atomic particle and its 'antiparticle', can pop up from nowhere! The particles are

evanescent, for they instantly crash into each other or a mutual antiparticle in the vicinity and annihilate.

Now, when this happens near a black hole one of the particle-antiparticle pair could get drawn into the hole and no longer be detectable. The other particle, then, has effectively come from nowhere! Its behavior, it turns out, needs to be 'opposite' and it 'streams' out from the black hole as "Hawking radiation".

Going one further, it turned out that this radiation from the black hole would finally bleed the black hole of all matter and the black hole would disappear! Now, the mass of a black hole consists of a huge quantity of information contained in everything that went into it. If all the mass were to disappear, philosophically, this meant that all information is lost, and this violates the laws of physics.

Hawking has announced that he has developed a way out of this contradiction and the world awaits what he says today at Dublin.

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