# Evaporation of black holes and string theory

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Black holes are objects so compact and so dense that in their vicinity, the escape velocity exceeds the speed of light : their gravitational attraction traps even the light which ventures too close and is then lost. However S. Hawking showed in the '70s that the black holes are not so black eventually. They have an entropy, which can only increase, and thus a temperature : the black holes emit particles and thermal " radiation ", with a temperature which depends only on their mass : the black hole is the more " hot " that it is not very massive. These particles are emitted in a zone right outside the horizon of the black hole (limit inside which nothing can escape). It is a quantum effect, based on the spontaneous creation of pairs of particle-antiparticles in the energy fluctuations of the vacuum.

Black holes of a fewsolar masses, residues of massive stars after their death, have a temperature quite lower than the cosmic background radiation and do not evaporate. On the other hand, the microscopic black holes formed very early in the Universe already evaporated if their mass is lower than the billion tons. In the intermediate mass range, it could exist very hot black holes, still evaporating today. At the time of the final phases of evaporation, the mass of the black hole becomes infinitely small, and thus its temperature tends towards infinity. The black hole disappears in a fantastic explosion. The last phases of the evaporation of the black hole still remain to be studied.

The microscopic black holes involving at the same time very strong gravity and quantum mechanics, should be explained within the framework of a quantum theory of gravity, which today is not established yet. The string theory is among the best candidates for that theory, which should also unify all the forces. This theory generalizes the individual elementary particles (with zero dimension to some extent) by particles with a dimension 1, the strings, at very high energy. The various modes of vibration of the strings correspond to various particles of different mass and energy.

Norma Sanchez, from Paris Observatory, and her collaborators endeavoured these last years to develop the emission mechanisms of black holes within the framework of the string theory. The black hole emits particles, and within the limit of high energies, it emits a whole spectrum of strings. The temperature of the strings is proportional to their mass. The temperature of the black hole cannot exceed that of the strings. When the temperature of the black hole is low, the individual particle emission is found. When the temperature of the black hole is high, and comparable with that of the strings, its emission is dominated by that of very massive strings, and one cannot distinguish the black hole any more from these strings : there is a phase transition of the strings which are transformed into microscopic black hole, or, alternatively, it is the black hole which towards its end is transformed into a string. Thus evaporation does not reveal any more infinite temperatures, as it was the case in the theory of the individual particles.

This work is detailed in an article to appear in Physical Review D (Mr. Ramon Medrano, N Sanchez hep-th/9906009 )