CALIFORNIA STATE SCIENCE FAIR
2004 PROJECT SUMMARY

Name(s)
Zachary R. Schmidt

Project Number
J1531

Project Title
Black Holes: An Analysis of Black Hole Thermodynamics

Abstract

Objectives/Goals
The purpose of this project was to determine the effects of the temperature of the universe on Black Holes as the universe ages.

Methods/Materials
1. Determine the size of the Black Hole using the classic Schwarzschild Radius formula.
2. Determine the amount of energy being radiated through Hawking Radiation.
3. Determine the temperature of a Black Hole
4. Compare the temperature of a Black Hole with that of the universe.
5. Determine how long it will take for the temperature of the universe to reach equilibrium with the temperature of a Black Hole.

I set up these equations in an Excel spread sheet and solved for Black Holes with 1 to 512 solar masses. I also explored the results for smaller Black Holes, such as the mass of the earth, moon and Chevy Suburban.

Results
The larger the Black Hole, the longer it would take to reach equilibrium with the temperature of the universe because it is cooler than smaller Black Holes. Once it does reach equilibrium, a larger Black Hole radiates less than a smaller one, so it would take longer for the larger Black Hole to radiate all of its mass away.

Conclusions/Discussion
My hypothesis was that as the universe expanded and cooled, it would absorb less CMB than it was radiating away, and therefore lose mass. Eventually, it would radiate away all of its mass and evaporate. According to my results, my hypothesis is correct. However, it would take a long time for a large solar mass to reach equilibrium with the temperature of the universe, and would take an even longer time for it to radiate it#s mass away.

Summary Statement
My project is about Black Hole Thermodynamics, in which I tried to determine the effects the temperature of the universe had on Black Holes.

Help Received
Mother proofread report; Dad helped type report; Kyle Lanclos helped understanding of subject; Professors George Brown, Donald Coyne, Anthony Aguirre, and Terry Schalk of UCSC physics department critiqued report.