Physics 161: Black Holes: Lecture 20: 22 Feb 2010

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20 General Black Holes

SHOW movies of moving around and into black holes.

So far we've talked only about the simplest black holes: spherical ones, described by the Schwarzschild metric. There are other more general solutions to Einstein equations that are known, but still much is not known. For example, it is *conjectured* by Kip Thorne that black holes are very general, that whenever a mass M is concentrated inside a region with circumference in any direction smaller than $2\pi r_S$, $(2\pi(2GM/c^2))$, then a horizon forms, i.e. that a region from which light cannot escape comes into existance. This conjecture has not been proved so is more like a physicists rule of thumb. The big problem is configurations that change with time, static situations are more well understood. I list below some general known things about black holes.

- When a black hole forms, the horizon grows from $r = 0$ outward to $r = r_S$. It is not an instaneous thing. This can be seen by following photons out of a star as it collapses. The ones near the center are the first to get trapped.

- Stationary black holes have no hair! This is the common way of stating a famous theorem about black holes: The metric of a black hole is completely specified by three things and only three things: it's mass, it's angular momentum, and its charge. Thus any information about stuff that fell into a black hole is completely lost. The Schwarzschild solution was found in 1916, and soon after Reissner (1916) and Nordstrom (1918) found the metric for a charged black hole. Kerr round the rotating black hole solution in 1963, and the charged rotating solution was found by Newman et al. in 1965. The proof of this theorem is due to Hawking (1972), Carter (1973), and Robinson (1975). This also implies that any intial quadrapole, octopole moments will be radiated away by gravitational waves and you are left with a Kerr hole or Schwarzschild hole.

- Hawking area theorem. In any process involving classical horizons, the area of the horizon cannot decrease. This implies that black holes can never bifurcate. The proof assumes that local energy density is greater than zero; quantum mechanical processes can can violate this assumption.

- Cosmic censorship: naked singularies can't exist. This is a conjecture. It says that whenever there is a singularity (place where curvature goes to infinity) there will be a horizon surrounding it. All known static solutions of GR obey this, but there have been recent claims by people doing numerical GR that there can be exceptions.