Overview/Preview

ASTR 2030 - BLACK HOLES

Rosalba Perna - Fall 2012
WHAT IS A BLACK HOLE?

A few definitions from the dictionary:

- Region of space resulting from the collapse of a star
- Region of space with strong gravitational field
- Dungeon or dark cell in a prison
- Project that requires large effort with no return

- Concentration of mass with a gravitational field so strong that not even light can escape its grip

(closer to what this course will be about….)
Starting point: our familiar world of “slow” human beings

Slow compared to what???
.... the velocity of light, “c”
In our everyday, “slow” world, everybody agrees on measurements of time and space independently of the motion. This constitutes our “common sense”
What happens when $V \rightarrow c$?

**Special Relativity** - Einstein 1905
Relativity of.....

Space

and ...

Time
Then **GRAVITY** comes into play.....

+ relativity of space and time

**General Relativity**  
Einstein 1915
BLACK HOLES are predicted....

Schwarzschild discovers that General Relativity predicts the presence of “singularities”, regions where gravity is so strong that not even light can escape...

Einstein refutes... “too bizarre to be true”....

... but research continues....
Properties of Black Holes... e.g.

- Time dilation,
- gravitational redshift,
- "spaghettification"

From inside this region no information can escape.

"No hair theorem"

... Hawking radiation.... Kerr black Holes....
“Exotic” phenomena connected to Black Holes....

Wormholes

Time machines
Do Black Holes exist in the "real" Universe???
Theoretically: Black holes believed to be associated with the “death” of massive stars.
Observationally: several pieces of evidence

(asterophsicists like to classify by the mass of the Sun)

- **Small-mass BHs** in X-ray binaries
  - a few

- **Supermassive BHs** in galaxy centers and Quasars
  - $10^6$-$10^{10}$
X-RAY BINARIES

Star “feeding” Black Hole

QUASARS

$L \sim 10^{46} \text{erg/s}$

$\sim 100000000000000 \ L_{\text{sun}}$
Do we ever “witness” the birth of a NEW Black Hole?

We probably do when we “see” a.... GAMMA-RAY BURST
We will also discuss...

The **BIG BANG** theory

.. and...

The theory of **INFLATION**

Under inflationary cosmology, the Universe underwent a phase change at the GUT era and expanded faster than the speed of light (the spacetime itself expanded, so there is no violation of special relativity).

The result is that only a small part of the original Big Bang is within our horizon, what we call our Universe.
A class will also be on **Black Holes and Popular Culture**

Excerpts from popular movies will be watched and discussed.
Focus of course: **CONCEPTS, IDEAS**

Required math background: **high school-level algebra**

But if you see something you don’t like...

**DO LET ME KNOW!**
If you find some of these concepts and ideas mind boggler's....
DO NOT DESPAIR !!!
YOU ARE NOT ALONE!

Some concepts defy our “everyday” intuition
GOALS of the course:

- Understand where concept of Black Hole comes from within context of General Relativity
- Become familiar with physical properties of Black Holes
- Gain a knowledge of the current status of the astrophysical evidence for the presence of black holes in the Universe
Hopefully by the end of the course **YOU WILL:**

- Be able to evaluate critically the things you read in the popular press and science fiction literature

- Have a glimpse of the process by which scientific theories are conceived, advanced and tested

- Understand enough to be able to offer correct explanations of black holes and related phenomena to friends and family and have an idea of “how science works”

....and all this while...
....having FUN!

So you created everything. Yes.

Including black holes. Yes.

Which will swallow up everything. Yes.

Including you.

I'm working on that.
However, BE AWARE that:

You will need to have a good understanding of the material discussed in class in order to get the grade you aim at.
CLASS ATTENDANCE IS VERY IMPORTANT!!

- Questions on tests that count towards grade will always be on topics discussed in class.

- Clicker questions will yield minimum gain for no answer (more on this later).

90% of success is showing up.

Woody Allen
“Practicalities”....

This is a “multi-media” class.

Lectures will be a mixture of:

- Demonstrations/explanations on the blackboard;
- Powerpoint presentations (images/clips)
- Videos and movies with discussions
- Practice problems
- Clicker questions followed by discussion
“Field” Trips to the Fiske Planetarium

Prof. Dick McCray will host a show on **Supernovae**

Prof. Andrew Hamilton will host a show on **Black Holes**
The Fiske planetarium team will host a show on The Milky Way, a City of Stars

Guest Lecture:

Prof. Webster Cash

on MAXIM on Galaxies
Textbooks:
Begelman & Rees “Gravity final attraction”
Thorne: “Black Holes and Time Warps”

NOTES from class

If you do happen to miss a class, make sure to get a copy of the class lecture notes.
What YOU will need to do and GRADING policy

- 40% : 4 in class projects (3 people) - the best 3 count counts for 13.33% each. The worst will be neglected.
- 20%: paper (on a topic of your choice related to class)
- 30%: final (December 15)
- 10% clicker questions (on most days)
More on **Clicker Questions**:

3 Types of questions:
On the material from the previous or recent classes (graded);
On issues that arise in class and that are related to the material being discussed (graded);
On background material not previously discussed- for me to know whether to make a digression (not graded)

Assessment:

- Right answer: 2 points
- Wrong answer: 1 point
- No answer: 0 points

4 days “bonus” (i.e. 4 days of absence will be discounted)
Office hours and contact info:

PROF:

Tue: 3:30pm-5:00pm
Thu: 12:30pm-2:00pm
903 in JILA tower
Rosalba.Perna@Colorado.EDU
Tel: 492-0389

TA:

Mon: 11:00am-12:30pm
Wed: 11:00-12:30pm
Duane 152
Jordan.Wheeler@Colorado.EDU
Tel: 314-574-1711

Course web site:
http://amalfi.colorado.edu/~rosalba/astro2030/astro2030.html