Wednesday, September 27
Thorne pgs.: Ch. 8-10

Agenda
- Announce:
  - Read up to Chs. 11-14 (and Epilogue)
  - Test one week
- Second Part of Movie
- Story so far
  - Ch. 8
  - Ch. 9
  - Ch. 10

Movie Part II
- Energy increases w/ square of velocity
- 1905—miraculous year for physics Einstein published papers:
  - Establishing existence of light quanta (photons)
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  - Laying out special theory of relativity
  - $E=mc^2$
- Far reaching consequences
  - Meitner & Hahn bombard big elements with neutrons to make bigger ones...end up with smaller ones
  - Sum of two smaller masses less than that of big mass atom
  - First to convert mass to energy

Story So Far
- 1915—General Theory of Relativity to handle acceleration ends up a new theory of gravity
- 1916—Schwarzschild solution
- 1930s—Not clear if star would stop collapsing before BH formation
- 1940s—Becoming clear that white dwarfs and neutron stars couldn’t stop massive stars
- WWII
- 1950s—Properties of BHs start being found
- 1965-1975—Golden Age of Relativity/BHs
- Modern day—searching for direct evidence of BHs

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Ch. 8—The Search for BHs
- Look for shock front effects in gas clouds
  - Idea: A BH passing through hot gas will produce shock fronts in its wake

X-Ray Binaries
- X-Rays:
  - Extremely energetic electromagnetic radiation...generally associated w/ very energetic events
  - Tends to go through things...hence hard to focus
  - Blocked by atmosphere
- X-Ray detectors associated with arms race:
  - Launched on rockets
  - Used to study nuclear testing (both ours and theirs)
- Look for BHs in accreting binary systems
- Best candidate: Cygnus X-1
Ch 9.—Supermassive BHs

- 1930s—Bell engineer finds radio noise from center of galaxy
- 1940s—Amateur builds first radio antenna and finds “radio loud” spots including center of galaxy
- Postwar: radar engineers help with radio astronomy (more interplay war/science)
- 1949—built radio interferometers...to get resolution
- 1950s—Discovery of radio galaxies
- 1960s—Discovery of quasars
  - Moving at incredible speeds (e.g. 57% of c)
  - Billions of light years away
  - Mean hugely bright
  - Not bigger than a light-month

What powers quasars?

- Chemical? Nuclear? Antimatter?
- Gravity? First case where one really needs GR?
- Gigantic, spinning black hole:
  - Fit the light-month size
  - Can power a jet stably for millions of years, hole’s rotation acts as gyroscope despite accretion
  - Can produce magnetic fields which can get electrons to radiate synchrotron radiation

Ch. 10—Gravitational Radiation

- History shows opening of new spectra brings new physics:
  - Radio astronomy
  - X-Ray astronomy
  - Gamma-ray astronomy
- These are all electromagnetic!

GR Waves

- What’s waving?
- What info do they carry?
- Why so weak?

GR Detection

- Weber
- Thorne
- LIGo
- Need to know roughly what to look for:
  - Amplitude
  - Frequency
  - Event rate
  - Matched filtering