



Monday, September 17

Thorne pgs.: 104—End of Ch. 5

## Agenda

- Announce:
  - Read up to Ch. 9 by next week
- Review Last week
- Tides

## Review

- Reference Frames
- Einstein's Special Theory of Relativity
  - What's relative/absolute?
  - Effects
- Einstein's General Theory of Relativity
  - Equivalence principle
- Emerging Picture of Einstein
  - Non-conformist
  - Does what he likes ("lazy dog")
  - Worked mostly in isolation (unusual)
  - Guided by aesthetics
  - Used thought (gedanken) experiments

## Tides

- What produces tides on Earth?
- Why were tides important for moving beyond the equivalence principle?

## Curvature

- Spacetime curvature the same thing as Newton's tidal gravity
- Objects move in geodesics
- Viewing curvature...embedding in a flat space (fig. 3.3 on page 129)

## The Math

- Einstein got help from friend Marcel Grossman
- Studied Riemannian geometry
- What did they seek?
- How did Einstein know if he had found it?

## The solution

- Needed a formula that gave the curvature
- Kept having problems finding one that gave the same answer in all frames
- Eventually found one that also gave a good number for the precession of Mercury's orbit

## Newton's Black Holes

- What's a dark star?

## Schwarzschild

- And let there be relativists... within a year Schwarzschild found important "solution"
- Dead four months later
- Described curvature of spacetime in vicinity of spherical star
- More massive or compact a star was, the more the effects:
  - Gravitational redshift and time dilation near surface
- Couldn't continue forever for the most massive of stars...

## The Prediction of Black Holes

- Einstein rejected them
- Claimed that as a star shrunk, particles would have to move faster than light to maintain pressure

## Massive Stars: White Dwarfs

- Very dense
- Most stars demonstrate a balance:
  - Thermal pressure
  - Gravitational squeezing
- What forces can balance gravity at extremes?

## The Search for Forces

- Chandrasekhar to the rescue
  - Use of quantum mechanics
  - Electron degeneracy pressure
  - Monstrous densities mean high speeds for trapped particles
  - Particle's now have max speed, hence density limit
- White dwarfs can't be heavier than 1.4 Suns!
- What happens to such stars?

## Zwicky

- Supernova
- Neutrons
- Neutron stars