PS# 5 due Thursday:

NOTE: orbital period = 8 hrs on prob 1

test after break
(test prep sheet upcoming review session 9:15pm night before)

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**POST-NEwTONIAN EFFECTS OF G.R.**

1) precession of perihelion
(Mercury’s orbit)

2) deflection of light

**eclipse observations**

-> gravitational lenses
3) gravitational redshift

\[ z = \frac{\Delta \lambda}{\lambda} = \frac{\Delta P}{P} \]

"redshift" \[ = \frac{1}{\sqrt{1 - \frac{R_s}{r}}} - 1 \]

 Schwarzschild radius of some mass

distance of the light source from mass

how much redshift do you observe from infinite distance

\[ \frac{R_s}{r} \rightarrow 0 \]

If observer is not at infinity

\[ z_{\text{obs}} = z_{\text{source}} \rightarrow -z_{\text{observer}} \rightarrow 0 \]
prob 2

has some redshift

\[ \text{has less redshift} \]

correction in redshift

4) gravitational waves

\text{effect: orbital period decreases}

\text{NOT observed in Solar system}

LAB POR C.R.

"Binary Pulsar"
pulsars: discovered in late 1960s

observed: pulses of radio waves

pulsation happen with period between milliseconds to tens of seconds

rotating magnetized neutron stars

FABLE: Jocelyn Bell and discovery of pulsars

MORAL: grad students never get the credit : thinking and doing are not the same
\[
\frac{\Delta P_p}{\Delta P_0} = \sqrt{\frac{1 + \frac{v_{rel}}{c}}{1 - \frac{v_{rel}}{c}}} - 1
\]

\[
\frac{\Delta v}{c} \approx \text{Nutation approx}
\]

Discovery of binary pulsar

P\text{\textsc{orbital}} \approx 8 \text{hrs}

measure pulse period to high accuracy

elliptical orbit

precession of periastron

4°/year

(More like ~43°/century)
also: grav. redsh. ft
seeing effect of the
companion object
(also neutron star)

object

at position 0 objects
close redsh. ft caused by
other object is large

at position 2 dish is quaker -> redsh. ft is
also: orbital period decreases due to grav. waves

only Newtonian measurements → determine \( M_{\text{tot}} \)
if you know inclination
measure precession of periastron
also depends on \( M_1, M_2 \)
and \( i \)

Solve for inclination

know \( M_{\text{tot}} \) but not each individual mass
grav. redshift: depends on $M_1, M_2, c$

now: solve for $M_1$ (also $M_2$)

know $M_1, M_2, c$ notice

PREDICT what the period change should be

measure this effect

$\rightarrow$ prediction correct to measurement amount

CLEAR that C.R. is "correct" in post-Newtonian approximation
But imagine a theory which is the Newton (1st term) like G.R. (2nd term "post-Nem..."

but different at very strong grav. fields

So it would be good to test strong field effect

$\frac{R}{r} \rightarrow$ close to 1