

#4

The Crab Pulsar has a period of  $P = 33 \text{ msec} = 0.033 \text{ sec}$ . How easy is it to detect the pulses of this object in  $\gamma$ -rays, and in the optical regime? Let's consider the statistics of photons...

a) In optical, at  $\lambda = 7000 \text{ \AA}$ , the flux of Crab Pulsar is

$$f_{\text{opt}} = 3 \times 10^{-12} \frac{\text{erg}}{\text{sq.cm} \cdot \text{s}}$$

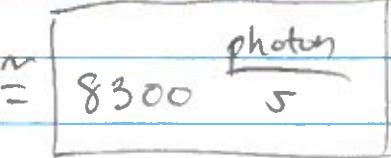
So if we use a telescope of aperture  $R = 50 \text{ cm}$ , and pretend that all the photons we detect are exactly  $\lambda = 7000 \text{ \AA}$

$$\text{collecting area } A = \pi R^2 = 7854 \text{ cm}^2$$

$$\text{energy per photon } E = hc/\lambda = 2.84 \times 10^{-12} \text{ ergs}$$

We collect this many photons per second

$$N(\text{opt}) = \frac{f \cdot A}{E} = \frac{3 \times 10^{-12} \frac{\text{erg}}{\text{cm}^2 \cdot \text{s}} (7854 \text{ cm}^2)}{2.84 \times 10^{-12} \text{ ergs}}$$

$\approx$  

b) Each second contains  $\frac{1}{P} = 30.3$  flashes, so the number of photons per flash is

$$N(\text{per flash}) \approx \frac{8300}{30.3} \approx \boxed{270 \frac{\text{photons}}{\text{flash}}}$$

#4

part 2

c) Now consider the  $\gamma$ -ray emission. For the sake of argument, pretend that the pulsar emits exactly the same flux in  $\gamma$ -rays of energy

$$E_\gamma = 10 \text{ MeV} = 10 \times 10^6 \text{ eV}$$

$$= 10^7 \text{ eV} \cdot 1.609 \times 10^{-12} \frac{\text{erg}}{\text{eV}}$$

$$= 1.6 \times 10^{-5} \text{ ergs per } \gamma\text{-ray}$$

#  $\gamma$ -rays per second  $N_\gamma = \frac{3 \times 10^{-12} \frac{\text{erg}}{\text{cm}^2 \cdot \text{s}} \times (7854 \text{ cm}^2)}{1.6 \times 10^{-5} \text{ erg}/\gamma\text{-ray}}$

$$N_\gamma = 1.47 \times 10^{-3} \text{ } \gamma\text{-ray/second}$$

d) If there are 30.3 flashes per second, then each flash must contain

$$N \text{ per flash in } \gamma\text{-ray} = \frac{1.47 \times 10^{-3}}{30.3}$$

$$\approx \boxed{4.9 \times 10^{-5} \frac{\text{ } \gamma\text{-ray}}{\text{flash}}}$$

It will be very hard to detect a periodic signal in  $\gamma$ -rays — but easy in optical photons.