

Problem Set 5 Solutions

Problem 1: E

Problem 2: C

Pulsars pulse because there is a large amount of radiation beamed outward from the magnetic poles, and if the magnetic poles are misaligned with the rotation axis, this beamed radiation could sweep periodically past an observer.

Problem 3: A

Once a stellar core exceeds the Chandrasekhar mass, electron degeneracy pressure can no longer support it, but neutron degeneracy pressure may still be able to. The core will collapse, not explode, and this is a possible end state of white dwarfs.

Problem 4: B

The main evidence for the presence of Sgr A* is the very eccentric orbits of stars around an invisible mass which is inferred to be very large to the high velocities of those stars at periastron.

Problem 5: C

Hawking radiation is theoretically produced by black holes, but its luminosity is very small. Thermonuclear fusion is the energy source for normal stars. Black holes can produce large luminosities, however, through the accretion of material, which releases the gravitational potential energy of that material as it moves inward.

Problem 6: A

The thin disk generally consists of younger stars.

Problem 7: B

Globular clusters generally consist of older stars.

Problem 8: A

The Sun is among the youngest generation of stars.

Problem 9: B

Spiral arms are thought to result from spiral density waves which travel throughout the galaxy relative to the (star-forming) mass that is present at each location.

Problem 10 (4 points)

If $v(r)$ is a constant, then $\rho(r) \propto r^{-2}$. Let's say $\rho = Kr^{-2}$. We also know that the enclosed mass is

$$M(R) = \int_0^R 4\pi r^2 \rho dr = \int_0^R 4\pi r^2 \rho = \int_0^R Kr^{-2} dr = 4\pi KR. \quad (1)$$

We can then solve for $K = M(R)/4\pi R$. We can get the mass enclosed using the velocity, since $M(R) = v^2 R/G$. Then $K = \frac{v^2}{4\pi G} = 5.77 \times 10^{20} \text{ gcm}^{-1}$. Plug this back into the expression for ρ and plug in 8 kpc, so $\rho(R) = 9.47 \times 10^{-25} \text{ g cm}^{-3}$.