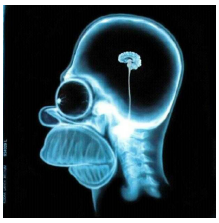
General Astronomy II, Spring 2019

Problem Set 1

Deadline: 11PM Thursday, March 28, 2019
Submission: iLMS platform



Early one morning, you bumped into Homer Simpson in a coffee shop. Homer had his own ideas of how and why everything is in the universe and insisted that his ideas were right. But you know that a lot of his thoughts may not be correct, not any better than what shows in an X-ray image of his brain.

After hearing what Homer had to say, you decided to convince him with what you have learned in the class. You must let Homer know which part of his arguments went wrong.

1. **Galactic Center (40%).** A supermassive black hole of 4 million $M_\odot$ resides in the Galactic Center. Let's hear what Homer says about the black hole.

   > **Homer:** I have heard about black holes appearing very dark because no light can escape. I also heard that the center of our Galaxy has a supermassive black hole because that part of the sky looks particularly dark at night (Fig. 1).

Figure 1: Optical image of the Milky Way.

   (a) (10%) Do you agree with Homer's idea about our Galactic Center? If not, tell him what is the expected outcome of his idea?

   (b) (20%) Can you tell him how this black hole is verified by astronomers?

   (c) (10%) Why the Galactic Center appear dark on the night sky?

2. **Spiral density wave theory (40%).** Many disk galaxies, including our Milky Way, display beautiful spiral arms. Let's hear Homer's ideas about these spiral arms.

   Homer: I know fluid dynamics! I watch how milk spiraling on my coffee every morning (Fig. 2). And I have seen those beautiful pictures of galaxies.

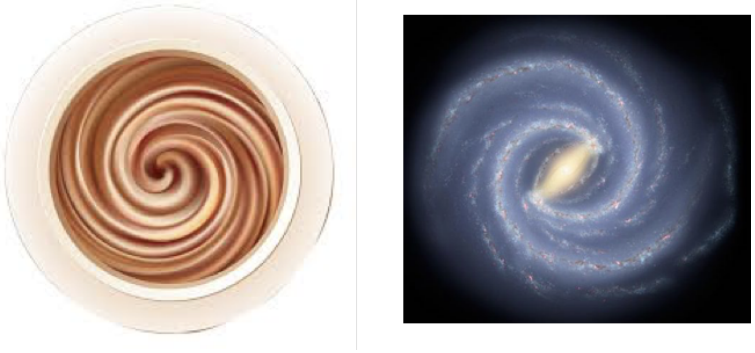


Figure 2: *Left:* Homer's morning coffee with milk. *Right:* Artist's concept of a face-on view of Milky Way.

   (a) (20%) Do you agree with Homer's idea about spiral arms in Milky Way? If not, tell him what is the expected outcome of his idea? *Hint:* You know that the Sun is 8 kpc away from the Galactic Center moving at a speed of 220 $\mathrm{km\,s^{-1}}$. Assuming the Galaxy is 13 billion years old, what is the expected outcome of Homer's idea?

   (b) (20%) Can you tell Homer how spiral arms are formed in Milky Way?