Writing Assignment 1: Astrobites

(Due Monday, October 5th)

All questions that require an answer are italicized.

Part 1: Read the astrobites article summarizing the recent paper by Conroy and Bullock (2015) titled "Beacons in the Dark: Using Novae and Supernovae to Detect Dwarf Galaxies in the Local Universe." If there are astronomy terms that you are unfamiliar with, don't be afraid to look them up! This first reading should not be easy.

1) **Get a sense of mass scale:** Please express your answers to the following in terms of rough orders of magnitude. For example: the Sun has a mass of 10^30 kg, while the Earth has a mass of about 10^24 kg. Therefore the Sun is about 6 orders of magnitude (10^6 times) more massive than the Earth.
    a. *How much larger is our own Milky Way galaxy than a dwarf galaxy like Segue 2?*
    b. *What about a dwarf like the Large Magellenic Cloud?*
2) **Get a sense of distance scale:** Our "Local Group" of galaxies is about 3.1 megaparsecs (3.1 x 10^6 parsecs) in diameter.
    a. *Can we observe dwarf galaxies that are much further outside the Local Group?*
    b. *Calculate the diameter of the Local Group in terms light-years (distance it takes light to travel in one year).*
    c. Assume that the New Horizons spacecraft, one of the fastest spacecraft ever sent into space, travels at about 16 km/s. *How long would it take this spacecraft to*

travel the diameter of the Local Group? Hint: The speed of light is about 3 x 10^5 km/s.

3) **Type Ia Supernova Channels:**
    a. *What are the two channels for forming a Type Ia Supernova?* These were discussed in class.

4) **Analyzing Figure 2:** Look at Figure 2 on the astrobites page. Surface brightness refers to the total brightness of an object over its area (units are magnitudes per square arcsecond, where arcsecond is a measure of angular size on the sky). Magnitude refers to the brightness of an object. For both magnitude and surface brightness, the SMALLER the number the brighter the object. Note the log axis on top for mass. This means log base 10, so those numbers are really 10^2, 10^4, 10^6, etc. solar masses.
    a. According to this plot, are any galaxies below about 10^5.5 solar masses resolvable by LSST if they are more than a few Mpc (megaparsecs) from us?

5) **Analyzing Figure 3:** Look at Figure 3 on the astrobites page. Read the caption and understand what the dotted versus solid versus dashed portions of the line represent. The shaded regions indicate where novae and supernovae can be detected by LSST.
    a. Is there a lower limit to the SNe and novae rate for inclusion in the shaded region, and if so what is it?
    b. For which mass range of galaxy (black, red or blue line) is this method not particularly useful? Hint: Find which mass range of galaxies is *already* resolvable out to great distances.
    c. What is one possible reason for the linear relationship between the SNe rate (y axis) and the distance (x axis)?

6) **Critically Reading the Text:** The author of the astrobites post says that in the mass range of 10^5 – 10^6 solar masses we

should be able to detect 100-10,000 supernovae per year arising from these dwarf galaxies.

   a. *Referring back to Figure 3, out to what distance is this statement valid?*

Part 2: Read the paper by Conroy and Bullock (2015) titled "Beacons in the Dark: Using Novae and Supernovae to Detect Dwarf Galaxies in the Local Universe" as outlined below. This is just a *suggestion* for how to approach reading papers in general.

7) **Start with the Abstract:** First read through the abstract of this paper.
   a. *Identify the two underlying assumptions that go into calculating the novae and supernovae rates on the y-axis of Figure 3.* Note that these assumptions are mentioned in the astrobites article (Paragraph 4), but in different words.
8) **Next Read the Conclusion:** In the case of this paper, there is no explicit "conclusions" section. Instead there is a "results" and "discussion" section. Start with the discussion section, since this is the last section of their paper. Note that in this discussion section they go much more in depth about the underlying assumptions they have made and how this might affect the conclusions that they have drawn. They also use this section to state the broader impacts (or "bigger picture") of their research on the overall astronomical community.
   a. *Are the assumptions underlying the calculation of the "luminous transient" rate that they mention in this section the same as what you gleaned from the abstract? If not, do NOT change your answer to 7a, but write the correct assumptions here.*
9) **Read the Results, Analyze Most Relevant Figures:** Note that the first paragraph of this section is essentially a more

detailed caption for Figure 3. This figure is the most important figure from the paper. Carefully read paragraph 2.

a. *Identify the answer to 6a in this paragraph. Again, do not go back and change your answer to 6a if it is incorrect, simply write the correct answer here.*
b. *Identify the answer to 5b in this paragraph. As above, do not go back and change your answer.*
c. The final paragraph of the results section refers to Figure 4, which is the same as Figure 3 but introduces the concept of supernovae and novae rates from "intrahalo stars," something not discussed in the astrobites article. This is the first instance where skipping to the end of the paper leaves us without a definition of something. *Go back to the introduction and copy down the definition for intrahalo stars. In your own words, how do the authors propose that we can distinguish between novae and supernovae from intrahalo stars versus dwarf galaxies?*

This last question should gauge your overall understanding of the paper, but note that it will NOT be graded. Instead, please take the time to at least reread the whole paper and think critically about each question posed below. We will take about 30 minutes to discuss this portion of the assignment as a class on Wednesday, October 7th.

10) **Reread the Whole Paper:** So far you have tackled almost all the elements of this paper, so it is time to (re)start at the beginning. What is left is "Introduction" and the "Methods" (or in this case "Model Ingredients") sections. The methods section of a paper is really the nitty gritty—it usually gives all the details of exactly how observations were carried out, how data was reduced, or how a simulation was run. This can

sometimes be overly technical and difficult to understand unless you are an expert in the field. The introduction section gives you the necessary background information for this topic and in addition usually delves into how this particular area of research connects more broadly to all of astronomy, i.e. puts the research topic in the context of the bigger picture.

a. **Think Big Picture:** *From what you have read so far (now including the introduction), what are two reasons why we should care that this method is capable of finding many more dwarf galaxies in the field?*
b. **Think Background:** *What are two reasons why we have not yet discovered the plethora of field dwarf galaxies that (according to theory) should exist?*
c. **Think Uncertainty and Error:** *From the "Model Ingredients" section, identify two assumptions they make about the star formation histories (amount of star formation over time) for these dwarf galaxies. Note that these are sources of uncertainty and possible error in their model.*
d. **Think Model Restrictions or Limitations:** This paper refers specifically to FIELD dwarf galaxies, which is not mentioned in the astrobites article. *Why do you think it is important that this method only be applied to field dwarf galaxies in particular? Give one reason. Hint: The authors spend time discussing intrahalo light.*