Astronomy 74: Astrophysics
Fall 2024
Dartmouth College

Prof. Emily M. Boudreaux
Emily.Boudreaux@Dartmouth.edu

Paper discussion: Brown dwarf aurorae

In this assignment, you will read a scientific paper and prepare a short review. The goal of this assignment is for you to see some of the radiative transfer concepts from class in action. In class, we will review the paper together in your discussion groups following the worksheet format. Following the discussion, each of you will write a short (3 paragraph, 1/2-3/4 of a page single spaced) summary of the article, including a description of the relevant radiative transfer and the key findings. Upload a pdf to Canvas. The target audience for this summary is you and your classmates prior to taking this course, which means, for example, that you should define any words that could be considered "jargon." Please be attentive to presenting the material clearly.

- Resolved imaging confirms a radiation belt around an ultracool dwarf: `https://www.nature.com/articles/s41586-023-06138-w`

This paper focuses on a brown dwarf, distinguished from a star by the lack of nuclear fusion (while they do undergo deuterium fusion, they still cool down with time). They mostly have spectral classes L, T, and Y, but the hottest (youngest, most massive) brown dwarfs actually have very late-type M dwarf spectral types (M6.5-M8). Brown dwarfs are often treated as more observationally accessible analogs to studying Jovian planets. When brown dwarf astronomers talk about aurorae, they usually mean observing radio emission from electrons traveling within the brown dwarf magnetic field. Solar system aurorae we often observe at other wavelengths, but they also produce radio emission. For the Earth's aurorae, the electrons come from the Solar wind. For Jupiter's aurorae, they come from the moons.

Your summary is due on **Friday November 8th by 11:59pm** via Canvas. Your summary will be graded on three areas (10 points total):

- Scientific scope: did the summary cover the key areas of the article, without unnecessary detail? (3 points)
- Radiative transfer scope: did the summary cover the key radiative transfer concepts underpinning the research? The discussion questions can help guide. (3 points)
- Accuracy: was the summary factually accurate? (2 points)
- Clarity: was the summary coherent and understandable to the target audience? (2 points)

For Tuesday, November 5th: Read the above article (you won't understand everything!) before class. When you are reading the articles, consider the following questions:

- What motivated this study? What were the key discoveries?
- On what physics is this study based? Where and how do radiative transfer concepts get used?
- What questions did this paper bring up for you? What things didn't you understand? How would you go about answering them?

Questions for in class. These questions have a mix of goals: to zero-in on what I thought were key parts of the paper, to connect back to broader astrophysics context (e.g. A15/A25 material), and to highlight the specific radiative transfer connections.

- What previous radio studies have been undertaken of this object? Note these weren't spatially resolved observations, which is the key part of the present study.
- Observations
  - What observatories combine to create the High Sensitivity Array? Thinking back to your intro astro, why was it necessary to use such a long baseline array?
  - Looking at Figure 1, the radio lobes appear elongated. Does this represent the true physical shape of the source?
  - What is the structure/size of the observed radio lobes?
- Results
  - At what frequency would non-relativistic cyclotron emission be observed? What equation from the textbook can you use to calculate this?
  - The observations detected radiation is at 8.4GHz. Why does this imply synchrotron emission?
  - Review Section 6.5 in the textbook. Are their circular polarization results consistent with synchrotron emission? If they observed in linear polarization, what would they predict they see?
  - How do they estimate the energies of the electrons responsible for the emission?
- Why do they argue that flares are not responsible for heating the electrons? It may be helpful to contrast their results to those previously observed for UV Ceti.
- What are the two possible origins of the electrons that the paper discusses?