

# Outline Term Paper Project Astro 421

9/16/08

**Title:** A review of the Proto-Planetary Nebulae

**Outline:**

1. Introduction

Here I will introduce the concept of a Proto-Planetary Nebulae (PPNe), explaining in what stage of evolution the star is, and what type of stars we expect to become Planetary Nebulae. I will also discuss why we want to study PPNe, for example they manifest a very brief period in the evolution of solar mass stars. In particular, during this period the mass loss switches from a spherical geometry into a bipolar one. This transition phase is not very well understood, but is important for understanding the late stages of a stellar life, and to understand the formation of many PNe observed today.

2. Previous work/observations

In this section I will present what we have learnt about PPNe so far. There are observations both in the optical and in the radio of these sources, and I will give an example of how these types of observations have made us understand the basics of what they are. If I can find a diagram and/or an image (e.g. HST) this will be included to illustrate the source geometry and characteristics.

3. The sub-group of water fountain PPNe

Here I will concentrate my discussion to a specific sub-group of the PPNe, the water fountain sources (see references by Boboltz, Marvel, Claussen etc). I will point out that these sources carry masers, which can be used to trace dynamics in these sources. In turn, the dynamics will give information about source age and so on. A figure will be included where I show how masers at the end-point of jets can be used to estimate the jet propagation speed.

4. New or future science

I will discuss the questions that still remains to be solved, and what challenges researchers in this area face. For instance, the distances to these objects are poorly constrained, which makes it hard to estimate true luminosities, masses, mass-loss rates and so on. However, this could be solved using parallax measurements, determining trigonometric distances (I will explain how this works).

5. Summary

This will be a brief section just summarize the main points of the term paper: what a PPNe is, why we study them and what the future prospects are of studying these objects (distance measurements will revolutionize the understanding of PPNe, and this will be possible within the next 5 years).