Radiative Transport Through a Slab

Lab report due: Wednesday, 25 April 2001

1 Introduction

By solving the equation of radiative transfer for a homogenous medium, one obtains the following equation:

$$I_\nu(D) \quad = \quad I_\nu(0)\, e^{-\tau_\nu(D)} + S_\nu^{tot} \left[1 - e^{-\tau_\nu(D)}\right]$$

where τ_ν is the optical path and D is the extension of the medium.

In these computer exercises, you will use a program that models an optically thin slab. By varying the incident intensity I_ν, the source function S_ν, the optical depth in the continuum τ_{cont} and the optical depth in the line τ_{line}, you can illustrate different cases of spectral line formation in a homogenous slab.

The idea is to play around with the interactive software and use it to help you develop some intuition about this abstract topic. The questions in this text are intended as a guide for you to write a report on radiative transfer and line formation.

2 Getting Started

The programs are written in the IDL language and are run in the IDL environment. You start up IDL by typing `idl` in the correct directory. The procedure is the following:

- User name: xxxxxx
- Password: xxxxxx
- type: `cd /u1/local/lab/stralningsprocesser/SlabLab`
- type: `idl` (or: `/usr/local/bin/idl_5.1` if that did not work)

You will start up the computer simulation of radiative transport through a slab by typing the command `xslab`. The program is operated by sliders that will change the value of the corresponding variable. To exit you press `Done`.

3 Questions

1. First play around a bit with the sliders and describe/explain what is being shown on the screen. (For example, if the x-axis of the plot is frequency or wavelength, what is the y-axis?)

2. Explain the two different optical depths τ_{line} and τ_{cont}. What kind of processes are responsible for each? Does the sum of the two have a meaning? Does $\tau_{cont} = \tau_{line}$ imply anything special? What does it mean to change the value of τ_{line}, or τ_{cont}?

3. Try to be systematic and cover all the cases you can think of. Describe what you observe; explain what is happening, and why. Draw relevant pictures and make notes for the report.

4. One way to start off is by choosing a value I_0 and setting τ_{cont} and τ_{line} to zero. (What does it mean to set τ_{line} or τ_{cont} to zero?) What happens when $\tau_{line} = 0$ and you vary τ_{cont}? Give an example in which you check the numerical values with the equation of radiative transport to see if they are correct.

5. What happens when $\tau_{cont} = 0$ and you vary τ_{line}? What can you deduce about α_{cont} and α_{line}?

6. Keeping τ_{cont} and τ_{line} fixed, try different values of I_0, or different values of S. Write down some interesting cases.

7. Is there any fundamental difference between an absorption line and an emission line? Give a examples, and cite values for the different variables if you want. What determines whether an absorption or emission line will be formed? Why is that?

8. Use the Eddington-Barbier approximation to explain how an emission or absorption line is formed. (Hint: refer to Figure 3.4 in Rutten.)

4 Report

A written report is required. It should contain a description of what you have been investigating and what you learned, both in text and pictures.

This computer exercise was adapted from the one written by Nils Ryde, Uppsala Astronomical Observatory, September 15, 1995. The software was developed by Mats Carlsson and Oivind Wikstol at Institutt for Astrofysikk in Oslo.

We would appreciate comments and suggestions regarding this laboratory exercise in order to be able to improve it further!