1 Overview of exercises

1. limb-darkening scattering exercise we did during the course. — You can look into your notes from that, and I attach here also a sample program which you can use a base. After you have familiarised yourself with this, you can start to think bout how you would go about to extend this to a 3D setting (assuming isotropic scattering).

2. (As prep for Monte-Carlo school) here is a script computing a UV resonance P-Cygni line in spherically symmetric wind with v beta-law. At top of routine, a few exercises are given, where you can modify and play around with code. Monte-Carlo program which computes a UV resonance spectral line from a fast outflowing spherically symmetric stellar wind (if you were not cc'd on that email, let me know so that I can send you the files as well). At the top of that little script, there are a few suggestions for exercises (additions) you could do to that program, in order to learn a bit more about the general workings of Monte-Carlo radiative transfer in this context. — So that might be a good idea for you to do as well ! (And you can also ask the others in the group for some tips etc. then.)

3. Some background reading:

   - Attached mc manual by Puls.
   - Paper by Sundqvist+ 2010 (Appendix, I think).

2 Limb darkening

2.1 2D case

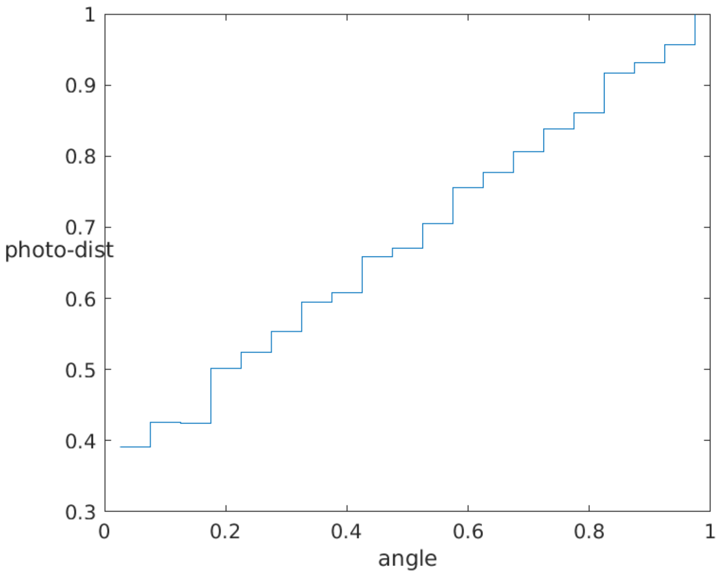

Figure 1: histogram for `mu`

Figure 1 is according to what is expected $I = I_0(0.4 + 0.6\mu)$

2.2 3D case

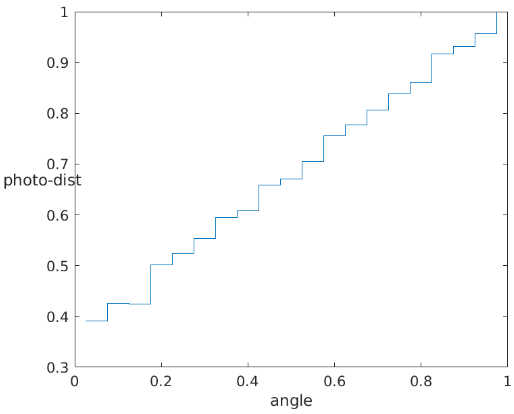

Figure 2: histogram for `mu`

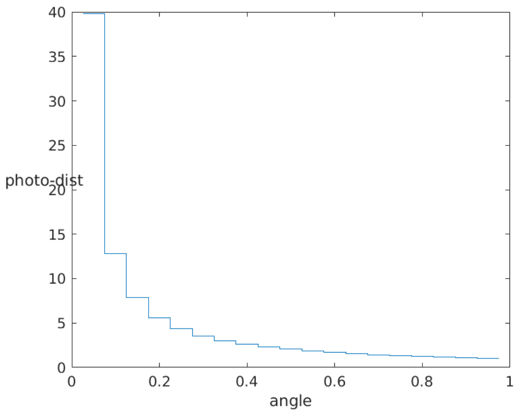

Figure 3: histogram for `phi`

Figure 2 and Figure 3 are according to what is expected, namely $I = I_0(0.4 + 0.6\mu)$ and a uniform distribution for phi, which corresponds to a $I \sim \dfrac{1}{\phi}$

3 Investigation of program: pcyg.f90

3.1 Overview of variables

name	explanation	scope
paramaters		
xk0		
alpha		
beta		
start frequency of the photon		
xstart	start frequency	
vmin		
vmax		
angle of the photon		
xmuestart	start angle	
xmuein	incident angle	
xmueou	outward angle	
pstart	impact parameter	
xnew	new photon frequency	
optical depth		
tau	optical depth	
number of photons admin		
nphot	number of photons	
nin	photons scattered back into core	
nout	photons escaped	
functions		
func	velocity profile	
	r	distance from center of star
xmueout	sign of outwards angle xk0 alpha r v sigma	

3.2 Exercises (at top of program)

Investigation of original code

In original version of the code, all photons are released radially from photosphere, thus `xmuestart` $= 1$

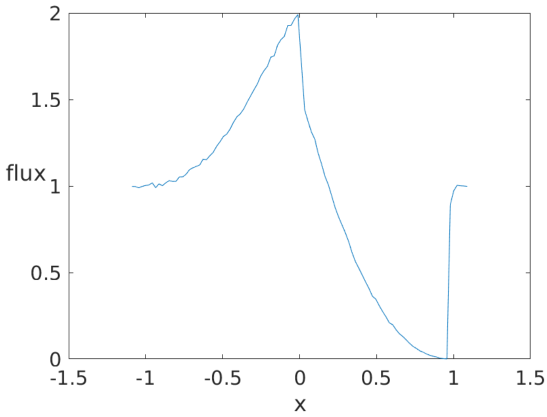

Figure 4: Original version of the code

3.2.1 First adaption: what if all photons are released radially from photosphere?

The code sets $mu = 1$. Results in Figure 5.

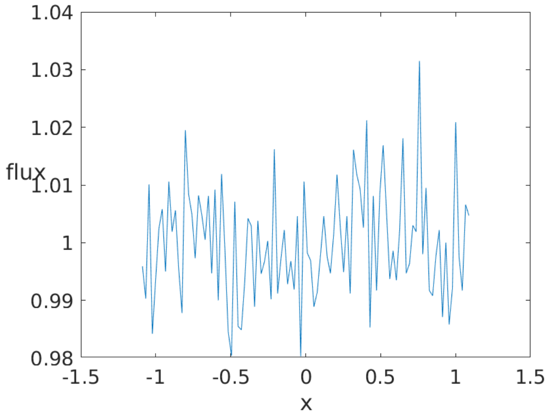

Figure 5: First adaption

3.2.2 Second adaption: isotropic scattering

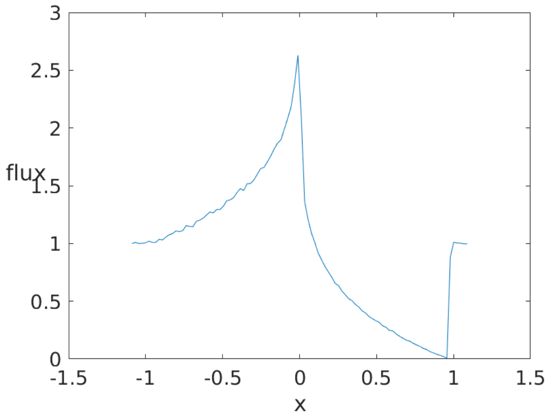

Figure 6: Second adaption

3.2.3 Third adaption: introduction of Eddington limb-darkening

General discussion: Eddington limb darkening The data are taken from Christensen, 2015.

- the source function $S =< I >= a + b\tau_\nu$ with $a = \dfrac{\sigma}{2\pi}T_{eff}^4$ and $b = \dfrac{3\sigma}{4\pi}T_{eff}^4$
- solve the equation
- this yields $\dfrac{I(\theta)}{I(0)} = \dfrac{a + b\cos(\theta)}{a+b} = \dfrac{2}{5} + \dfrac{3}{5}\cos(\theta)$

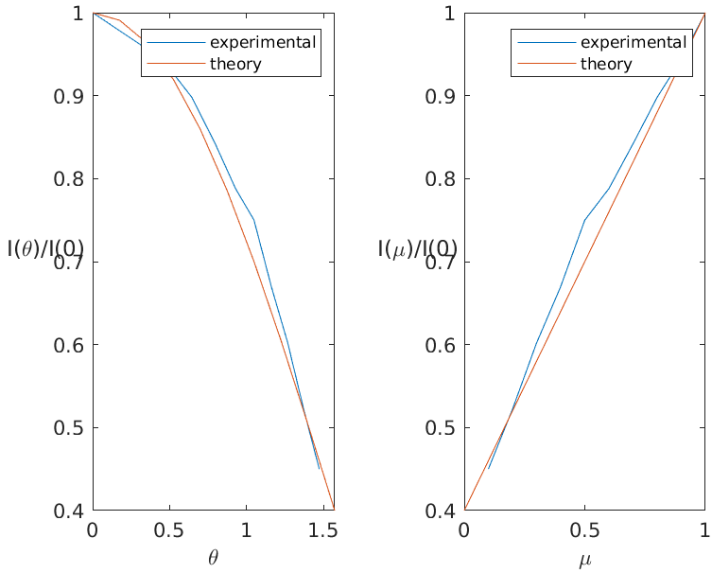

Figure 7: Second adaption

Application to exercise

3.2.4 Fourth adaptaion: photospheric line-profile

4 Mass loss from inhomogeneous hot star winds (Sundqvist)

- GOAL: synthesis of UV resonance lines from inhomogeneous 2D winds
  - clumped in density
  - clumped in velocity
  - effects of non-void inter-clump medium
- WIND MODELS
  - symmetry assumptions
    * 1D: spherical symmetry
    * 2D: symmetry in Φ
  - models
    1. time-dependent radiation-hydrodynamic from Puls and Owocki (POF)
       * 1D
       * isothermal flow
       * perturbations triggered by photospheric sound waves
    2. time-dependent radiation-hydrodynamic from Feldmeier (FPP)
       * 1D
       * treatment of energy equation
       * perturbations triggered by photospeheric sound waves or Langevin perturbagions (photospheric turbulence)
    3. stochastic model, clumped in density
       * smooth winds with $v_\beta = (1 - b/r)^\beta$ with $\beta = 1$
       * clumping factor f_{cl}
    4. stochastic model, clumped in density and in velocity (non-monotonic velocity field)
       * smooth winds with $v_\beta = (1 - b/r)^\beta$ with $\beta = 1$
       * clumping factor f_{cl}
- RADIATIVE TRANSFER (MC-2D)

5 Asymptotic preserving Monte Carlo methods for radiative transfer equation in diffusion limit (Dimarco+ 2018)

5.1 Goldstein-Taylor

5.2 Radiative transfer