Last time…

- Fourier synthesis
  - Tophat function
- Center-to-limb variation
  - Connection with mu
  - Other pleasures on the way
- What else can go into the report
  - Relation to other work
  - Where to go from here

Lecture 38

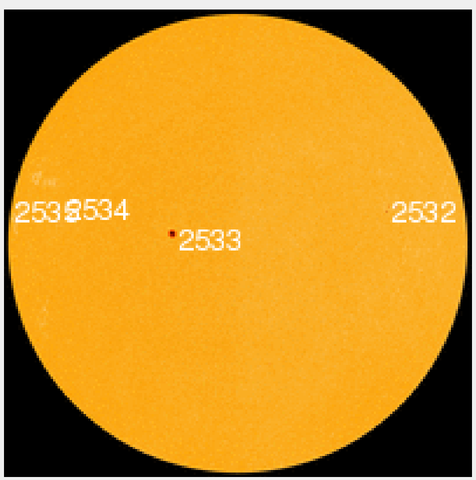
- Notes on Homework 4+5 resit
  - Numerical integration of moments of intensity
  - Iteration steps in solar wind equation
- Center-to-limb variation
  - Connection with mu
- About final report
  - Relation to other work (introduction)
  - Where to go from here (conclusions)

Current Conditions

Solar wind
speed: **512.1** km/sec
density: **2.7** protons/cm^3
explanation | more data
Updated: Today at 1358 UT

X-ray Solar Flares
6-hr max: **B2** 0821 UT Apr25
24-hr: **B2** 0821 UT Apr25
explanation | more data
Updated: Today at: 1400 UT

Daily Sun: 25 Apr 16



Sunspot AR2533 has a stable magnetic field that poses no threat for strong solar flares. Credit: SDO/HMI

What's up in space

Monday, Apr. 25,

Looking for a unique Mother's Day gift? How about Space Roses? Proceeds from the sale of these far-out blooms support student space weather research.

ALMOST NO CHANCE OF FLARES: Solar activity is very low. There are four sunspots on the solar disk, but not one has the type of unstable magnetic field that poses a threat for explosions. NOAA forecasters say the chance of a strong flare today is no more than 1%. **Solar flare alerts**: text or voice

ASTEROID FLYBY: Newly-discovered asteroid 2016 FY3 is flying past Earth today about 1.5 million miles away. There's no danger of a collision, but the 310 meter-wide space rock is close enough to see through amateur telescopes. Dennis Simmons photographed it this morning from Brisbane, Qld, Australia:

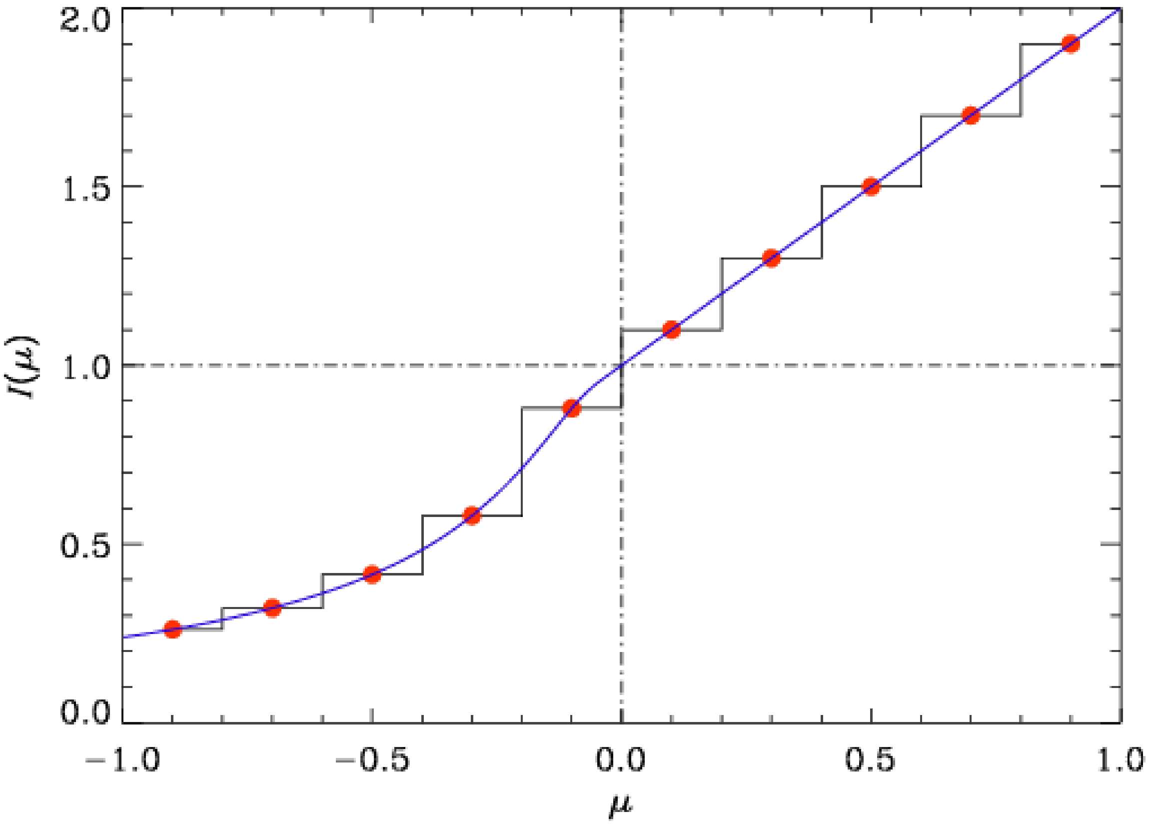
Numerical integration

Discretize: $$\int_{-1}^{1} I(\mu)\,\mathrm{d}\mu \approx \sum_{i=1}^{n_\mu} I(\mu_i)\,\Delta\mu_i$$

Here:
τ=1/3
constant intervals

$$\Delta\mu_i = 2/n_\mu$$

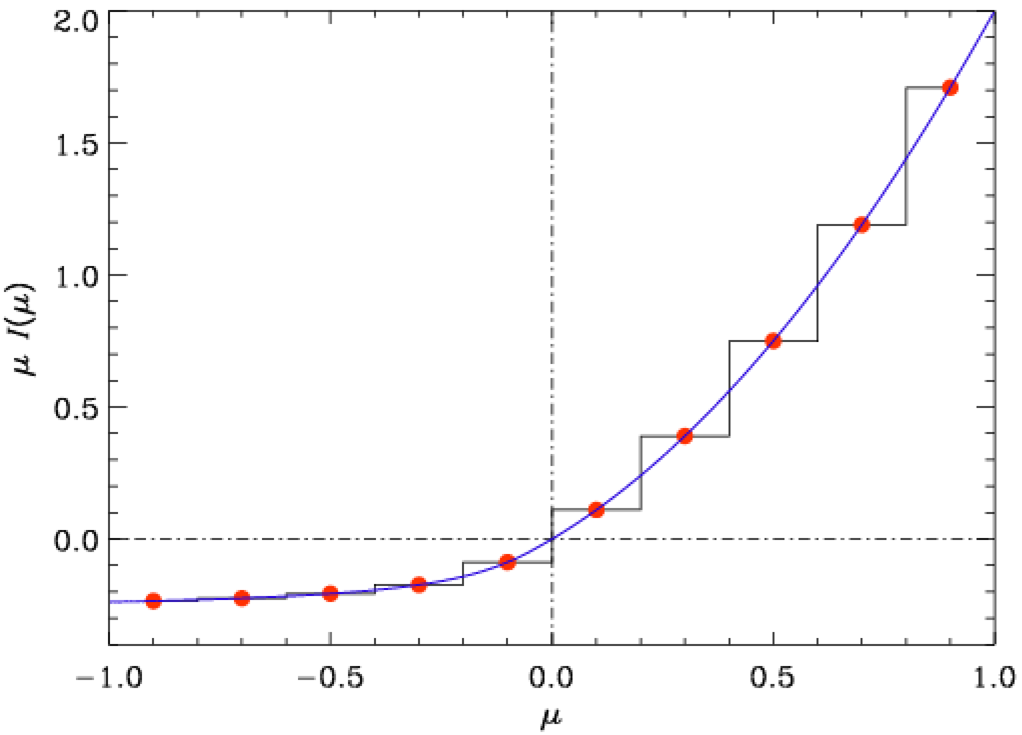
origin excluded
and $I(0)=1$



1^{st} moment

Discretize:

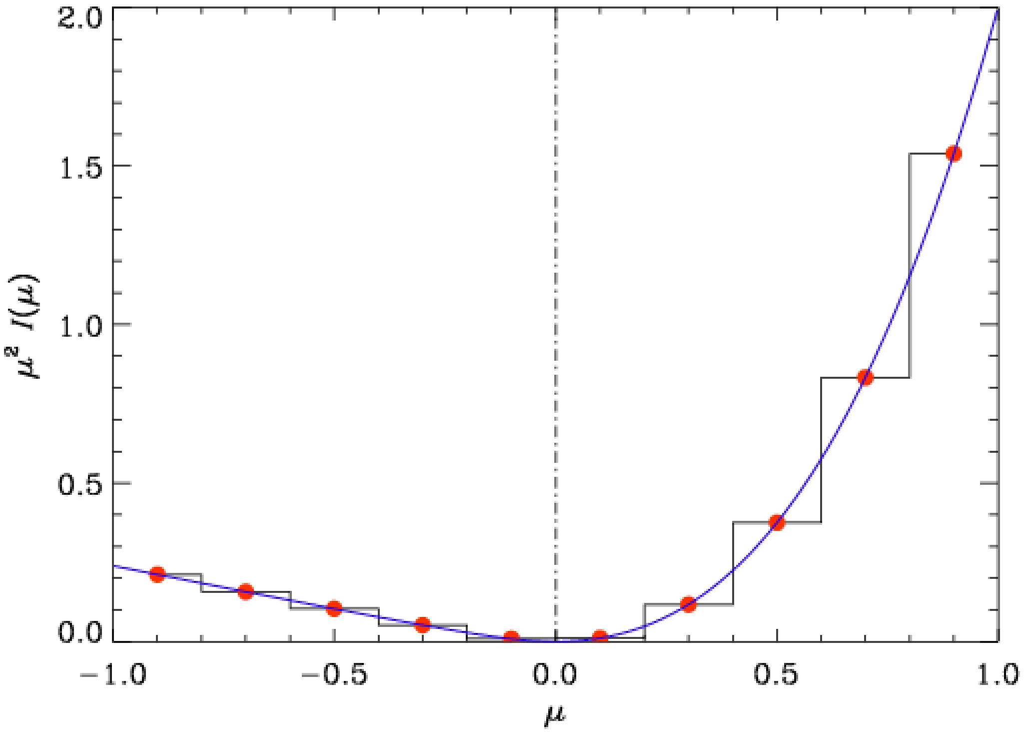
$$\int_{-1}^{1} \mu\, I(\mu)\, \mathrm{d}\mu \approx \sum_{i=1}^{n_\mu} \mu_i I(\mu_i)\, \Delta\mu_i$$



now $I(0)=0$

2^{nd} moment

Discretize: $$\int_{-1}^{1} \mu^2 I(\mu)\,\mathrm{d}\mu \approx \sum_{i=1}^{n_\mu} \mu_i^2 I(\mu_i)\,\Delta\mu_i$$



again $I(0)=0$

2^{nd} moment

Discretize: $$\int_{-1}^{1} \mu^2 I(\mu)\,\mathrm{d}\mu \approx \sum_{i=1}^{n_\mu} \mu_i^2 I(\mu_i)\,\Delta\mu_i$$

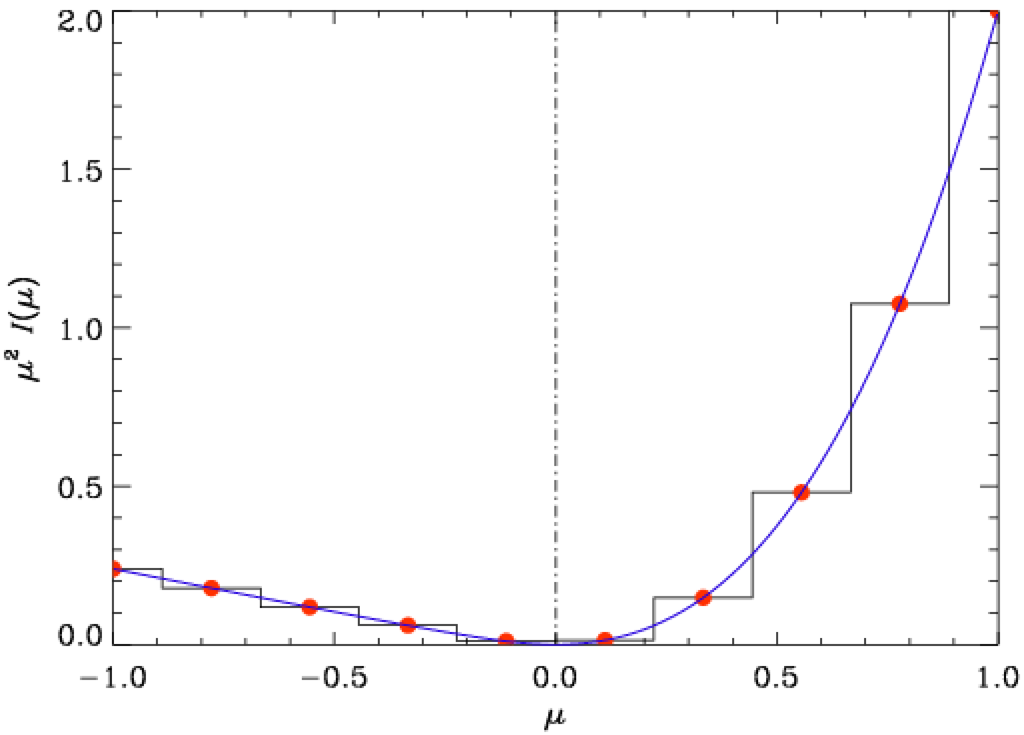
Nonuniform intervals

$$\Delta\mu_i = 2/(n_\mu - 1)$$

Except for:

$$i = 1 \text{ or } i = n_\mu$$

$$\Delta\mu_i = 1/n_\mu$$

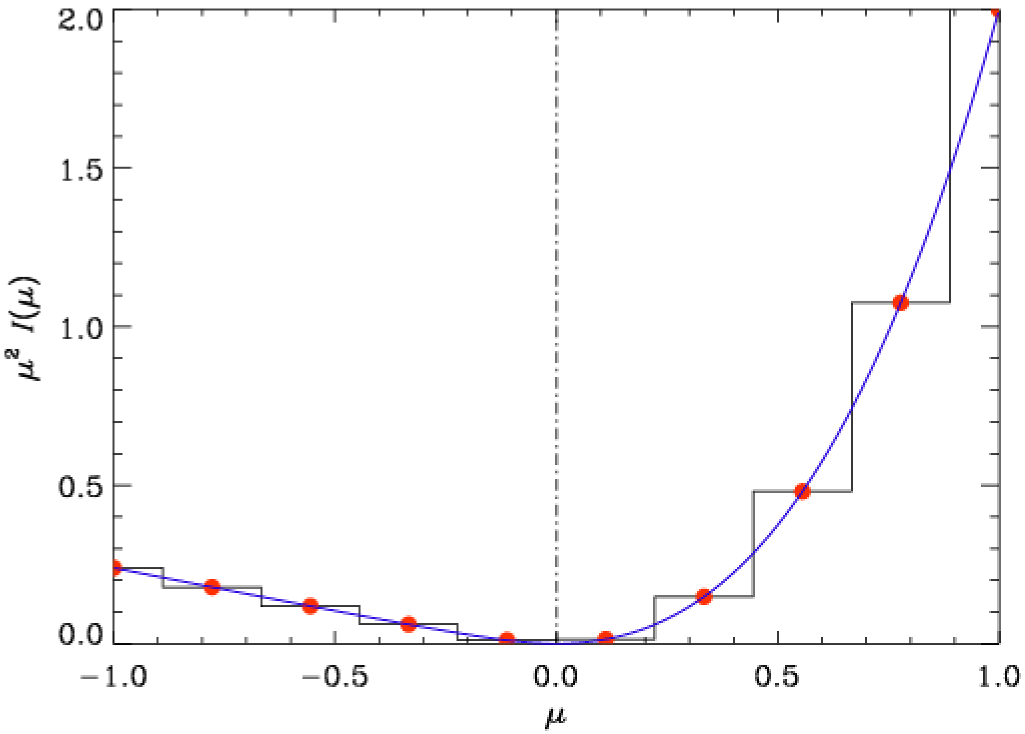


Why the factor 2

Nonuniform intervals

$$\Delta\mu_i = 2/(n_\mu - 1)$$

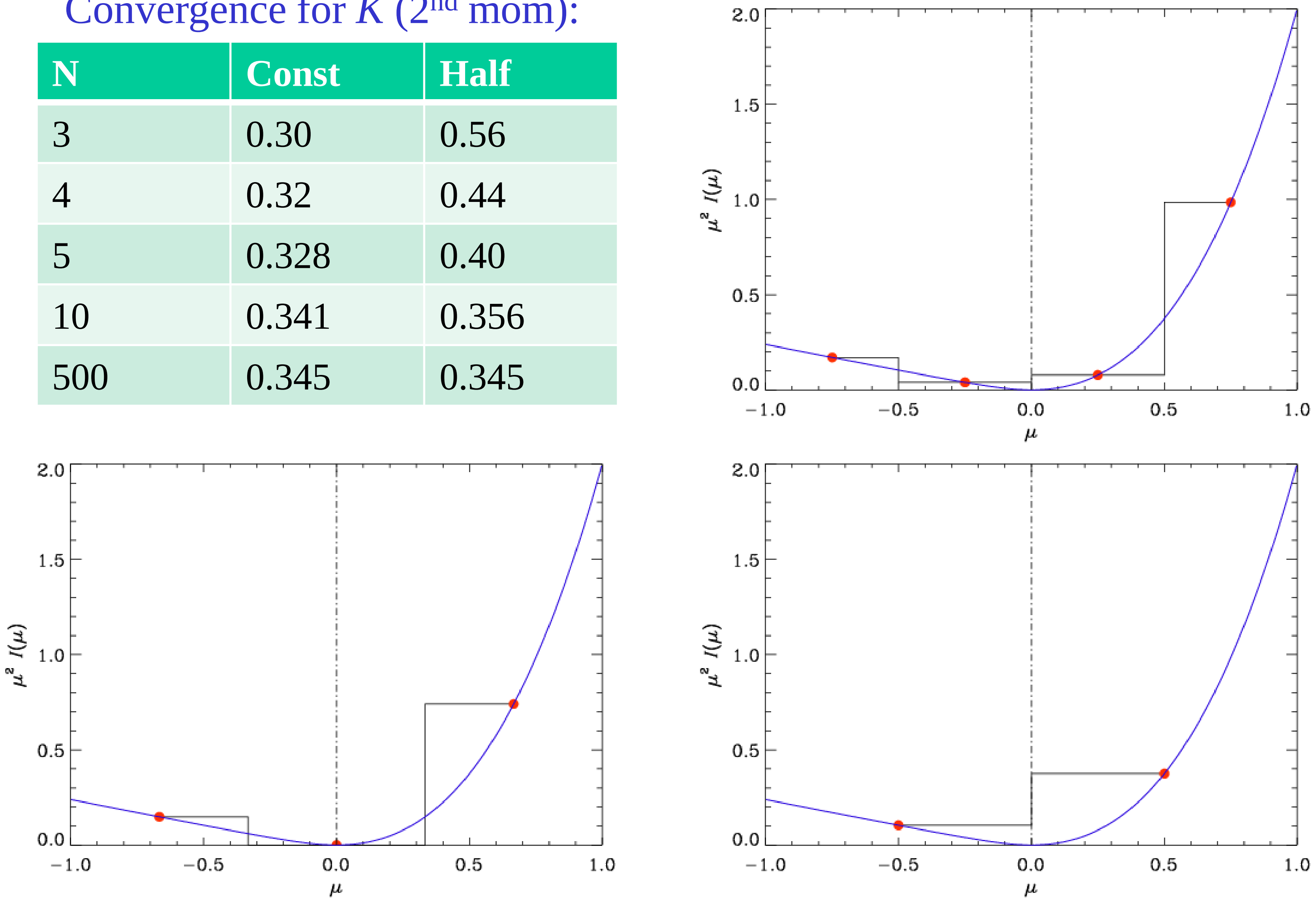
A. Boundary points now included
B. Length of interval
C. Even number of points

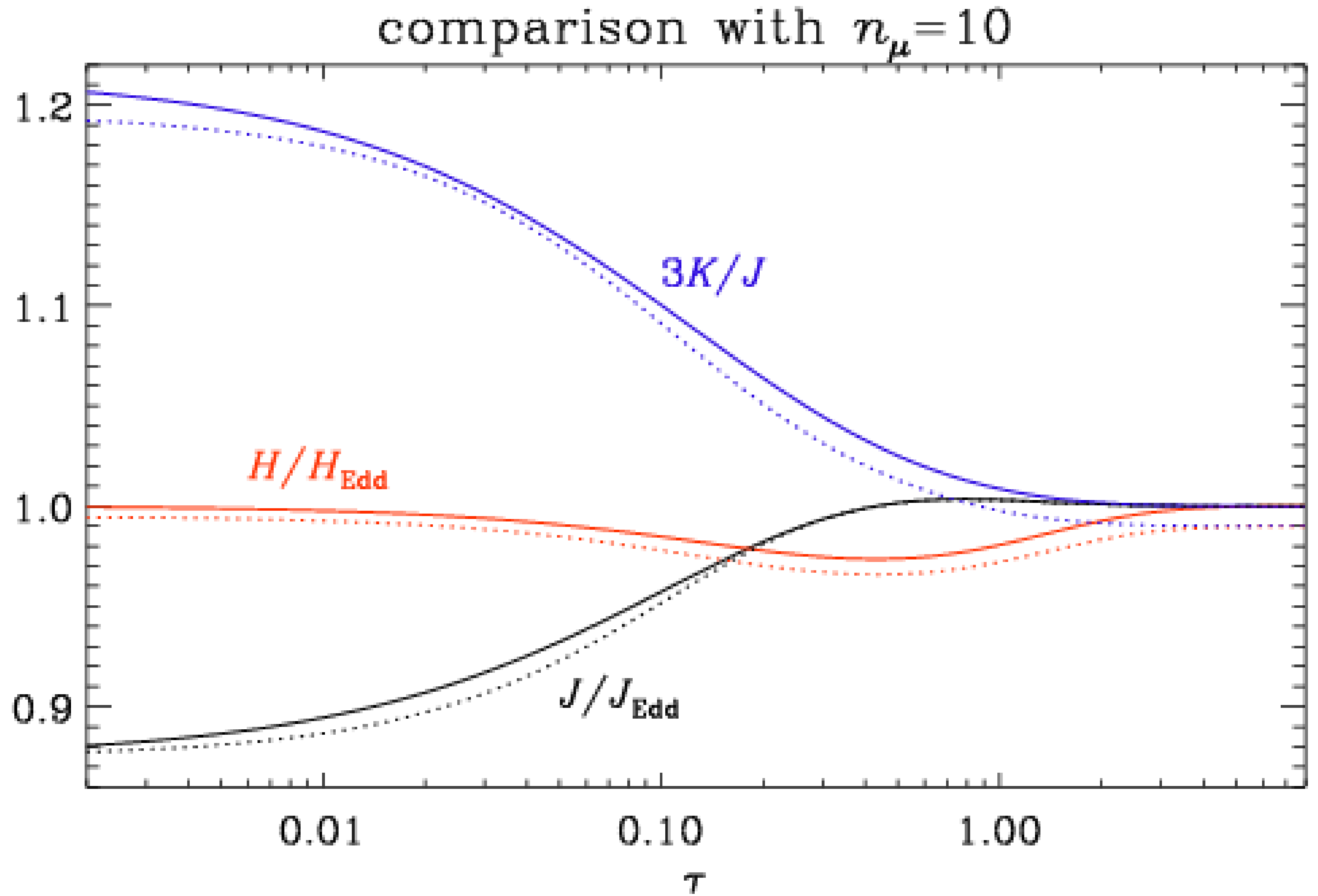


Fewer points

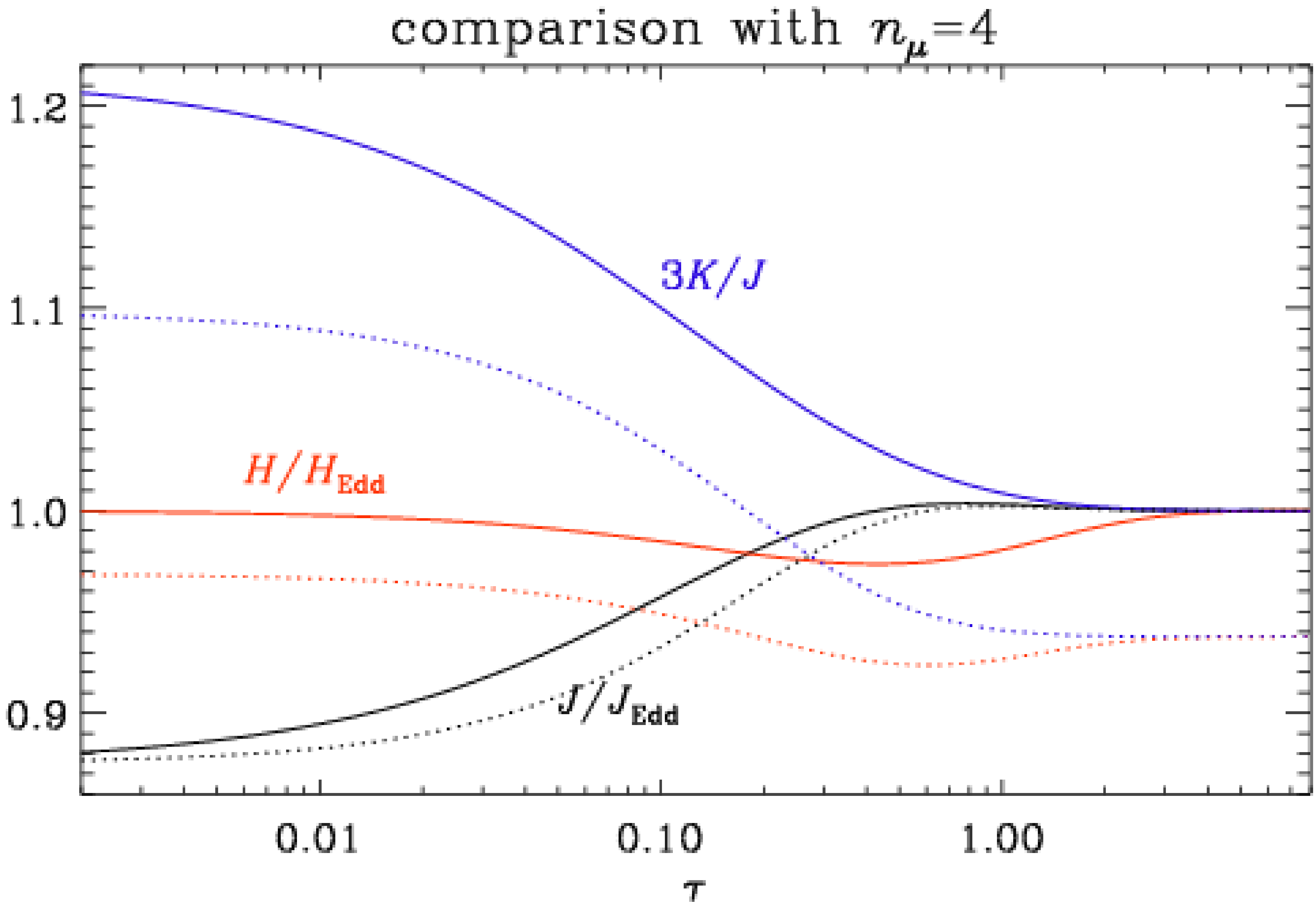
Convergence for K (2^{nd} mom):

N	Const	Half
3	0.30	0.56
4	0.32	0.44
5	0.328	0.40
10	0.341	0.356
500	0.345	0.345

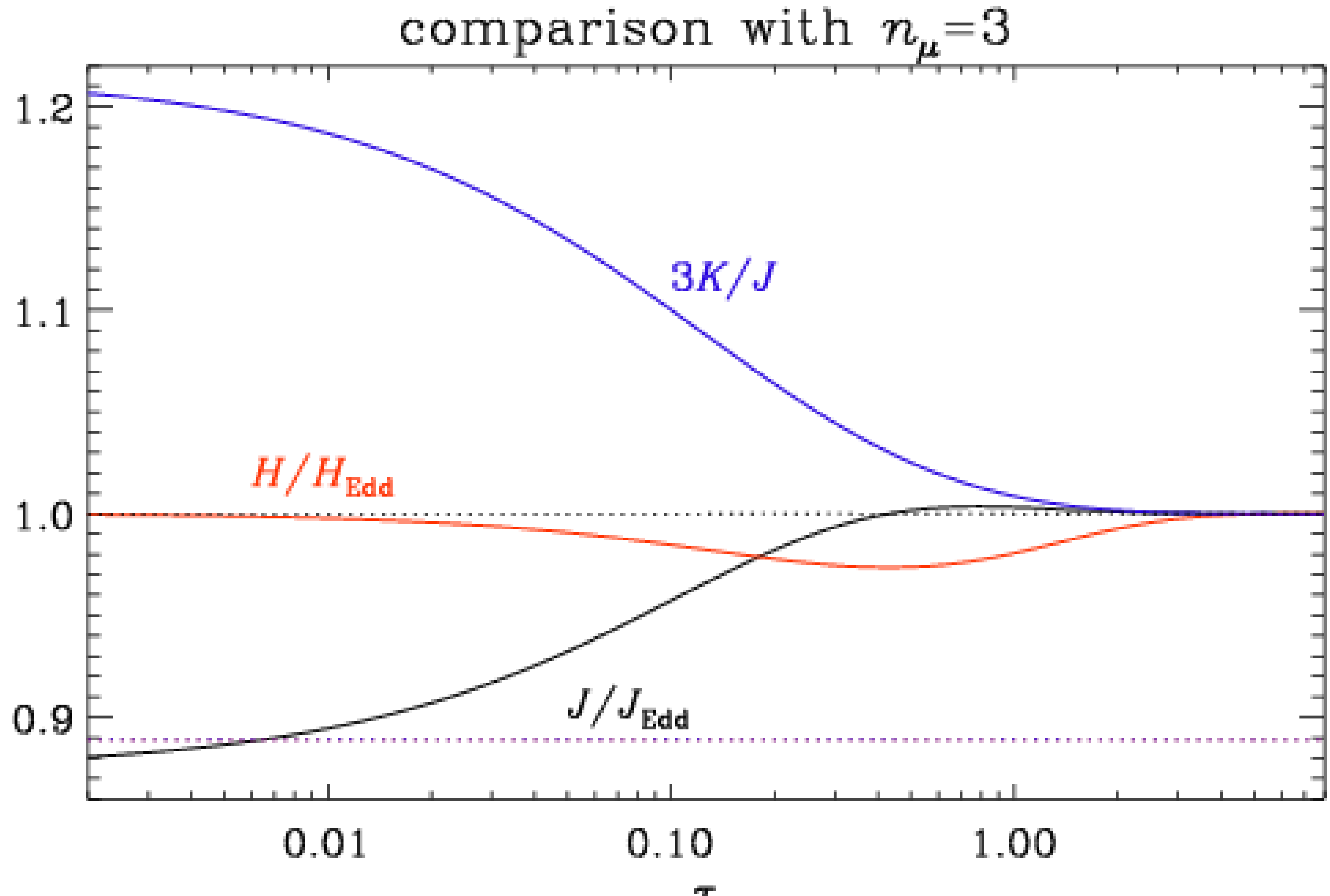




comparison with n_μ=10
1.2
1.1
1.0
0.9
3K/J
H/H_Edd
J/J_Edd
0.01
0.10
1.00
τ



comparison with n_μ=4
1.2
1.1
1.0
0.9
0.01
0.10
1.00
τ
$3K/J$
H/H_{Edd}
J/J_{Edd}



comparison with n_μ=3
1.2
1.1
1.0
0.9
3K/J
H/H_Edd
J/J_Edd
0.01
0.10
1.00
τ

Integrating wind equations

Continuity eqn

$$\frac{d}{dr}\left(r^2 \rho u_r\right) = 0$$

so $$r^2 \rho u_r = \text{const} = \dot{M}/4\pi$$

or $$\ln r^2 + \ln \rho + \ln u_r = \ln\left(\dot{M}/4\pi\right)$$

Momentum eqn

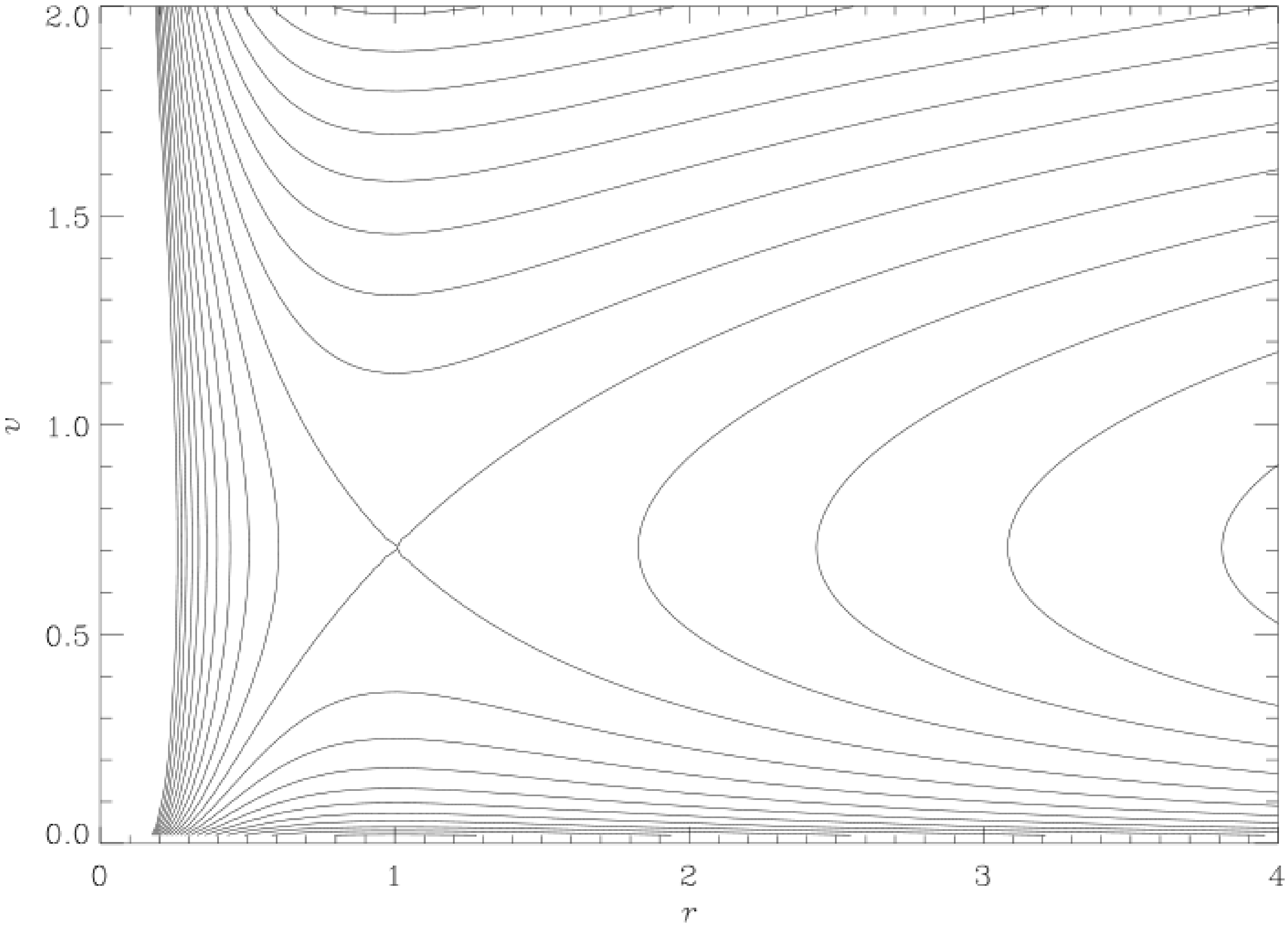
$$u_r \frac{du_r}{dr} = -c_s^2 \frac{d\ln\rho}{dr} - \frac{GM}{r^2}$$

$$\frac{d}{dr}\left(\tfrac{1}{2}u_r^2 + c_s^2 \ln\rho - \frac{GM}{r}\right) = 0$$

insert

$$\tfrac{1}{2}u_r^2 - c_s^2 \ln u_r - c_s^2 \ln r^2 - \frac{GM}{r} = \text{const}$$

Just plot contours of this in the u_r – r plane!


2.0
1.5
1.0
0.5
0.0
v
0
1
2
3
4
r

Resit homework 4+5, problem 6

(c) Show that Eq. (3) can be written as

$$\mathcal{M} = \sqrt{C + 2\ln\mathcal{M}}, \tag{4}$$

where $\mathcal{M} = |u_r|/c_s$ and

$$C = 4\left(\ln\tilde{r} + \frac{1}{\tilde{r}}\right) - 3,$$

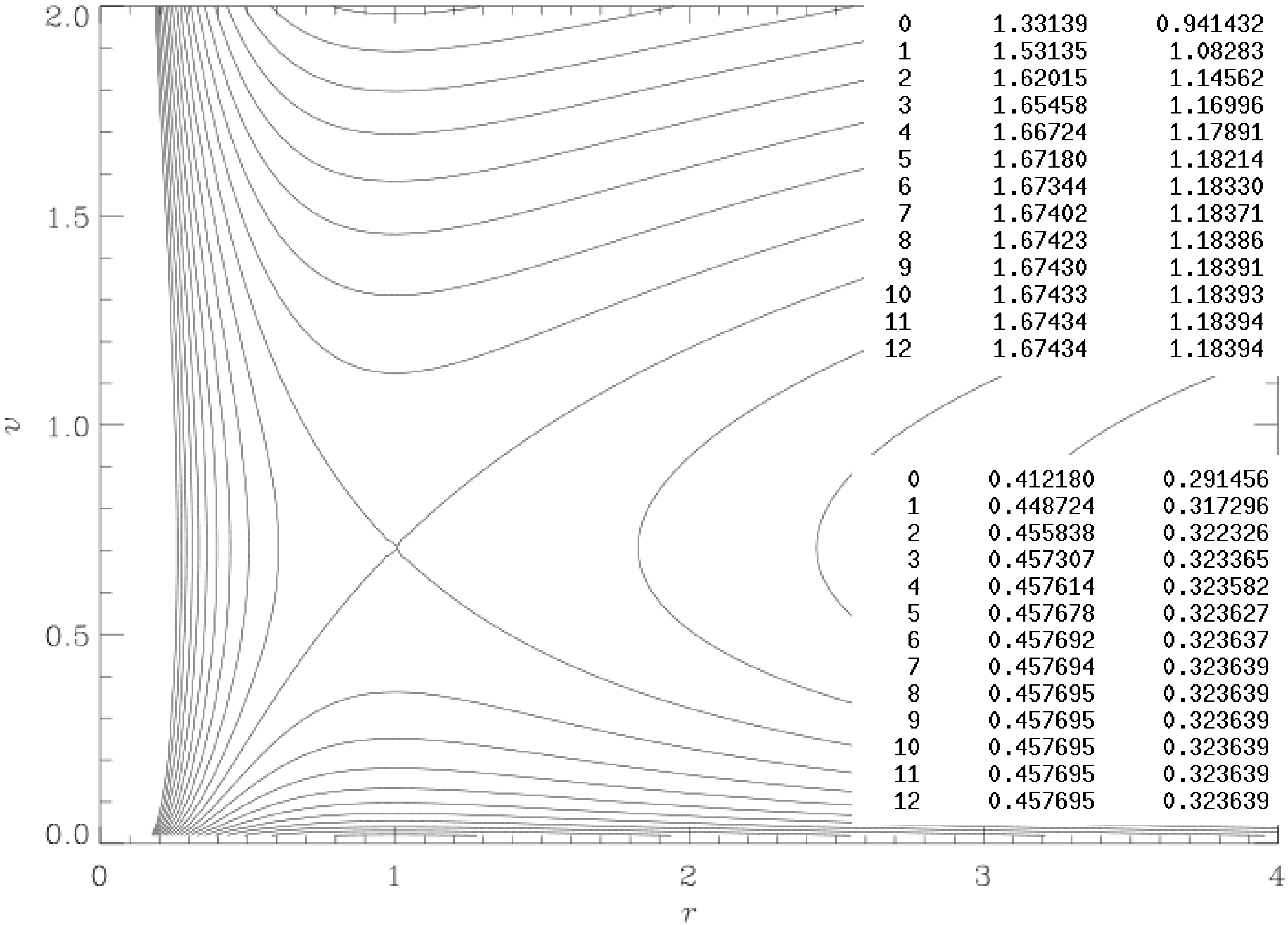
with $\tilde{r} = r/r_*$.

(d) Calculate the value of C for $\tilde{r} = 10$, and find the corresponding value of $\mathcal{M}$ using three iteration steps starting with $\mathcal{M} = 1$. Show your working in all intermediate steps. Sketch the solution for $\mathcal{M}$ against $\tilde{r}$, and indicate the points where $\tilde{r} = 1$ and 10.

(e) Show that Eq. (4) can also be written as $\mathcal{M} = \exp\left[\frac{1}{2}(\mathcal{M}^2 - C)\right]$, and, for the same value of C, iterate for $\mathcal{M}$ starting again with $\mathcal{M} = 1$ (use three iterations, show your working). Again, sketch the solution of $\mathcal{M}$ against $\tilde{r}$, indicate the points where $\tilde{r} = 1$ and 10, and show the direction of the flow. In what area of stellar physics can this model be applied?

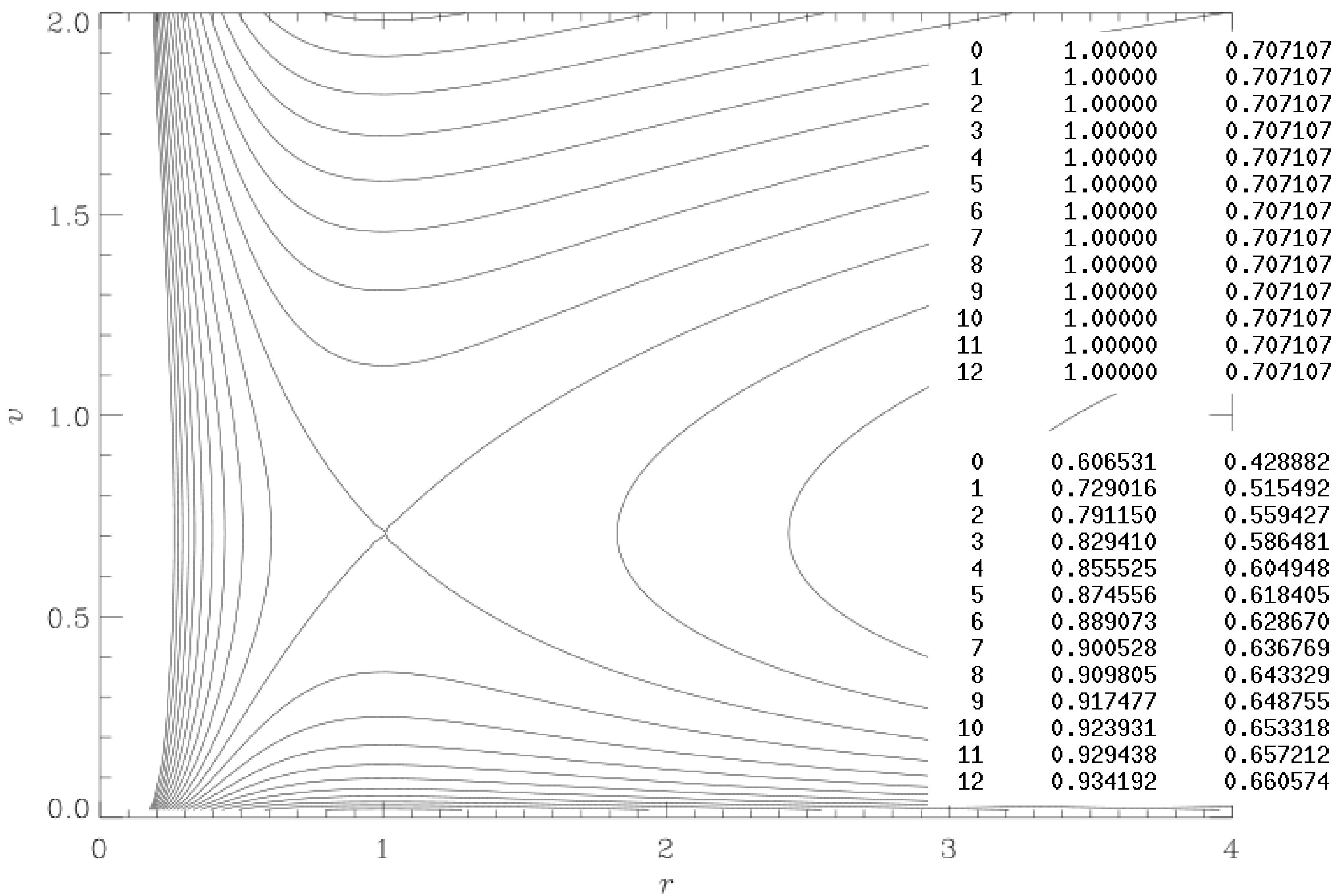
Iteration steps for r=2

	m	$m/\sqrt{2}$
0	1.33139	0.941432
1	1.53135	1.08283
2	1.62015	1.14562
3	1.65458	1.16996
4	1.66724	1.17891
5	1.67180	1.18214
6	1.67344	1.18330
7	1.67402	1.18371
8	1.67423	1.18386
9	1.67430	1.18391
10	1.67433	1.18393
11	1.67434	1.18394
12	1.67434	1.18394



0	1.33139	0.941432
1	1.53135	1.08283
2	1.62015	1.14562
3	1.65458	1.16996
4	1.66724	1.17891
5	1.67180	1.18214
6	1.67344	1.18330
7	1.67402	1.18371
8	1.67423	1.18386
9	1.67430	1.18391
10	1.67433	1.18393
11	1.67434	1.18394
12	1.67434	1.18394

0	0.412180	0.291456
1	0.448724	0.317296
2	0.455838	0.322326
3	0.457307	0.323365
4	0.457614	0.323582
5	0.457678	0.323627
6	0.457692	0.323637
7	0.457694	0.323639
8	0.457695	0.323639
9	0.457695	0.323639
10	0.457695	0.323639
11	0.457695	0.323639
12	0.457695	0.323639


2.0
1.5
1.0
0.5
0.0
v
0
1
2
3
4
r
0 1.00000 0.707107
1 1.00000 0.707107
2 1.00000 0.707107
3 1.00000 0.707107
4 1.00000 0.707107
5 1.00000 0.707107
6 1.00000 0.707107
7 1.00000 0.707107
8 1.00000 0.707107
9 1.00000 0.707107
10 1.00000 0.707107
11 1.00000 0.707107
12 1.00000 0.707107
0 0.606531 0.428882
1 0.729016 0.515492
2 0.791150 0.559427
3 0.829410 0.586481
4 0.855525 0.604948
5 0.874556 0.618405
6 0.889073 0.628670
7 0.900528 0.636769
8 0.909805 0.643329
9 0.917477 0.648755
10 0.923931 0.653318
11 0.929438 0.657212
12 0.934192 0.660574

Webpage updates

- Take pictures and describe the apparatus briefly. Again this will be part of your project report.
- Determine $I_\lambda(\mu)$ by scanning with the spectro-photometer across the solar disk. Make sure you cover reasonably well both limbs. Check this before taking data for `production runs'. Record spectra in fine enough intervals (either 13 or 26 points corresponding to 10 or 5 revolutions on this little `crank'. Make sure yoou can translate the revolutions into μ and estimate an error for this procedure.
- Repeat measurements ***at least*** 3 to 5 times. Double-check that the weather is ok all the time. If small clouds appear, make a clear note of this. Such data are in principle useless, but maybe you can learn something from them anyway. Write down any irregularities in the measurements. This might help in tracing the course of systematic changes that might occur over the 1.5 months period that measurements are taken.
- If there is time, perform additional experiments that you can think of. This will give you **extra points** and the five best innovative ideas will be rewarded at the end.
- Determine the solar spectrum in integral light without telescope by going outside with the with the detector and computer.
- Determine the angular characteristics (angular dependence) of the detector. Try to fit this dependence locally around the maximum to a $\cos^n\theta$ dependence, where θ is the angle from the normal.

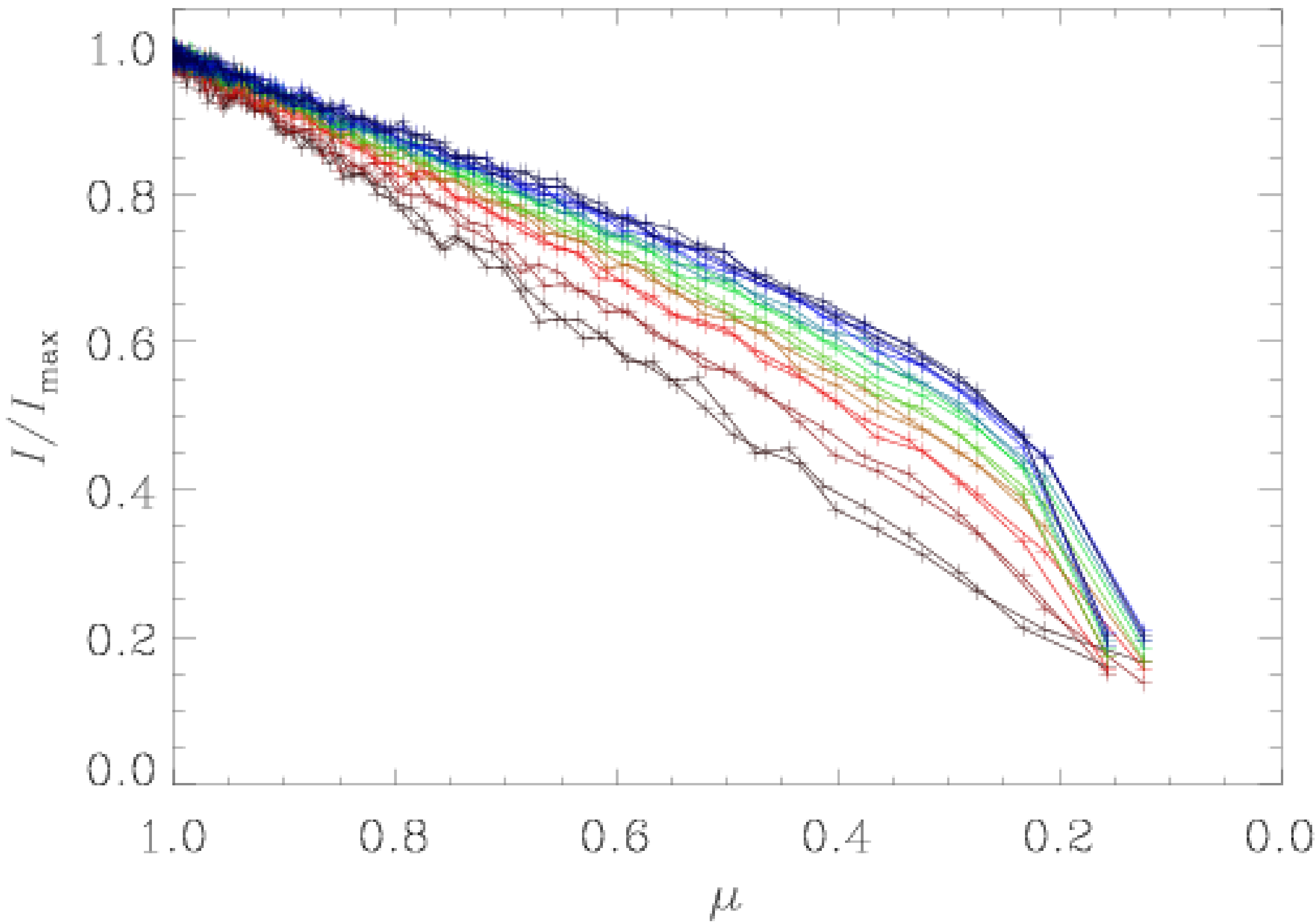
Regarding the theoretical interpretation

For the case of a gray atmosphere (no λ dependence), see Homework key 2.

- Back to main course page
- notes on the analysis
- See Lecture 37 for further details
- Link to Axel's idl directory

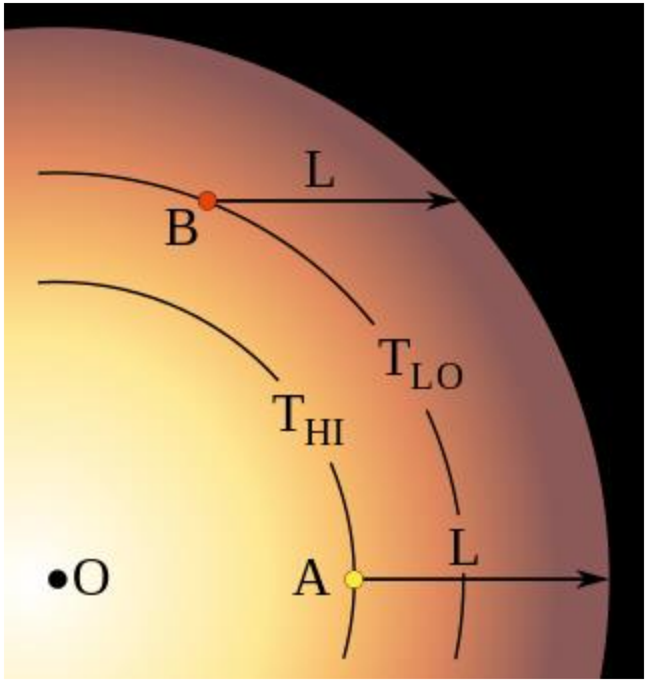
- Schedule (past+future)

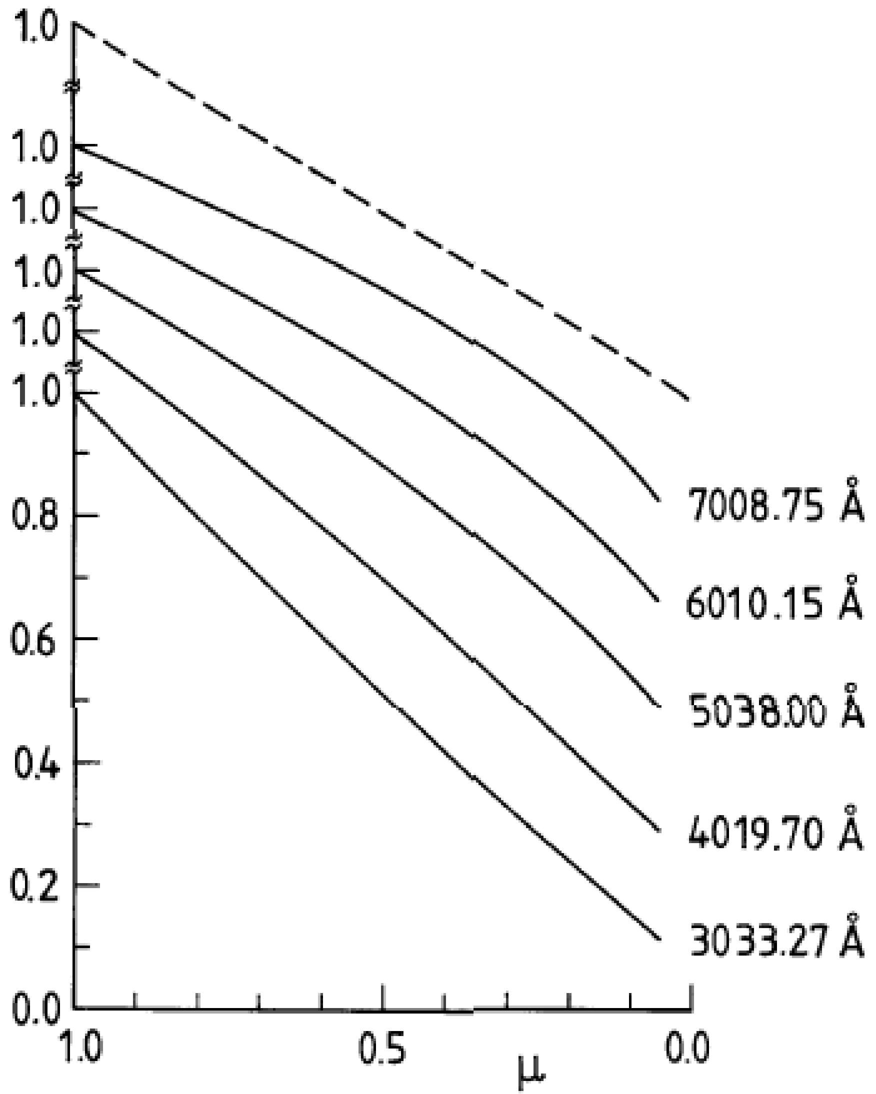
μ dependence



Limb darkening

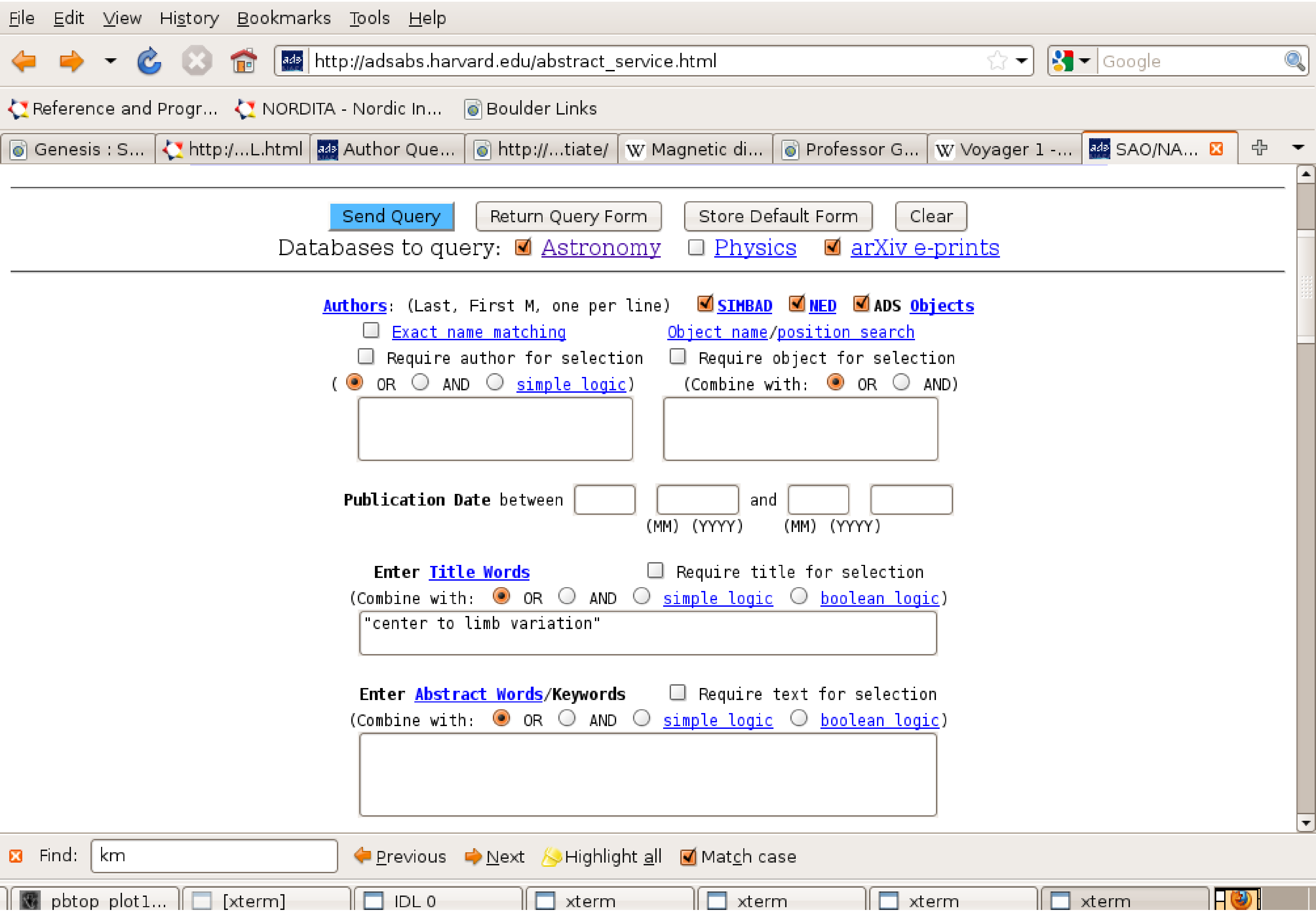
- Stix Sect. 4.3.1
- See deeper





What else can go into report?

- Literature search
  - History
  - earlier work
- Setup, description
- Results, details
- Conclusions, where to go from here
- References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Author Que...
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Professor G...
Voyager 1 -...
SAO/NA...
Send Query
Return Query Form
Store Default Form
Clear
Databases to query: Astronomy Physics arXiv e-prints
Authors: (Last, First M, one per line)
SIMBAD NED ADS Objects
Exact name matching
Object name/position search
Require author for selection
Require object for selection
(OR AND simple logic)
(Combine with: OR AND)
Publication Date between and
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(Combine with: OR AND simple logic boolean logic)
"center to limb variation"
Enter Abstract Words/Keywords
Require text for selection
(Combine with: OR AND simple logic boolean logic)
Find: km
Previous
Next
Highlight all
Match case
pbtop plot1...
[xterm]
IDL 0
xterm
xterm
xterm
xterm

Lect.3, relation to opacity

Leading order $$I_\nu = B_\nu$$

Insert

$$\cos\theta \frac{dB_\nu}{dr} = -\rho\kappa_\nu \left(I_\nu - B_\nu\right)$$

so

$$I_\nu = B_\nu - \frac{\cos\theta}{\rho\kappa_\nu}\frac{dB_\nu}{dr}$$

Interested in flux

$$\int_{4\pi} I_\nu \cos\theta \, d\Omega = 2\pi \int_{-1}^{1} I_\nu \cos\theta \, d\cos\theta$$

What we did today

- Notes on Homework 4+5 resit
  - Numerical integration of moments of intensity
  - Iteration steps in solar wind equation
- Center-to-limb variation
  - Connection with mu
- About final report
  - Relation to other work (introduction)
  - Where to go from here (conclusions)