A user-friendly graphical interface for photoionization codes

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What is CLOUDY?

- A code developed to simulate complex physical conditions in photoionized clouds.
- Continous developing since 1978

- It can simulate many of this parameters and produce a spectra output

- Much of the properties of the ionized gas (kinetic temperature, chemical state, level of ionization, and level populations…) are determined by microscopic processes, rather than a single temperature

- We can run cloudy with different input datasets and compare the outputs with the real data

Cloudy project web: www.nublado.org

Why CLOUDY?

- Observation of soft X-ray emission in highly obscured AGN

- The narrow Radiative Recombination Continua (RRC) and ratios on He-triplets and higher order series confirm photoionization as the radiation source

- CIELO : Catalog of Ionized Emission Lines in Obscured AGN

- 64 highly obscured AGN (type 1.5) observed with the XMM-Newton/RGS
- 35 objects exhibit 5 lines
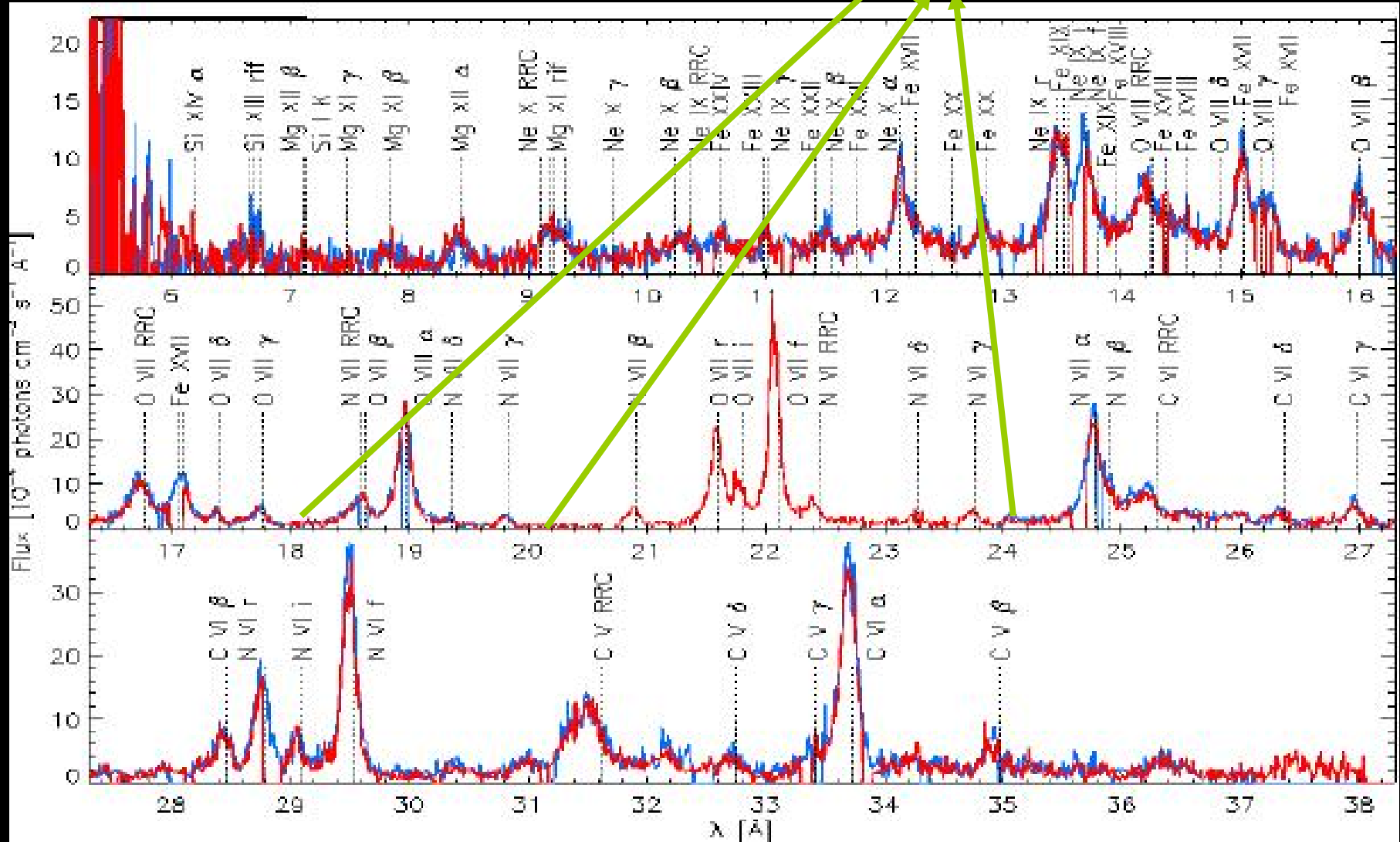- 34 objects exhibit RRC (CV, OVII, OVIII)

Cloudy can simulate several parameters associated with this clouds.

With this GUI, we could compare the cloudy output data with real observations.

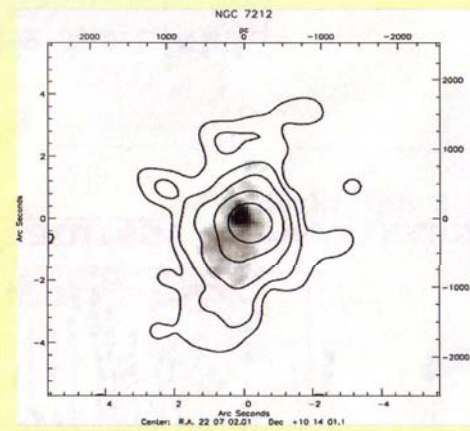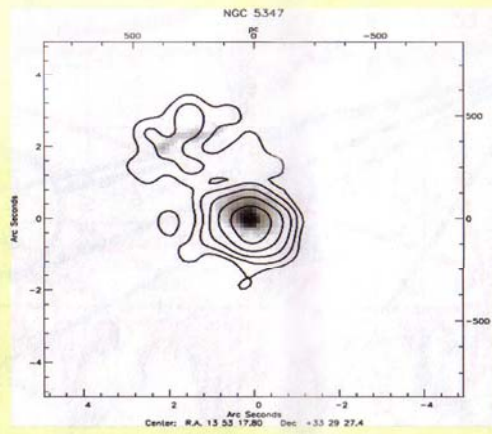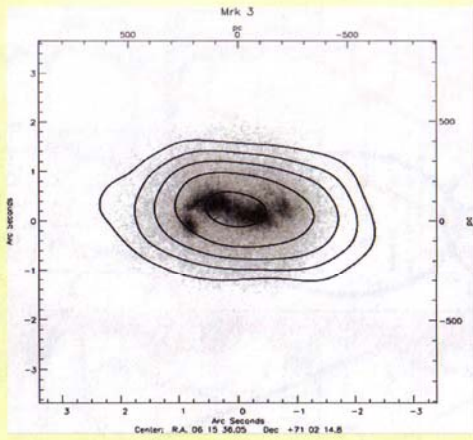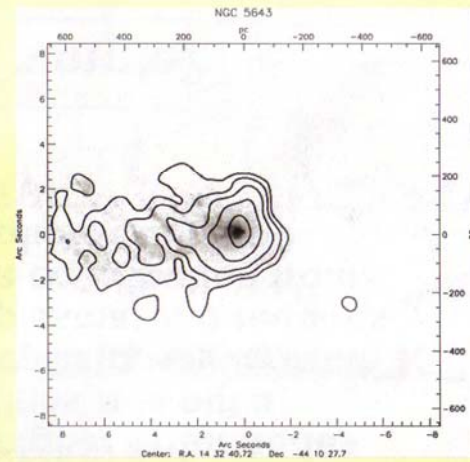CIELO-AGN, and the origin of soft X-ray emission in highly obscured AGN.
Matteo Guainazzi, Stefano Bianchi, Mar Sierra. European Space Astronomy Center Research and Science Support Division of ESA.

NGC1068

Dominated by Emission Lines

No continuum

Kinkhabwala et al. 2002

Contours: Chandra/ACIS   Grayscale: HST/O[III]
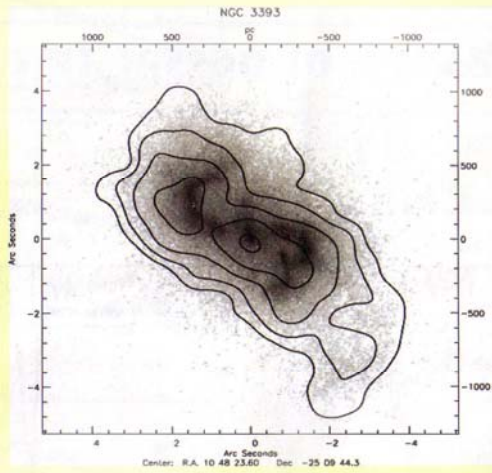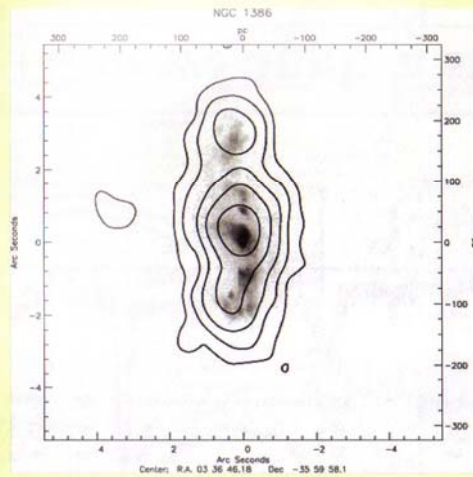
Why a GUI?

Write a lot of input files, given initial and final values for dataset.

Plot the results at once

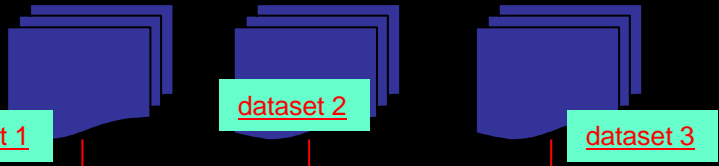Compare real data (FITS , RGS spectral files…) with simulated plots.

Cloudy input files (several datset values)

cloudy

Cloudy output files

dataset 1

dataset 2

dataset 3

Element ionization data files

Plot form

oxygen plot

Plot

FITS file

FITS reader

Spectra overplot

```
agn kirk
ionization parameter -0.8
hden=3.0, power=-2
radius 18.59 21.06
filling factor 0.005
stop temperature _off
normalize to "o  3" 5007
print diffuse continuum
print line inward
print line column
punch column densities "nlr_U0.8_n3.0_f0.005_nh.dat"
punch overview "nlr_U0.8_n3.0_f0.005_overview.txt"
punch last element oxygen "nlr_U0.8_n3.0_f0.005_oxygen.dat"
punch last element nitrogen "nlr_U0.8_n3.0_f0.005_nitrogen.dat"
punch last lines, emissivity, "nlr_U0.8_n3.0_f0.005_emi.dat"
O   3 5007A
N   7 24.78A
O   7 22.10A
O   7 18.63A
O   8 16.01A
Ne 9 13.44A
Ne10 12.14A
Ne 9 11.55A
Ne10 10.24A
Mg11 7.850A
Mg12 7.106A
Si13 6.743A
Si14 5.219A
end of lines
iterate
```

dataset

generate the element data files

CLOUDY GUI: Parameters Introduction

Continuum Type   agn kirk

Ionization Parameter   0   3   2

hden   0   3   2

power   0   3   2

filling factor   0   3   2

Radius   0   0

☑ Apply Temperature Stop Criterium?

☐ Normalize

Punch Options

☑ Column Densities (default yes)

☑ Overview (default yes)

dataset

Text File Preview

```
agn kirk
ionization parameter 0.0
hden=0.0, power=0.0
filling factor 0.0
print diffuse continuum
print line inward
print line column
radius 0 0stop temperature _off
punch column densities "Z:\home\alex\cloudy\templates/
punch overview "Z:\home\alex\cloudy\templates/U0.0_n0
iterate
```

	☐ Punch	Z=1: hidrogen	☐
	☐ Punch	Z=2: helium	☐
	☐ Punch	Z=3: lithium	☐
	☐ Punch	Z=4: beryllium	☐
	☐ Punch	Z=5: boron	☐
	☐ Punch	Z=6: carbon	☐
	☐ Punch	Z=7: nitrogen	☐
	☐ Punch	Z=8: oxygen	☐

Directory   /home/alex/cloudy/templates/

Select Folder

Write File and Exit   **Write file**

```
alex@linux:~/cloudy/templates> ls
U0.0_n0.0_p0.0_f0.0_.in  U0.0_n3.0_p3.0_f0.0_.in  U3.0_n3.0_p0.0_f0.0_.in
U0.0_n0.0_p0.0_f3.0_.in  U0.0_n3.0_p3.0_f3.0_.in  U3.0_n3.0_p0.0_f3.0_.in
U0.0_n0.0_p3.0_f0.0_.in  U3.0_n0.0_p0.0_f0.0_.in  U3.0_n3.0_p3.0_f0.0_.in
U0.0_n0.0_p3.0_f3.0_.in  U3.0_n0.0_p0.0_f3.0_.in  U3.0_n3.0_p3.0_f3.0_.in
U0.0_n3.0_p0.0_f0.0_.in  U3.0_n0.0_p3.0_f0.0_.in
U0.0_n3.0_p0.0_f3.0_.in  U3.0_n0.0_p3.0_f3.0_.in
alex@linux:~/cloudy/templates>
```

Example of an element data file

"_U0.8_n3.0_f0.05_helium.dat"

#depth	He 1	He2	He 3
1.21773e+17	0.00e+00	9.93e-10	6.02e-06
2.66823e+17	0.00e+00	9.71e-10	5.90e-06
4.10476e+17	0.00e+00	9.77e-10	5.93e-06
5.58230e+17	0.00e+00	9.78e-10	5.94e-06
7.11363e+17	0.00e+00	9.76e-10	5.93e-06
8.69618e+17	0.00e+00	9.76e-10	5.93e-06
1.03341e+18	0.00e+00	9.77e-10	5.93e-06

"_U0.8_n3.0_f0.09_helium.dat"

#depth	He 1	He 2	He 3
1.21773e+17	1.56e-13	1.21e-08	3.94e-05
2.66823e+17	1.51e-13	1.18e-08	3.88e-05
4.10476e+17	1.53e-13	1.19e-08	3.91e-05
5.58230e+17	1.53e-13	1.19e-08	3.92e-05
7.11363e+17	1.54e-13	1.19e-08	3.92e-05
8.69618e+17	1.54e-13	1.19e-08	3.92e-05
1.03341e+18	1.54e-13	1.20e-08	3.93e-05

"_U1.2_n3.0_f0.05_helium.dat"

#depth	He 1	He 2	He 3
1.21773e+17	1.56e-13	1.21e-08	3.94e-05
2.66823e+17	1.51e-13	1.18e-08	3.88e-05
4.10476e+17	1.53e-13	1.19e-08	3.91e-05
5.58230e+17	1.53e-13	1.19e-08	3.92e-05
7.11363e+17	1.54e-13	1.19e-08	3.92e-05
8.69618e+17	1.54e-13	1.19e-08	3.92e-05
1.03341e+18	1.54e-13	1.20e-08	3.93e-05

Select Plot

Select element file

Select Curves to plot

Select Plot X variable

Select constant parameters

ionization Parameter (U)

Density (n)

Filling Factor (f)
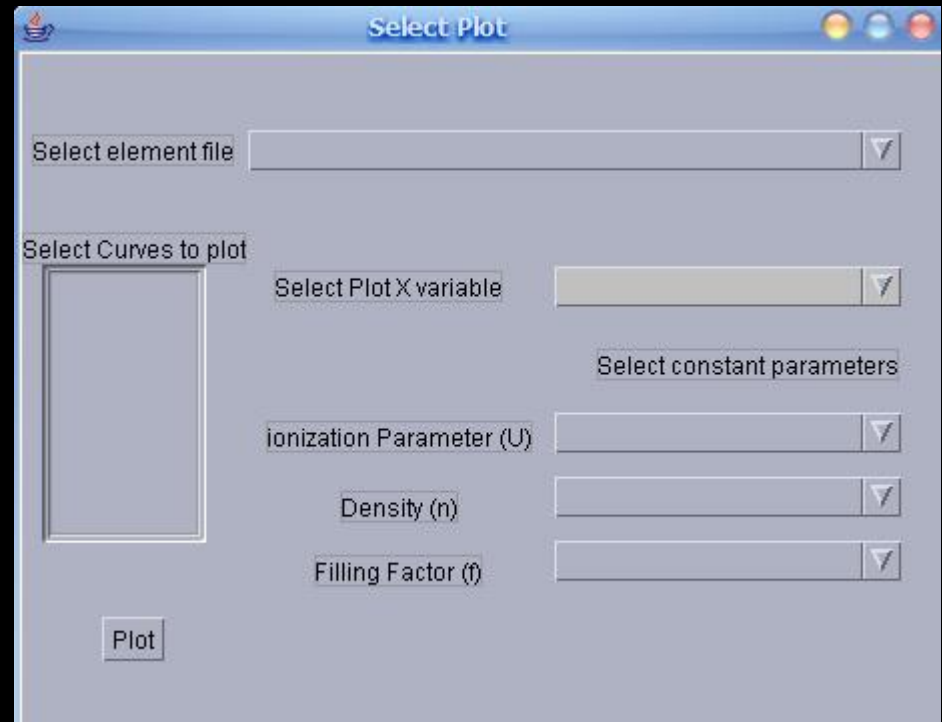
Plot

oxygen plot
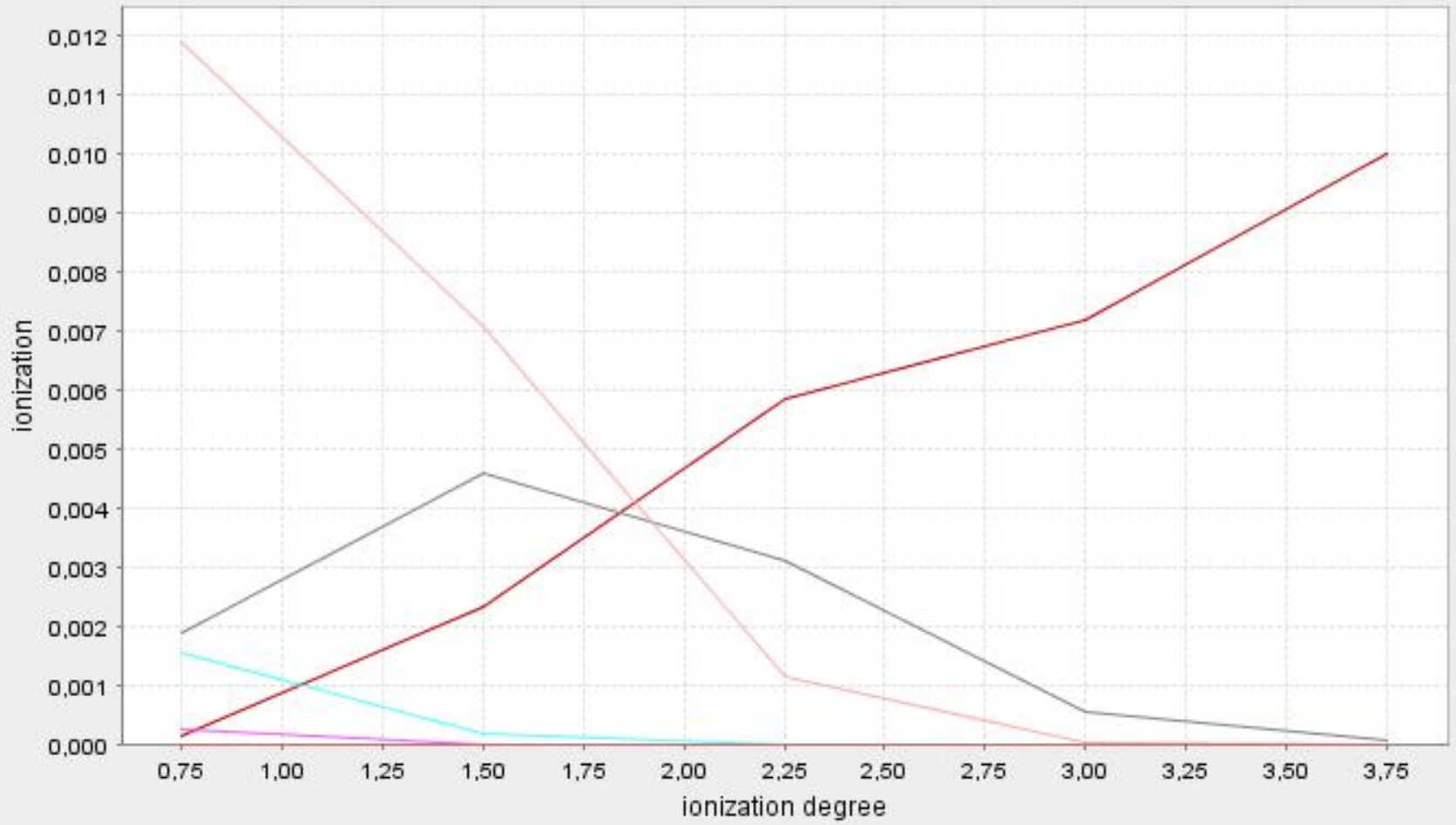
```
alex@linux:/windows/D/Compartido/cloudy/outs> ls
U0.75_n3.0_p3.0_f3.0_.in          U2.25_n3.0_p3.0_f3.0_oxygen.dat
U0.75_n3.0_p3.0_f3.0_.out         U3.0_n3.0_p3.0_f3.0_.in
U0.75_n3.0_p3.0_f3.0_oxygen.dat   U3.0_n3.0_p3.0_f3.0_.out
U1.5_n3.0_p3.0_f3.0_.in           U3.0_n3.0_p3.0_f3.0_oxygen.dat
U1.5_n3.0_p3.0_f3.0_.out          U3.75_n3.0_p3.0_f3.0_.in
U1.5_n3.0_p3.0_f3.0_oxygen.dat    U3.75_n3.0_p3.0_f3.0_.out
U2.25_n3.0_p3.0_f3.0_.in          U3.75_n3.0_p3.0_f3.0_oxygen.dat
U2.25_n3.0_p3.0_f3.0_.out
alex@linux:/windows/D/Compartido/cloudy/outs>
```