

CHIIS-BURGER: CLOUDY simulation of HII around StarBURst Galaxy Emission Region

CLOUDY @ IUCAA 2015

1. Abhishek Paswan
ARIES, Nainital

2. Anindita Mondal
SNBNCBS, Kolkata

3. Joe Philip Ninan
TIFR, Mumbai



4. Gargi Shaw
CBS, Mumbai

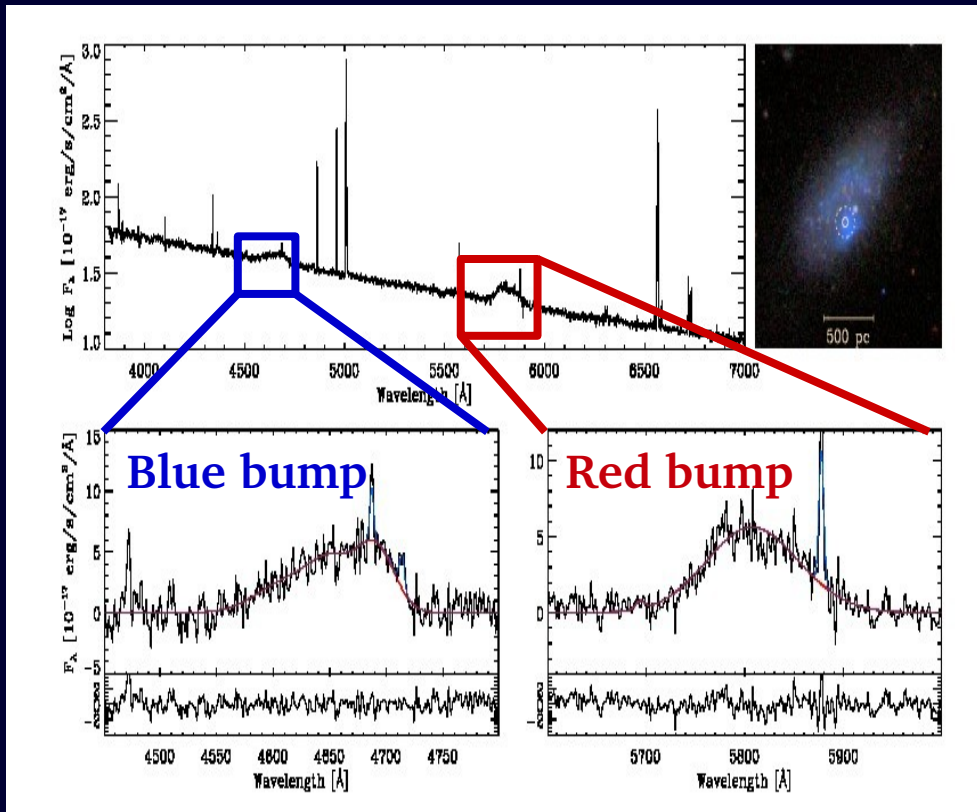
5. Ramkrishna Das
SNBNCBS, Kolkata

6. Vishal Joshi
IUCAA, Pune

Introduction

Wolf-Rayet Galaxy ?

A subset of H II galaxies whose integrated spectra show broad emission line (HeII, CIV) features. They are a special type of star-burst galaxies where massive star formation is only few Myr old (Schaerer et al. 1999).



The broad emission line features attributed to the presence of Wolf-Rayet stars (Conti 1991).

There should be a large number ($10^2 - 10^5$) of WR stars in a galaxy in order to observe it in the WR-phase (Vacca & Conti 1991).

The most massive O-type stars ($M \geq 25M_{\odot}$) undergo WR phase after few Myr from their birth, spending only a short time ($\leq 0.5 \text{ Myr}$) in this phase before their supernova explosion. (e.g., Lopez - Sanchez & Esteban 2008).

HII region in galaxy

WR star/O-type star



Massive star

Very hot

Short life



WR stars ionized the ISM (neutral hydrogen).



Recombination takes place

Where,

Recombination rate = ionization rate

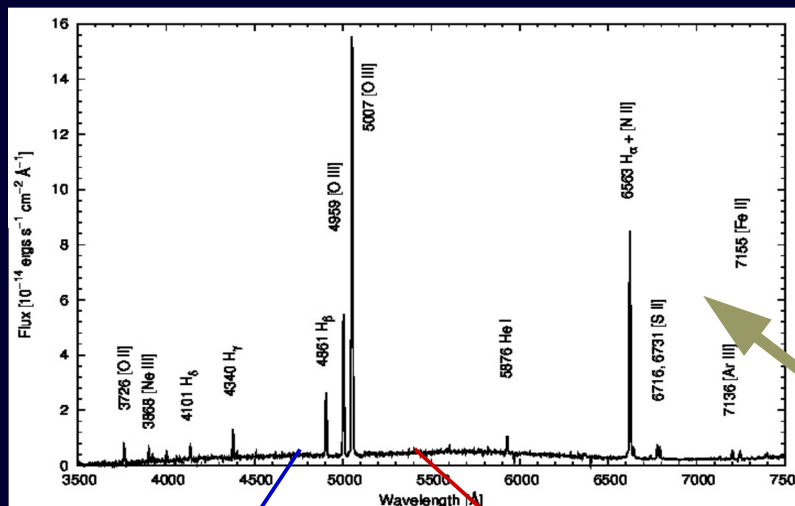


Generation of H line series (H α /Optical region)

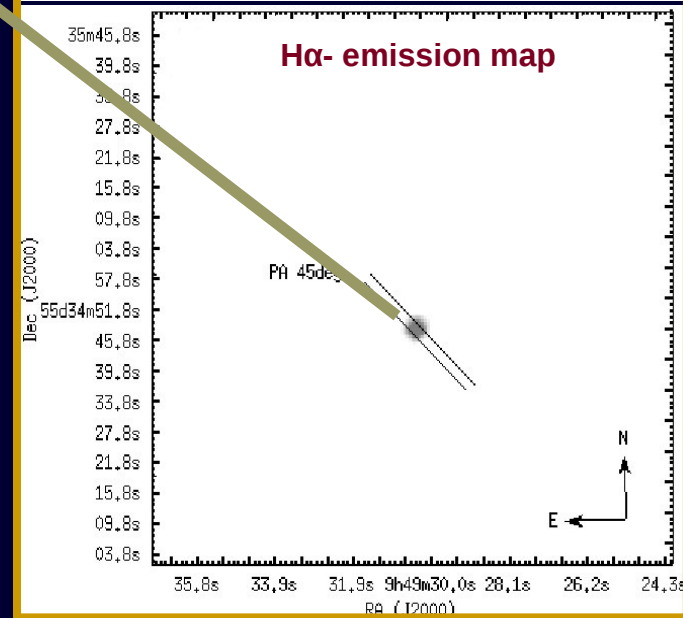
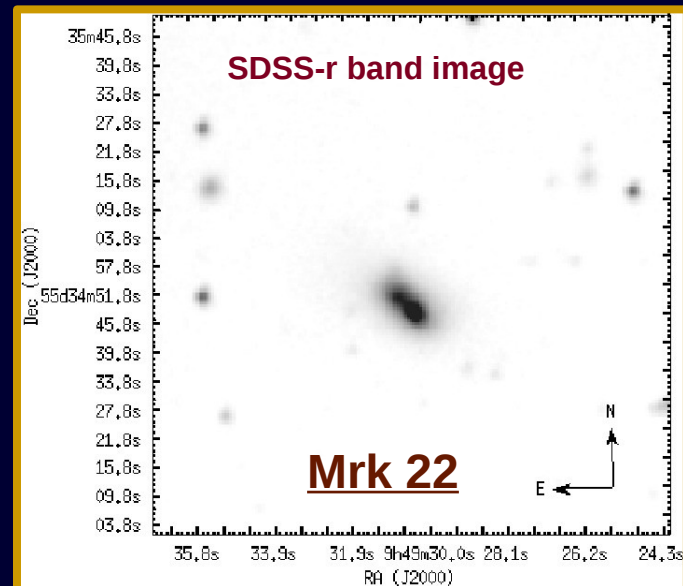
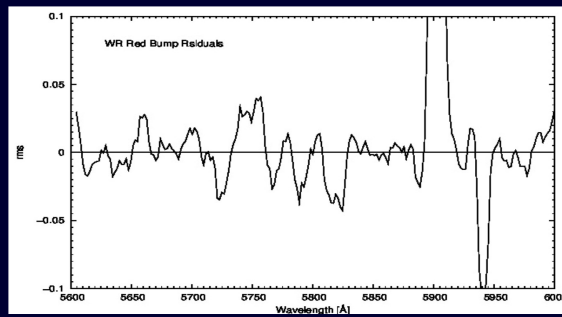
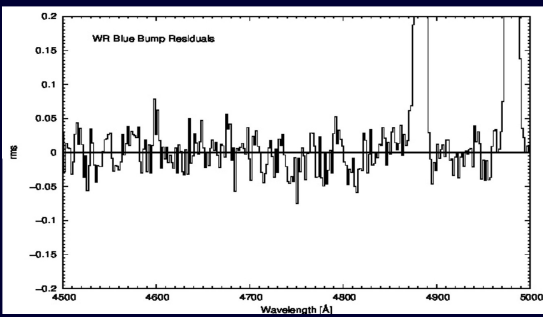
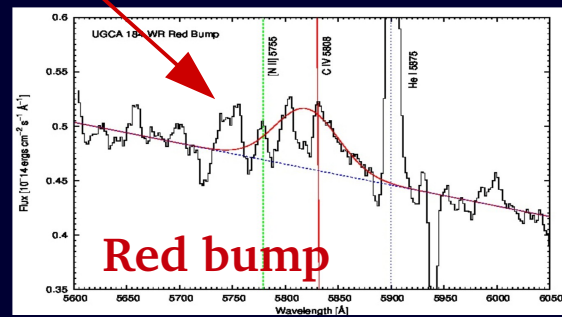
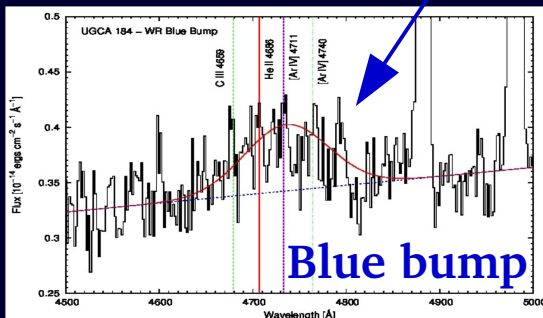


Optical spectroscopy

Spectrum of HII region

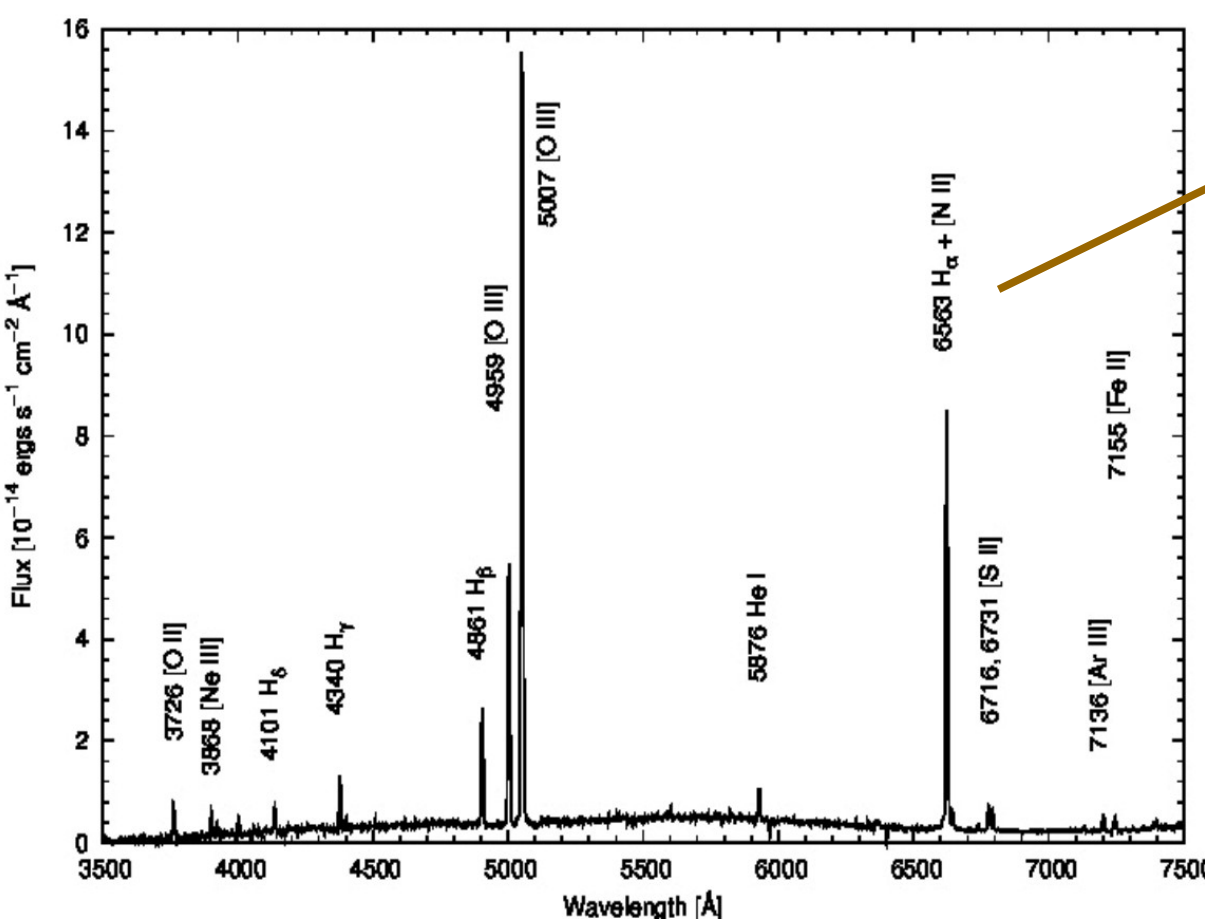
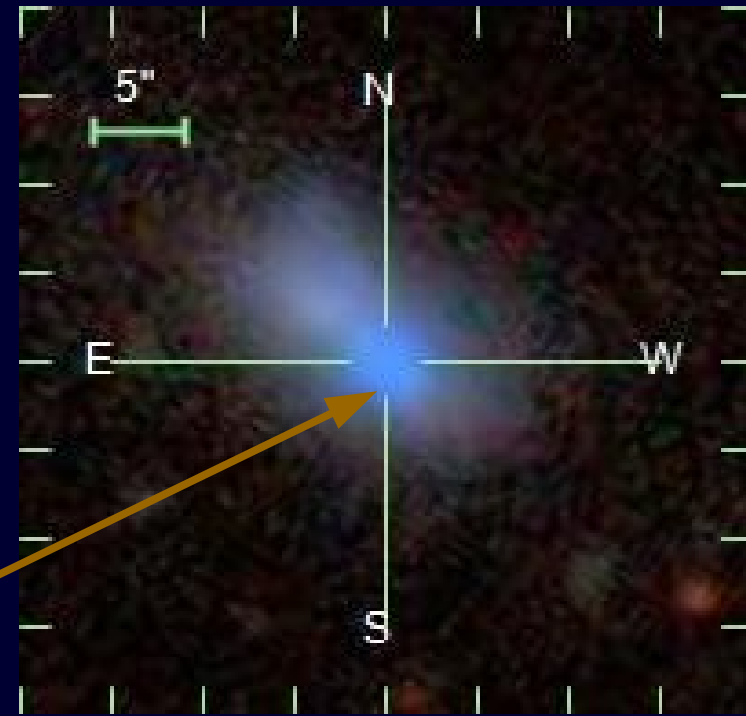


Wolf-Rayet features



Mrk 22 W-R starburst galaxy

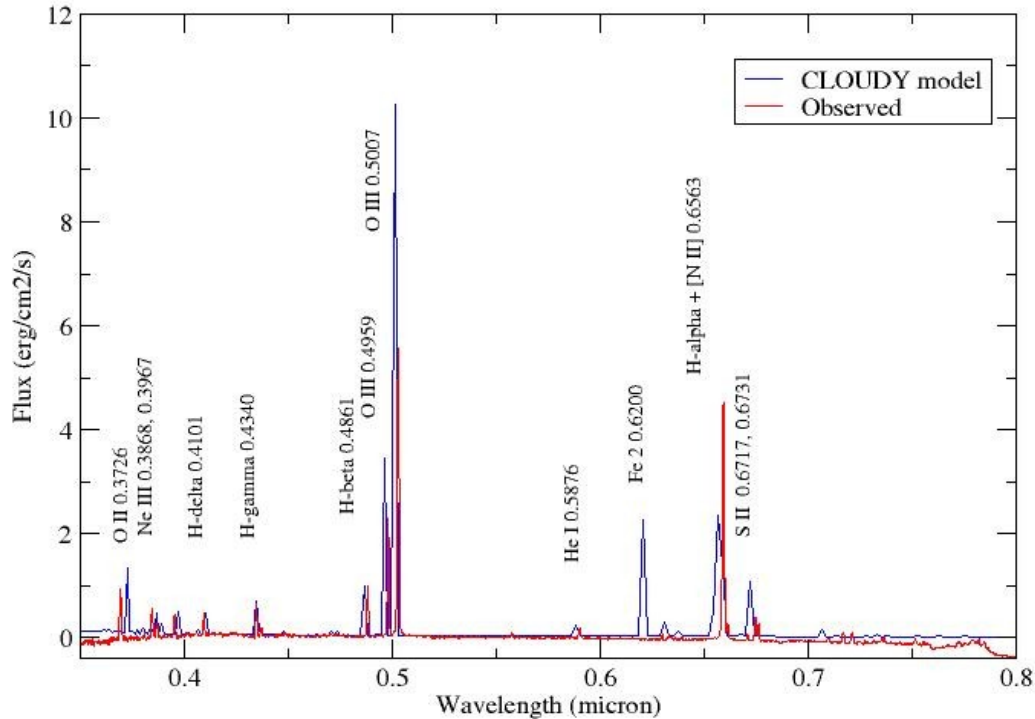
Spectrum of HII region



Aim:
To find the abundances and other Physical conditions using Cloudy

Method:
To generate synthetic spectrum that matches the observed spectrum.

Fitting Spectrum of HII region



Day 2:

Hden=3.43 LOG

Blackbody= 4.57 LOG

IONIZATION PARAMETER=
1.76 LOG

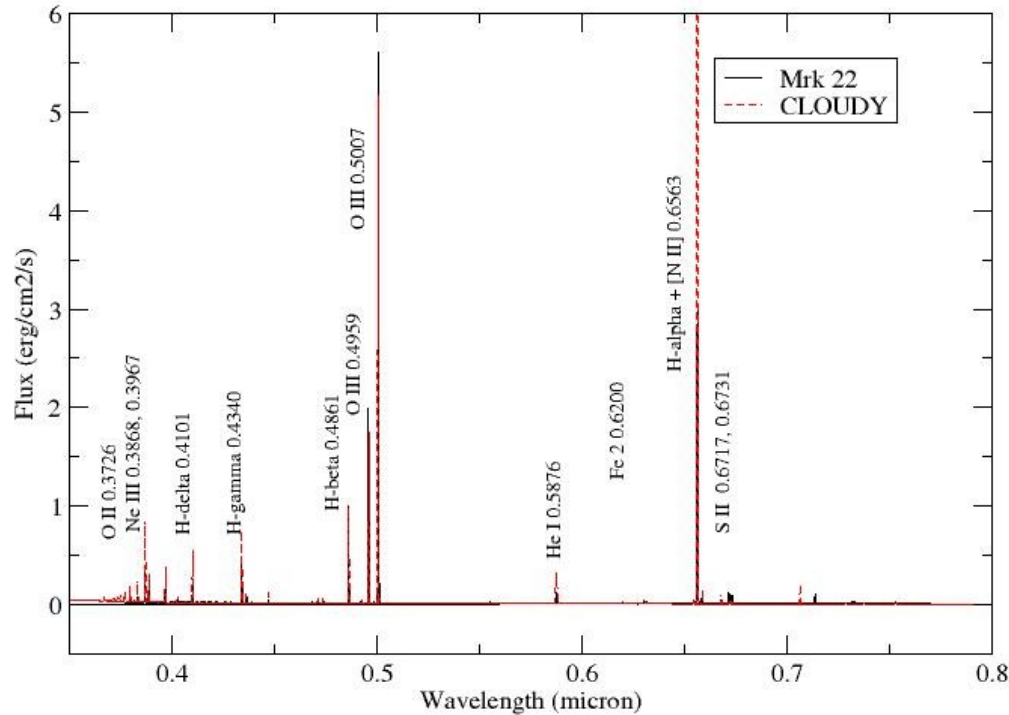
STOP NEUTRAL COLUMN
DENSITY 25.04

Abundance: H II region with no
grains.

Problem:
Mismatches in the Fe, O, S
and Ne lines.

Plan for the next day: Need to match the lines Correctly by changing
Individual elemental Abundances.

Fitting Spectrum of HII region



Day 4:

Fe = 0.001

O = 0.1

S = 0.2

Ne = 0.3

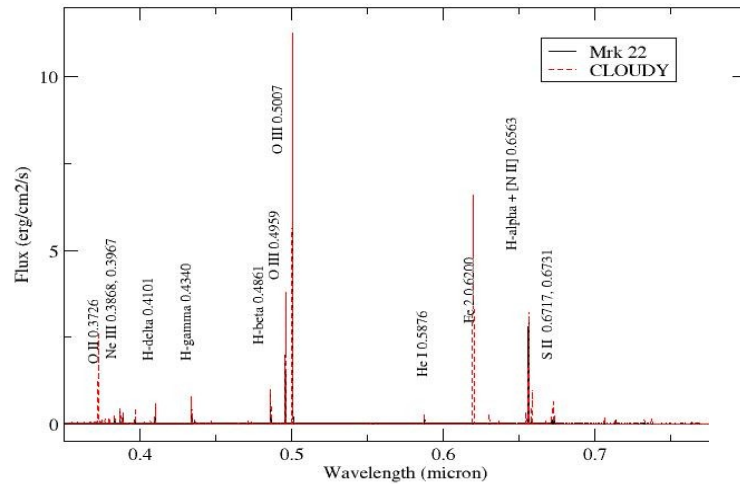
Ar = 0.1

Higher Continuum resolution

Problem: Ha/Hbeta ratio not matching!

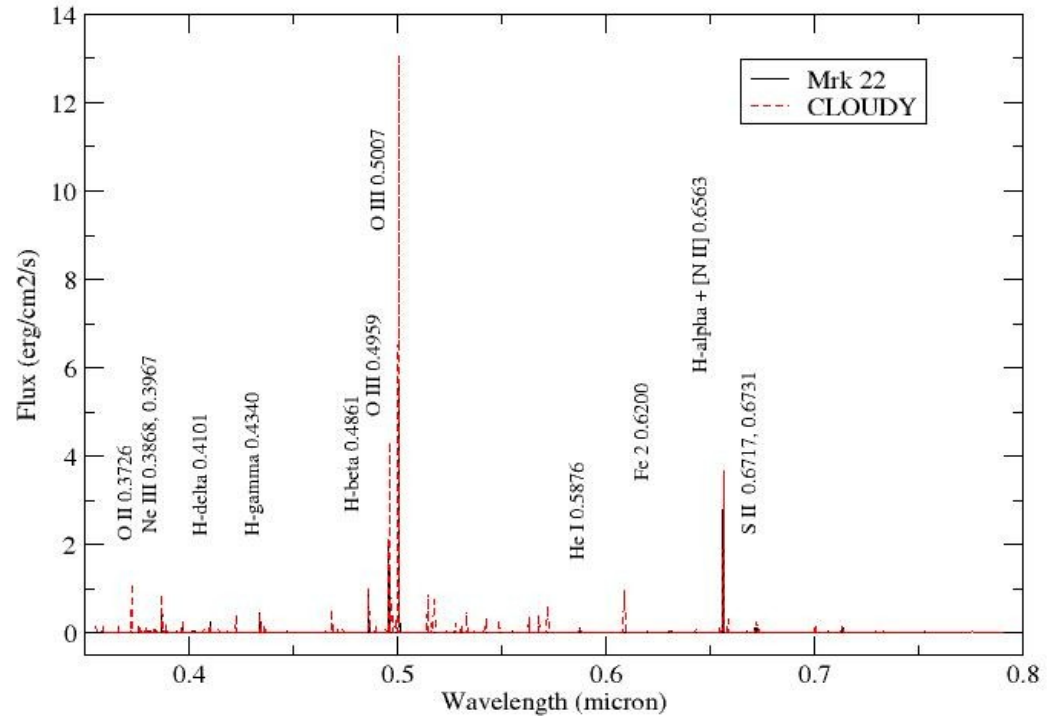
Plan for the next day: Need to match the lines Correctly by trying out different Abundances.

Fitting Spectrum of HII region



Abundance is
Solar with no grains.

Fe II is still strong!!



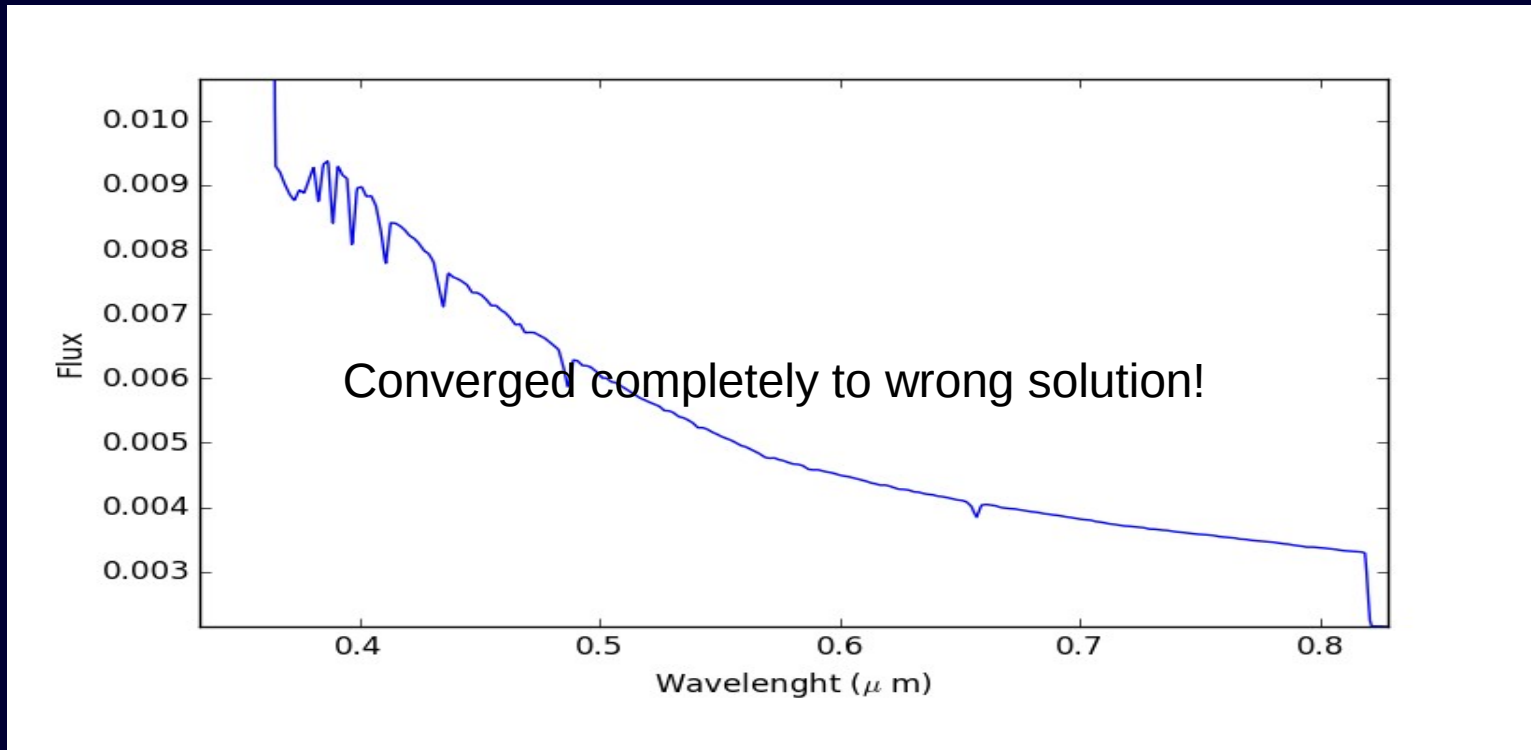
Abundance is
Solar with ISM grains.

Fe II reduced :-)
but other lines appeared :-)

Changed input flux SED to starburst99

Adventures with optimization!

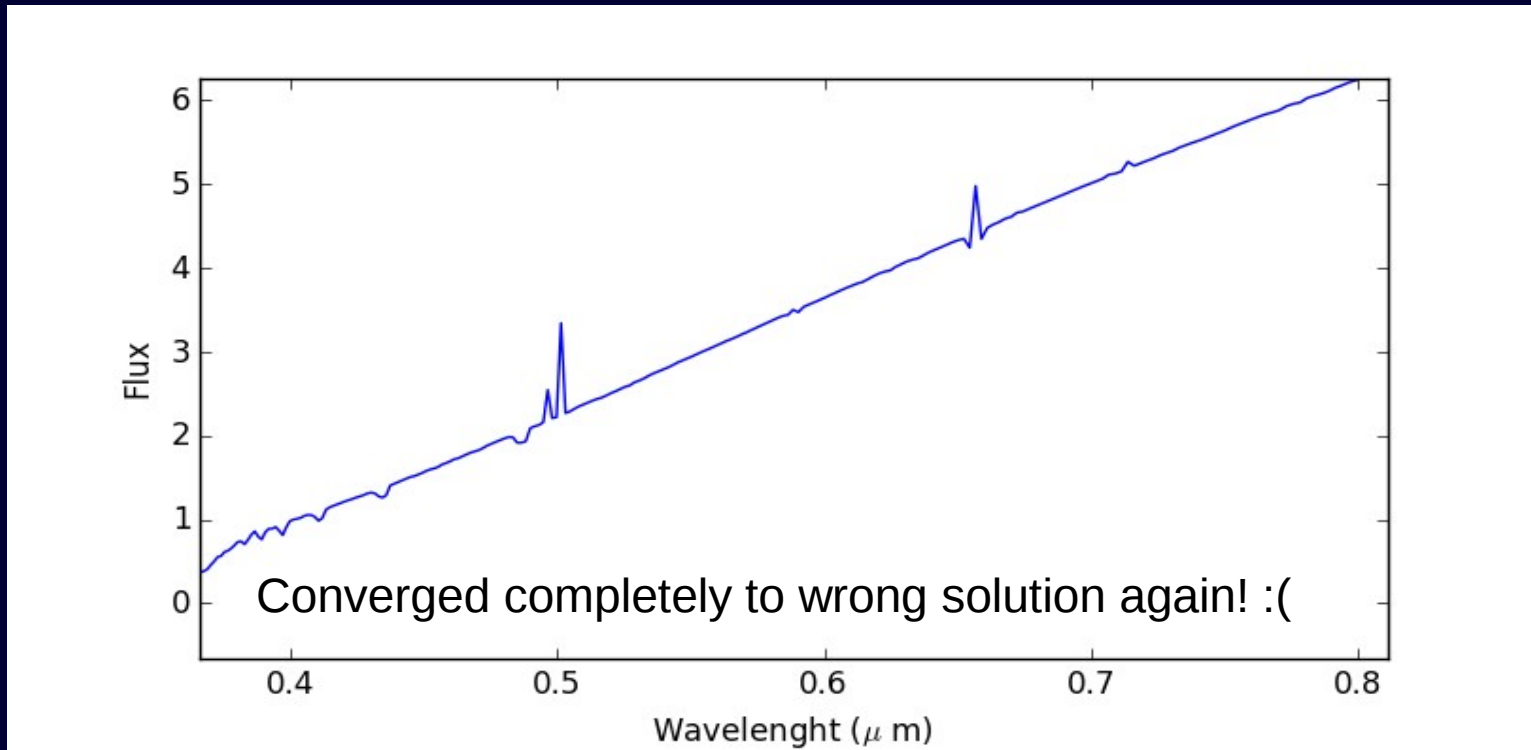
Starburst99 (age: 10^8) : [Solar abundance, ISM grain]



Changed input flux SED to -> starburst99

Adventures with optimization!

Starburst99 (age: 10^6) : [HII abundance, ISM grain]



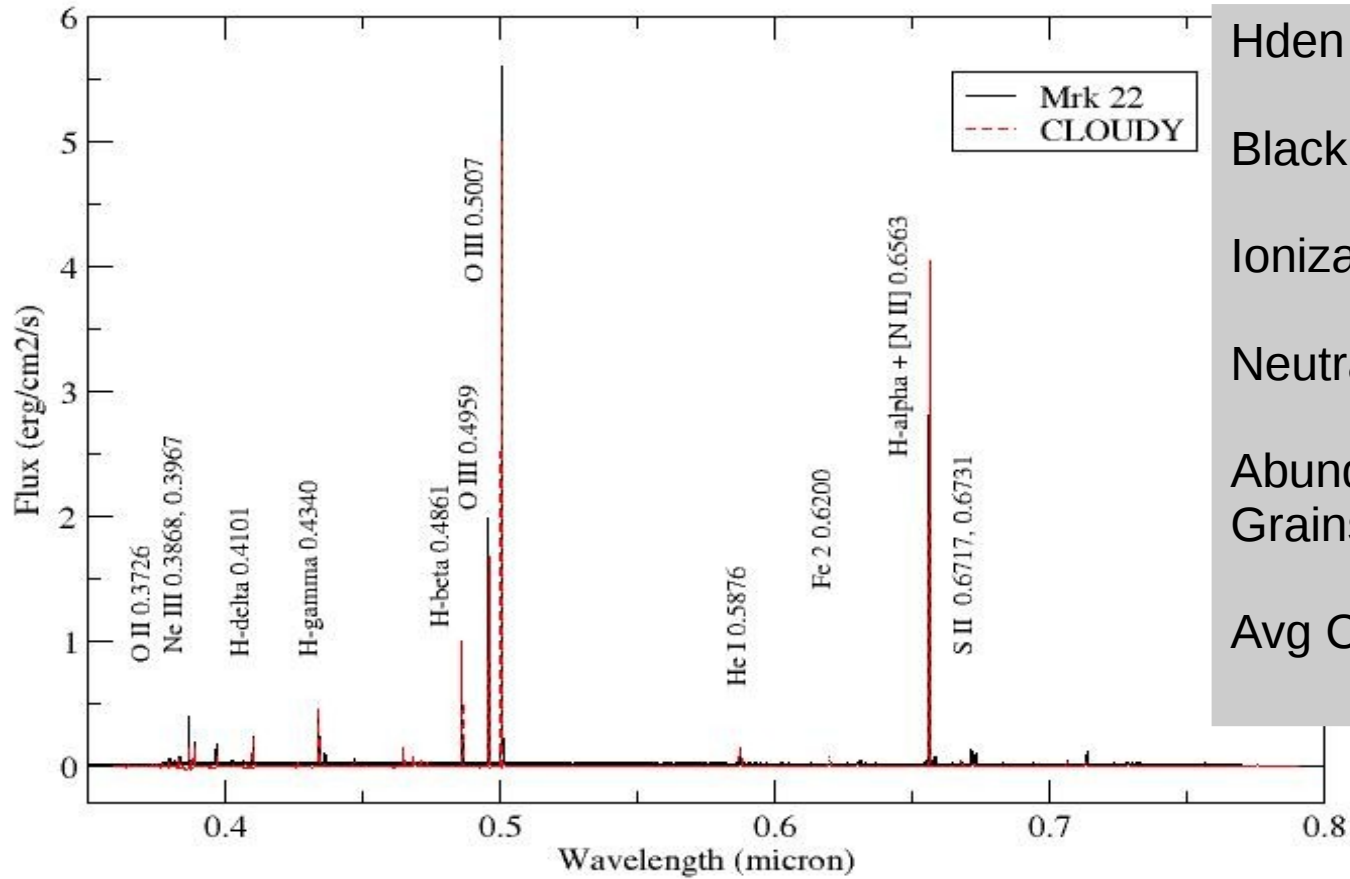
More experiments...

- Gave more constrains including all the lines in the spectrum.
- Better initial conditions
- Tried non unity filling factor

Still no significant progress

- Issue with the star burst model?
- Finally we tried multiple black body radiation field.

Finally it worked!!



Hden = -1.497 (log)

Blackbody = multiple temp

Ionization Parameter= 1.09 log

Neutral Column Density 23.5

Abundance: H II region

Grains: Orion

Avg ChiSqr ~ 19

Future work

Optimization codes are still running.

Better calculation of input radiation field using population synthesis models of star burst WR galaxies.

More fine tuning of elemental abundances as well as filling factor.

Particle Swarm Optimizer

Present default optimization algorithm prevents us from using threads more than 2 times the number of parameters.

Highly susceptible to local minima.

Little control over quantities to optimize.

Quick solution:

- 1) **Pycloudy** already has pythonic interface to manage input and output to Cloudy.
- 2) Each cloudy run is independent.

Particle swarm optimization on top of PyCloudy with number of particles equal to number of threads.



THANK YOU

Gary, resource persons, organizers and all the participants of CLOUDY school.