Simulation of Temperature Fluctuations in HII Regions

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RESUME

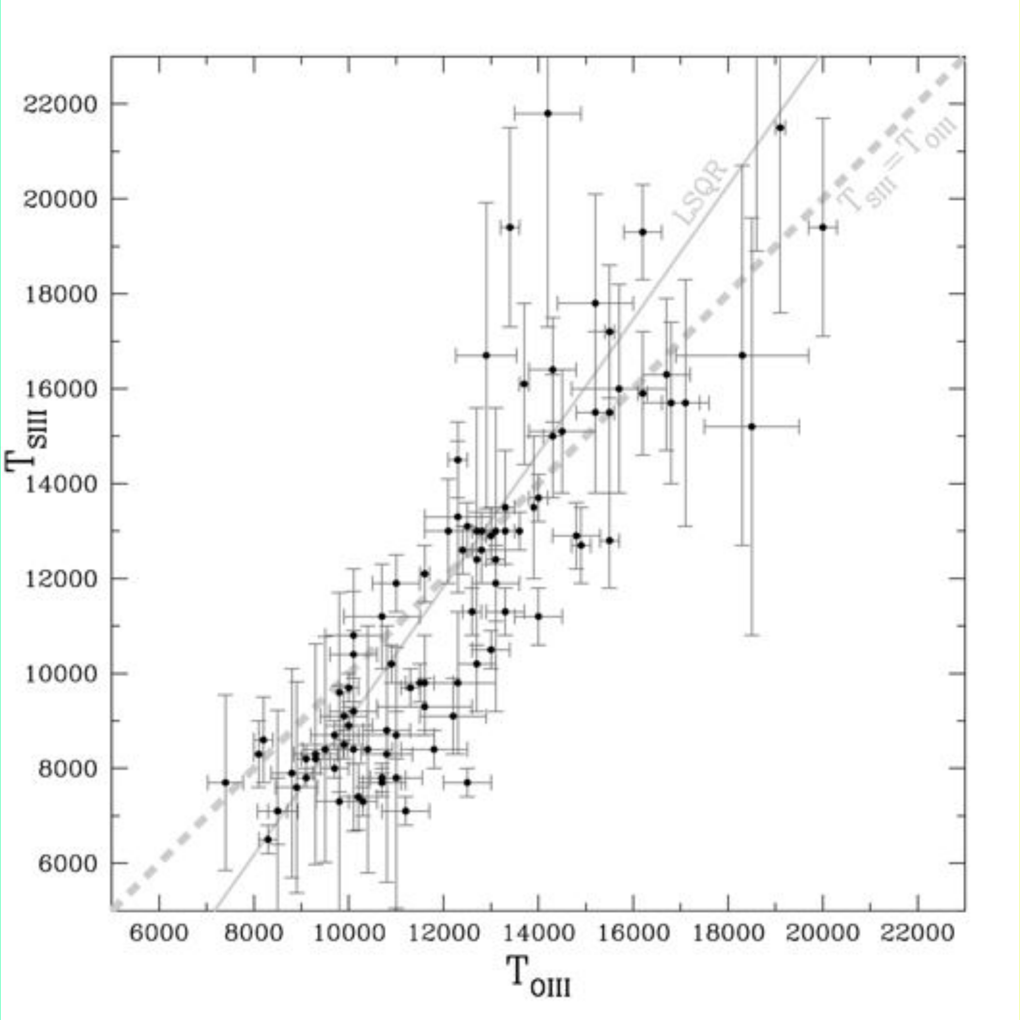
An analysis of the [OIII] and [SIII] temperatures derived mostly from Sloan Digital Sky Survey measurements of objects consisting in HII galaxies, giant extragalactic HII regions, Galactic HII regions and HII regions from the Magellanic Clouds reveals that the [OIII] temperatures are higher than the corresponding values from [SIII] in most objects.

We look for an explanation for such differences and explore the parameter space of models with the aim at reproducing the observed trend of having $T_{OIII} > T_{SIII}$.

Using standard photoionization models, we vary ionization parameter, the hardness of the ionizing continuum and the gas metallicities in order to characterize how models behave with respect to the observation. We explore the posibility of inhomogeneities in abundances by combining two models of widely different metallicity. We introduce temperature fluctuations and vary their mean squared amplitud t^2. We also consider shock heating of the photoionized nebula.

DATA SAMPLE

- Hägele et. al (2006) (see also Pérez-Montero et al. 2006)
- Sloan Digital Survey (SDSS)(Data Release 2: DR2)
- 42 HII galaxies
- 34 giant extragalactic HII regions (GEHRs)
- 14 Galactic HII regions
- 12 HII regions from Magellanic Clouds
- [OIII](4363Å/5007Å) and [SIII] (6312Å/9532Å) temperatures



$T_{SIII} = 1.41 \times T_{OIII} - 5090$ K

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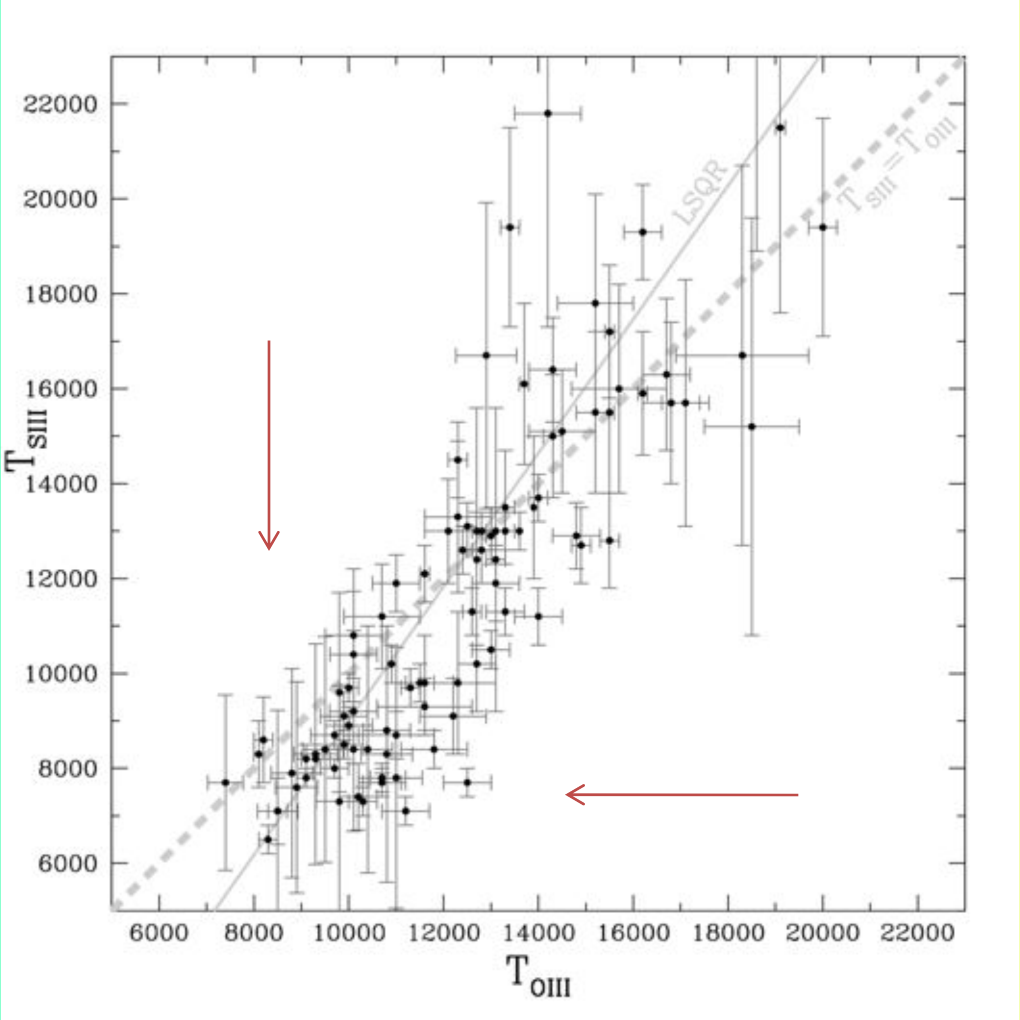

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PHOTOIONIZATION CALCULATIONS

- Multipurpose shock-photoionization code MAPPINGS IC (Ferrruit et al. 1997) (see also Binette, Dopita & Tuhony 1985)
- Standard (steady-state)(assuming ionizing and temperature equillibrium)
- Simple slab geometry
- $n_H = 10\ cm^{-3}$ (low density limit)
- Asplund & Grevesse (2006) solar abundances (we explored $Z = 0.01 – 2\ Z_\odot$)
- Zero-age instantaneous stellar burst, IMF estandard, Msup $=100\ M_\odot$ Magris et al. (2003) hereafter M03.
- $T_{eff} = 55\ 000$ K Hummer & Mihalas (1970) herefater HM70
- Ionization bounded slab ($U = 0.001 – 0.046$)

IONIZATION PARAMETER SEQUENCE

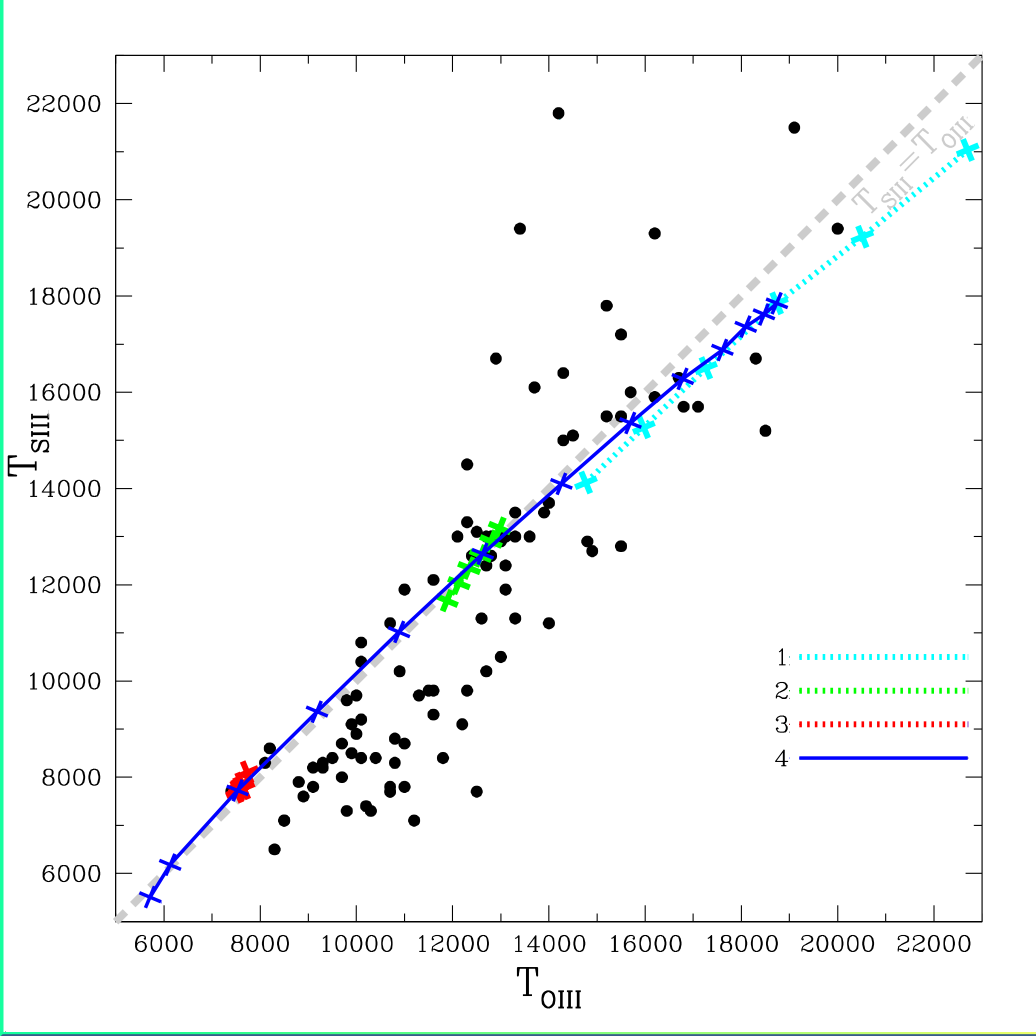
U = 0.001 – 0.046
SED of M03

1. Z = 0.01
2. Z = 0.2542
3. Z = 1

METALLICITY SEQUENCE

U = 0.01
SED of M03

4. Z = 0.01 – 2.4



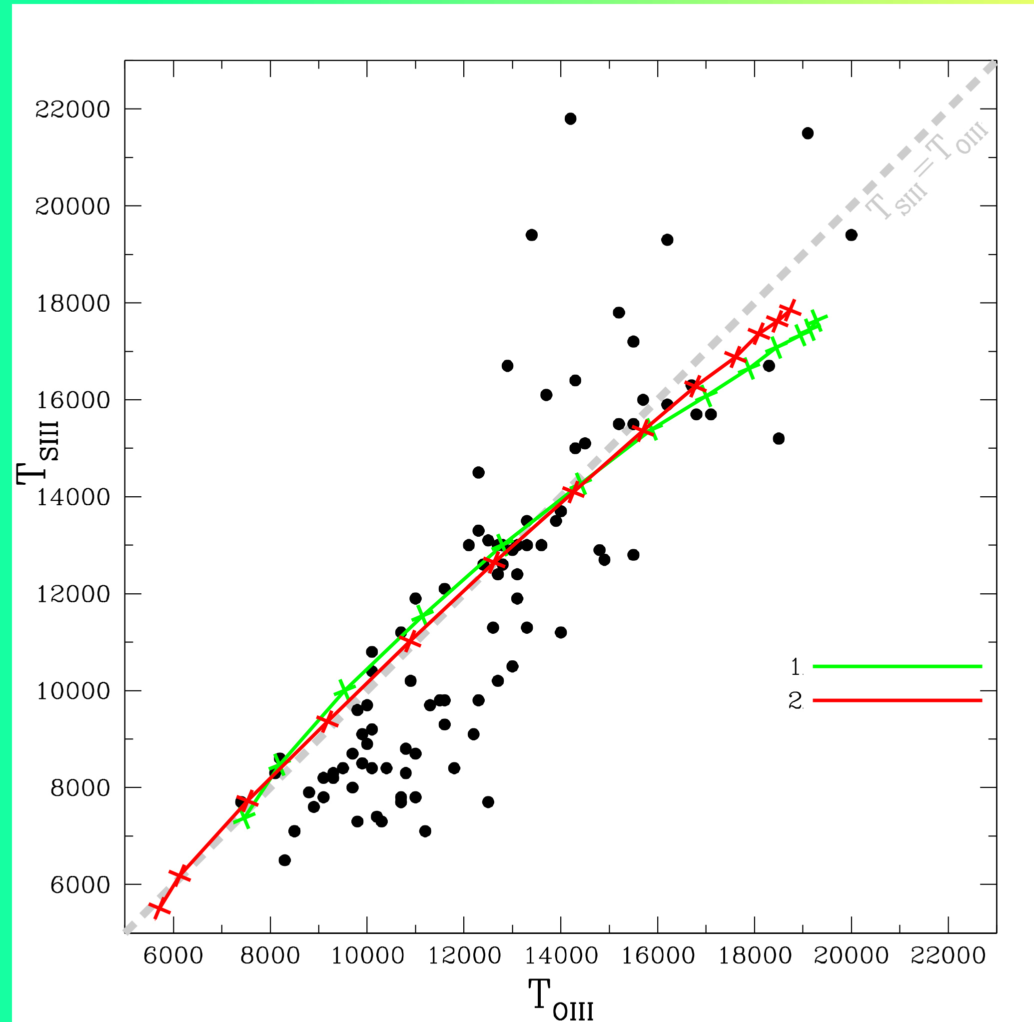
•Ionization parameter is not a significant parameter.
•There is not a significant departure in the metallicity sequence.

METALLICITY SEQUENCE (two different SED)

All with U = 0.01, Z = 0.01 – 2.4

1. SED 1
Hummer & Mihalas (1978)
T_{eff} = 55 000 K

1. SED 2
Magris et al. (2001)
IMF estándar
M_{sup} =100 $M_{\odot}$



To using different SED does not cause any improvement in reproducing the spread in the[OIII] and [SIII] temperatures of the lower left quadrant.

METALLICITIES INHOMOGENEITES (Combining two models)

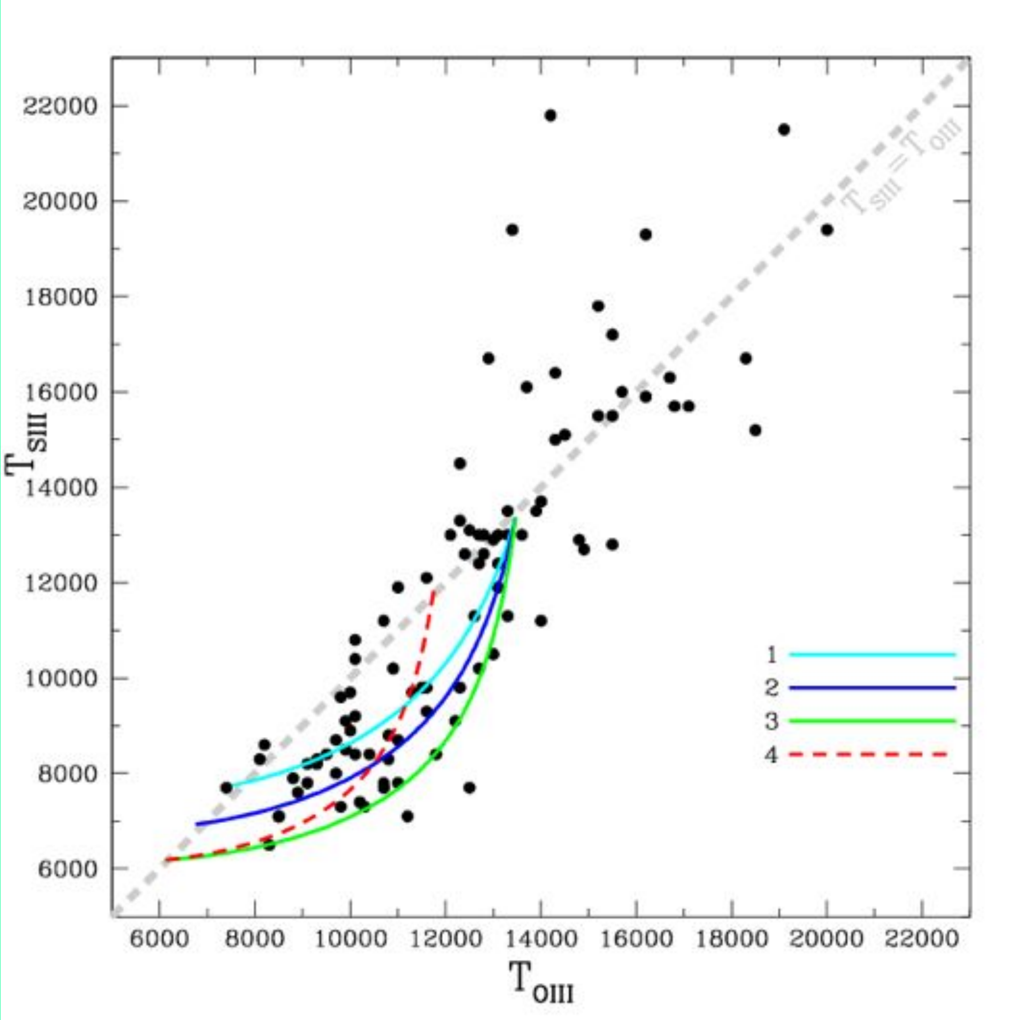
All with U = 0.01

1. Z = 0.2 + 1.0

2. Z = 0.2 + 1.26

3. Z = 0.2 + 1.58

4. Z = 0.32 + 1.58

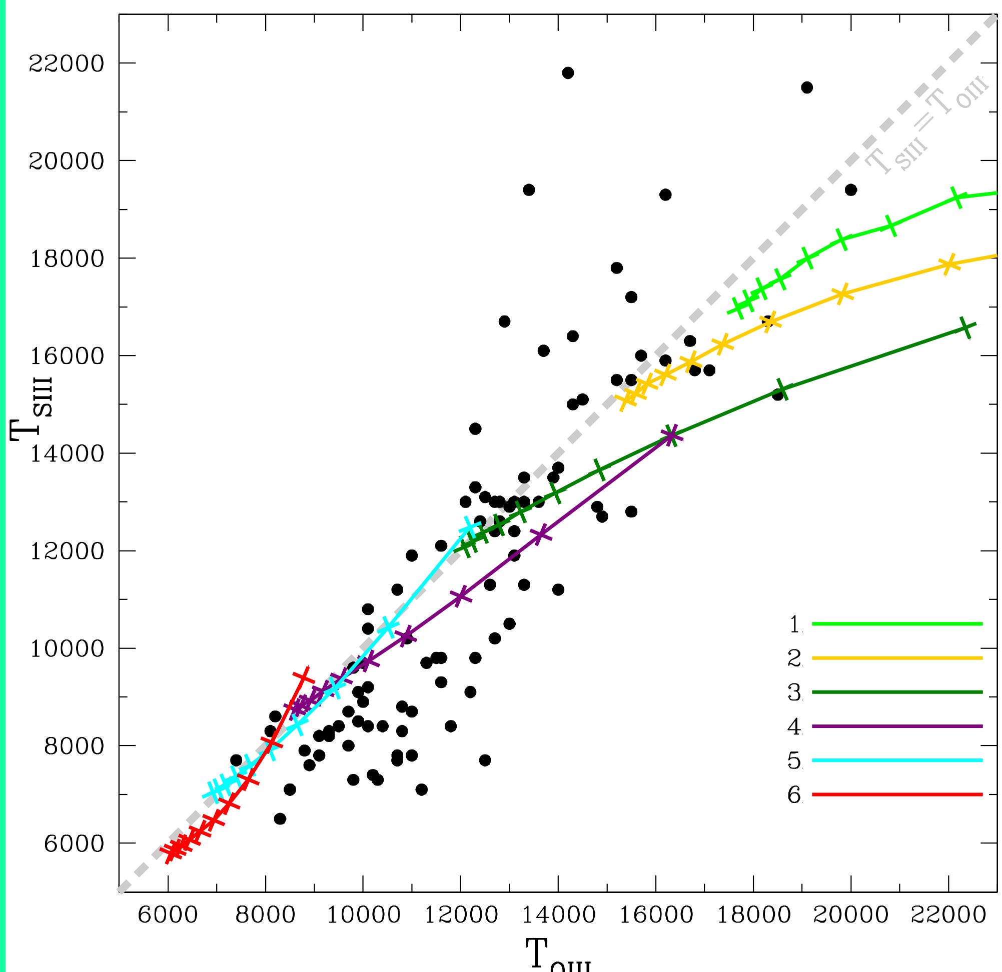


Metallicity inhomogeneities are certainly an interesting possibility that deserves further consideration.

FLUCTUATIONS TEMPERATURES

All with U = 0.01
t^2= 0.004−0.25

1. Z=0.05
2. Z=0.1256
3. , Z=0.3155
4. Z=0.7924
5. Z=1.27
6. Z=2.0

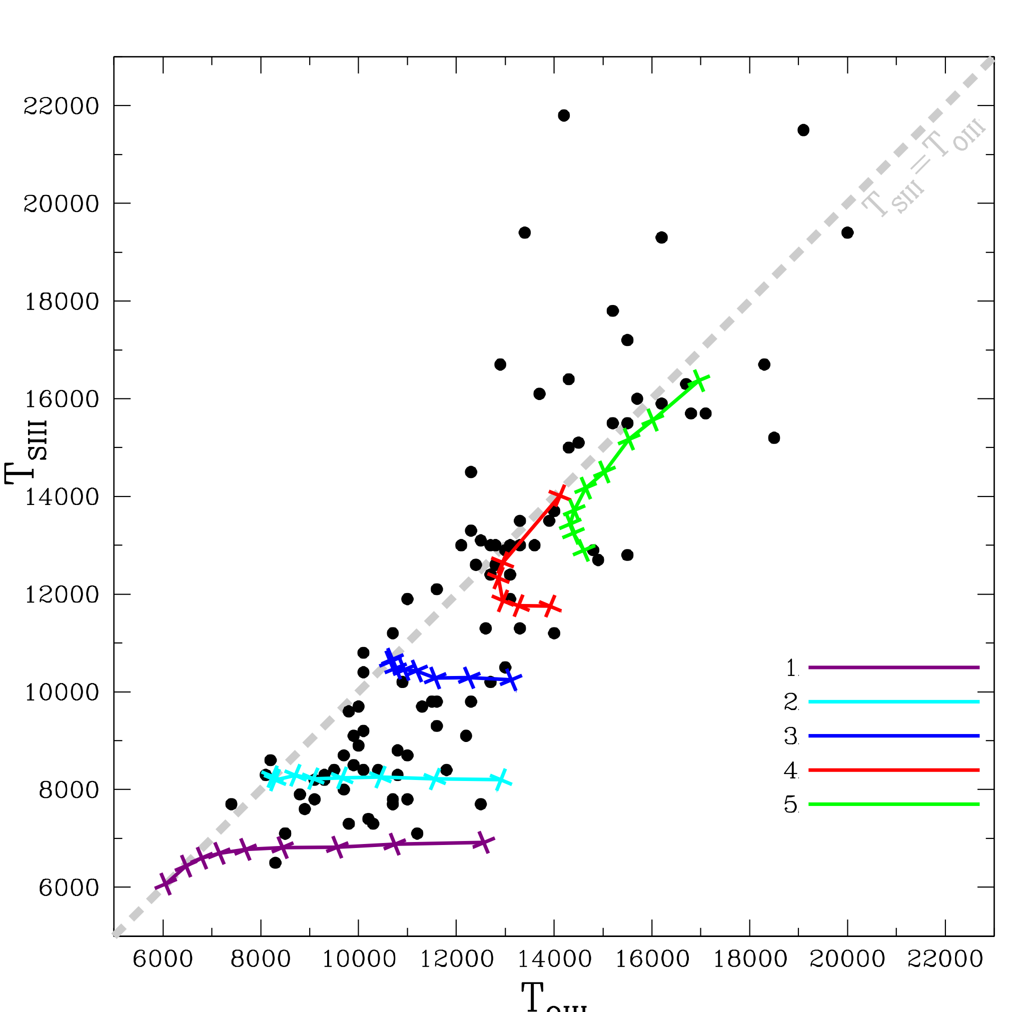


Pure temperature fluctuations cannot account for the excess in [OIII] temperatures seen in the left quadrant.

SHOCK SEQUENCES

All with U = 0.01
V_s increasing (20–60 Km/s)

1. Z = 1.58
2. Z = 1.0
3. Z = 0.51
4. Z = 0.2
5. Z = 0.10



In the lower-left quadrant, the models are surprinsingly succesfull in covering the spread in objects position to the right of the dashed line.

CONCLUSIONS

•Simple photoionization calculations result in essentially equal [OIII] and [SIII] temperatures in the range of interest (T_{SIII} < 14 000 K). Varying either the ionization parameter *U* or the metallicity *Z* or the hardness of the ionizaing SED over a wide range does not alter this result.

•Including temperature fluctuations of significant mean squared amplitude (t^2) does not result in values of T_{OIII} higher than T_{SIII} in the quadrant of interest (T_{SIII} < 14 000 K).

•Metallicity inhomogeneities can reproduce the observed excess in T_{OIII} temperatures. Combining two photoionization models of widely differing metallicities can reproduce most of the spread in temperature values.

•Shock waves that propagate in the photoionized gas can account for the observed excess in T_{OIII}. The 1D models that computed are simplistic and cannot be considered a fully autoconsistent description of shock waves propagating in a cahotic medium. 3D hydrodynamical calculations would be required that include proper radiative transfer in the context of outward propagating shocks.

Future:

We must perfomed models with more detail in the direction of inhomogeneities abundances and shocks in HII regions.

The main aim of this project was to explore and open the discussion in this interesting subject.

THANK YOU VERY MUCH!