The Sunny Side of Cloudy:
Varying stellar temperature and incident radiation field

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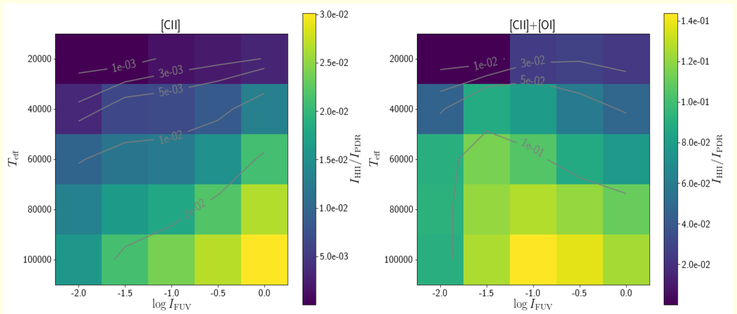
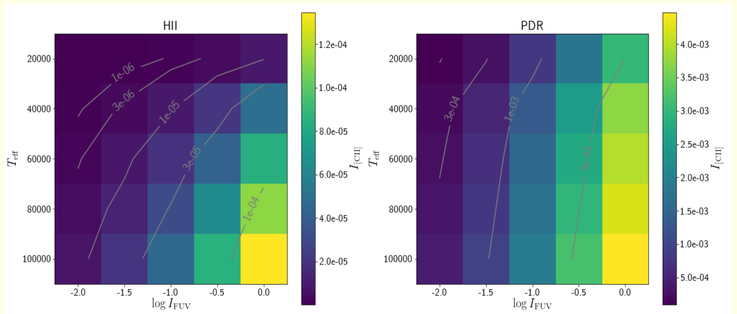
Introduction

We use Cloudy to study the effect of the temperature of the central star on the [CII] 158 μm emission from a PDR as compared to the adjacent HII region. In order to do so we set up a Cloudy grid with a hydrogen density of $n_{\rm H} = 10^4\,{\rm cm}^{-3}$, varying $T_{\rm eff}$ between $20,000\,{\rm K}$ and $100,000\,{\rm K}$, modeling the spectrum as a blackbody, and varying the intensity of the incident far-UV radiation (within $6\,{\rm eV} < h\nu < 13.6\,{\rm eV}$) as $\log I_{\rm FUV}$ between -2 and 0, corresponding to $6.25 < G_0 < 625$ in Habing units, $1.6 \cdot 10^{-3}\,{\rm erg\,s^{-1}\,cm^{-2}}$. Here, we compute a 5×5 grid, the PDR truncated at $A_{\rm V} = 1$, because the computations are rather time-consuming. Moreover, we compare the [CII] emission to the FIR emission from the PDR, a diagnostic tool used in extragalactic studies. As an aside, we use Cloudy to calculate the heating efficiency for several elemental abundances and grain/PAH distributions and compare it to the curve computed by Bakes & Tielens (1994).

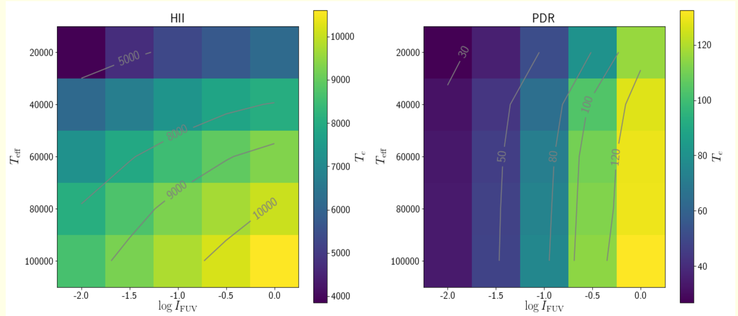
Intensity ratio HII region/PDR



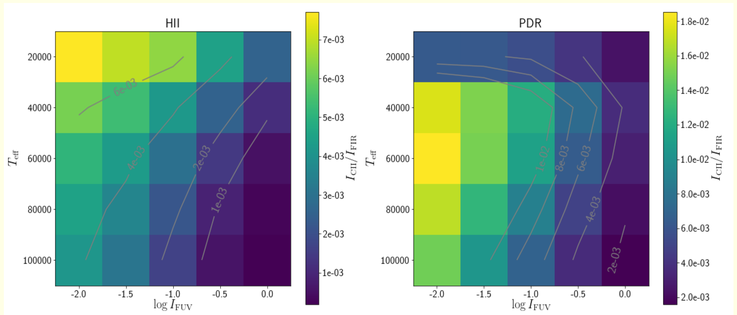
[CII] intensity



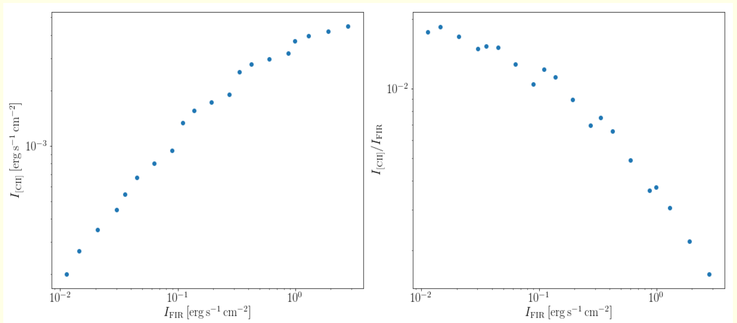
Kinetic Temperature



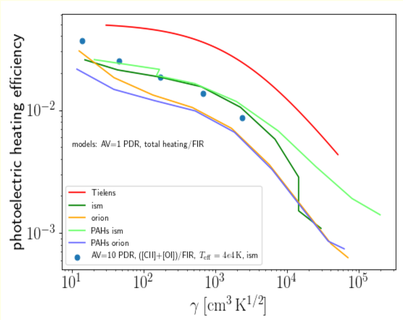
[CII] cooling efficiency



[CII] vs. FIR



Heating efficiency



With our model runs here, i.e. with Cloudy library abundances, we cannot replicate the Bakes & Tielens (1994) curve (in red).

Conclusions

The pattern of absolute [CII] intensity resembles the kinetic temperature pattern of the grid. Both are more strongly dependent on $T_{\rm eff}$ in the HII region than in the PDR. At the gas density considered, also the [OI] 63 μm line becomes an important coolant, hence we show a figure of the combined [CII]+[OI] emission, as well.
The study shows that the stellar effective temperature does influence the emission characteristics, albeit more in the HII region than in the PDR. A caveat applies: At $\log I_{\rm FUV} < -0.5$ and $T_{\rm eff} = 20,000\,{\rm K}$, there is not sufficient ionizing radiation to produce an HII region. Although $T_{\rm eff}$ does affect the absolute values slightly, the [CII] and FIR intensities lie on a single curve.

References

Cloudy 17.00: Ferland et al. (2017), Bakes & Tielens (1994)