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The Origin of [CII] 158 μm Emission toward the HII Region Complrex S235

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Although the $^2P_{3/2} - ^2P_{1/2}$ transition of [C II] at $\lambda \simeq 158\,\mu$m is known to be an excellent tracer of active star formation, we still do not have a complete understanding of where within star formation regions the emission originates. Here, we use *SOFIA* upGREAT observations of [C II] emission toward the H II region complex Sh2-235 (S235) to better understand in detail the origin of [C II] emission. We complement these data with a fully-sampled Green Bank Telescope radio recombination line map tracing the ionized hydrogen gas. About half of the total [C II] emission associated with S235 is spatially coincident with ionized hydrogen gas, although spectroscopic analysis shows little evidence that this emission is coming from the ionized hydrogen volume. Velocity-integrated [C II] intensity is strongly correlated with *WISE* 12 μm intensity across the entire complex, indicating that both trace ultra-violet radiation fields. The 22 μm and radio continuum intensities are only correlated with [C II] intensity in the ionized hydrogen portion of the S235 region and the correlations between the [C II] and molecular gas tracers are poor across the region. We find similar results for emission averaged over a sample of external galaxies, although the strength of the correlations is weaker. Therefore, although many tracers are correlated with the strength of [C II] emission, only *WISE* 12 μm emission is correlated on small-scales of the individual H II region S235 and also has a decent correlation at the scale of entire galaxies. Future studies of a larger sample of Galactic H II regions would help to determine whether these results are truly representative.

Theme/Motivation

[CII] 158 μm は遠赤外線で明るく銀河の星形成を探るトレーサとして注目されている.
空間的には photo dissociation region (PDR) の, エネルギー的には UV 強度の指標となる.
[CII] 158 μm の HII region からの寄与は先行研究によって幅がある (5–50 %).
実際に [CII] 158 μm が何をトレースしているのか HII region スケールでの検証が必要.
SOFIA/upGREAT によって [CII] 158 μm 空間・速度的に分解して議論をする.

Observations

SOFIA/upGREAT: 空間・速度分解した [CII] ([NII]) 輝線マップ;
Green Bank Telescope: 空間・速度分解した水素・炭素原子再結合線マップ (RRL);
WISE: 空間分解した 12 μm, 22 μm 強度マップ (archive);
NVSS: 空間分解した 1.4 GHz 電波連続放射マップ (≈ free-free emission; archive).

Discussion/Conclusion

空間構造を見ると [CII] 158 μm は WISE 12 μm (≈ PAH ≈ UV) とよく相関している (Figure 4).
[CII] 158 μm は WISE 22 μm (≈ VSG) とも diffuse 成分ではそこそこ相関が良い (YSO の部分は除く)
HII region のトレーサ (1.4 GHz, H RRL) や分子雲のトレーサ (CO) とは空間構造が異なる

Figure 4 では [CII] 158 μm の半分ほどが ionized region から来ているように見える.
Position-velocity diagram (Figure 7) によると ionized gas と [CII] 158 μm, C RRL の速度が異なる.
膨張する HII region を通して backside の PDR を見ていると考えると整合的 (Figure 8).

S235 にて [CII] 158 μm が HII region のスケールで PDR & UV のトレーサであることを検証した.
空間・速度分解した観測で個々の HII region + PDR の構造を理解 ⇒ 銀河の星形成の理解へ.

論文では S235 の結果を踏まえて近傍銀河の [CII] 158 μm との相関を議論していたが
正直なところほぼ内容がなかったので割愛...

Comments

[CII] 158 μm (11.3 eV) と WISE 12 μm (PAH ≈ a few eV) の強度比が輻射の硬さの指標となる.
Spitzer/IRAC 8 μm や AKARI/IRC 9 μm のマップと合わせてみてもおもしろそう.

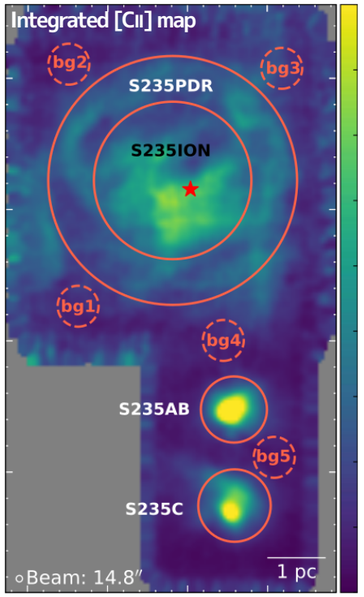

Figure 2: Regions of Interest

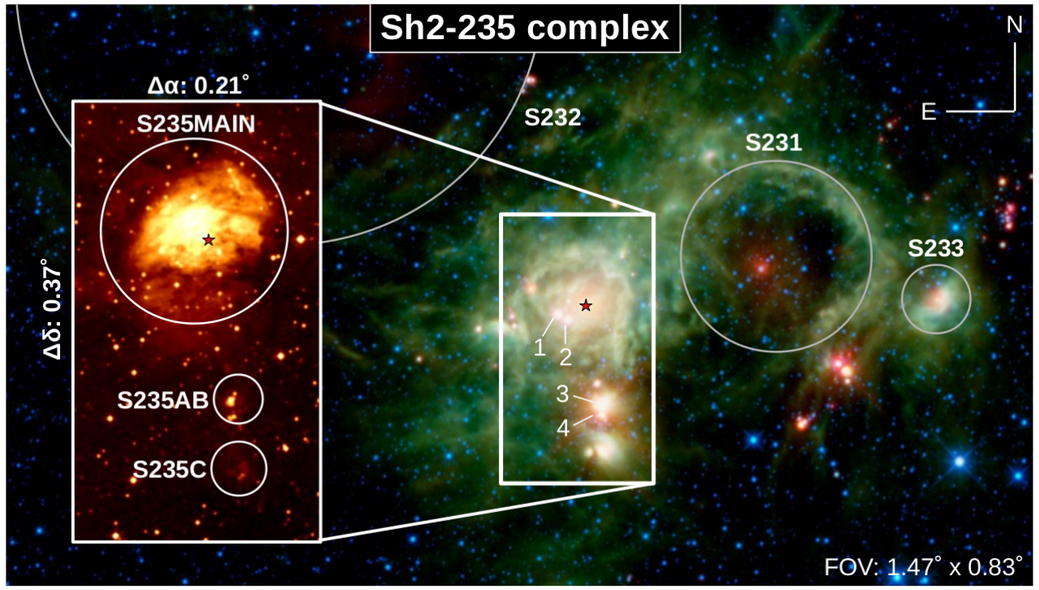

Figure 1: an overview of S235 (WISE false color map & DSS red inset)

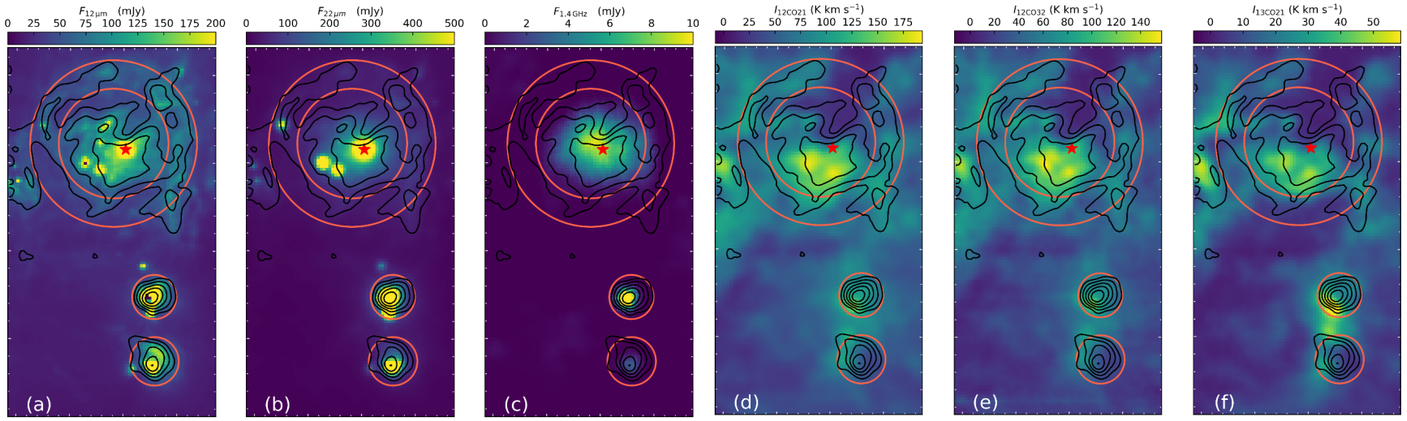

Figure 4: spacial correlations of [CII] 158 μm and other tracers (integrated intensity maps)

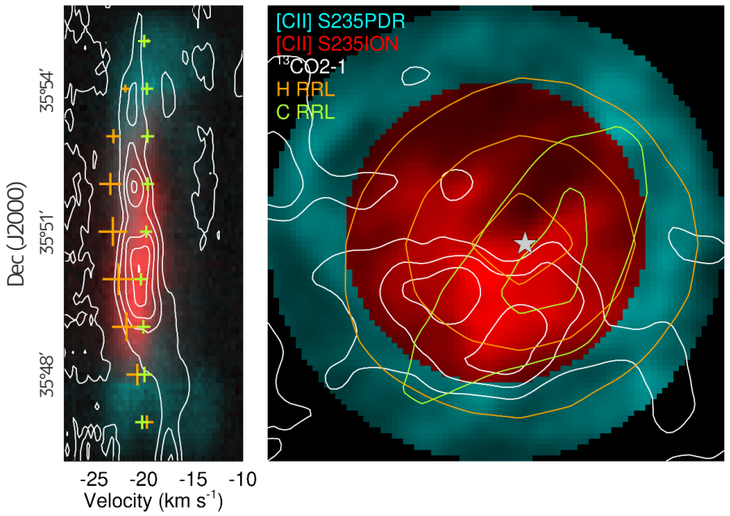

Figure 7: a position-velocity diagram of S235

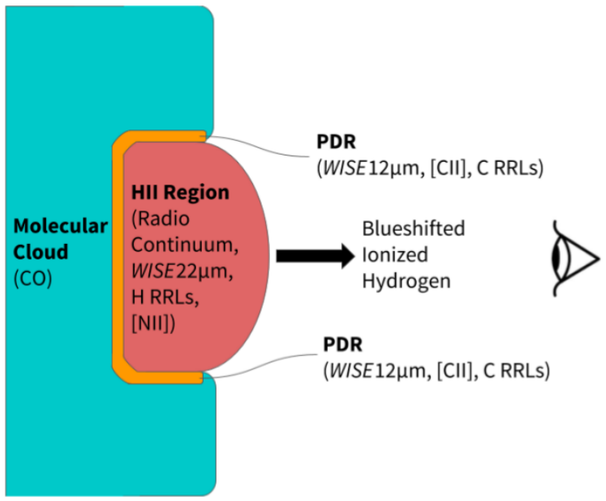

Figure 8: a schematic (side) tview of S235