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[CII] 158µm and [NII] 205µm emission from IC 342

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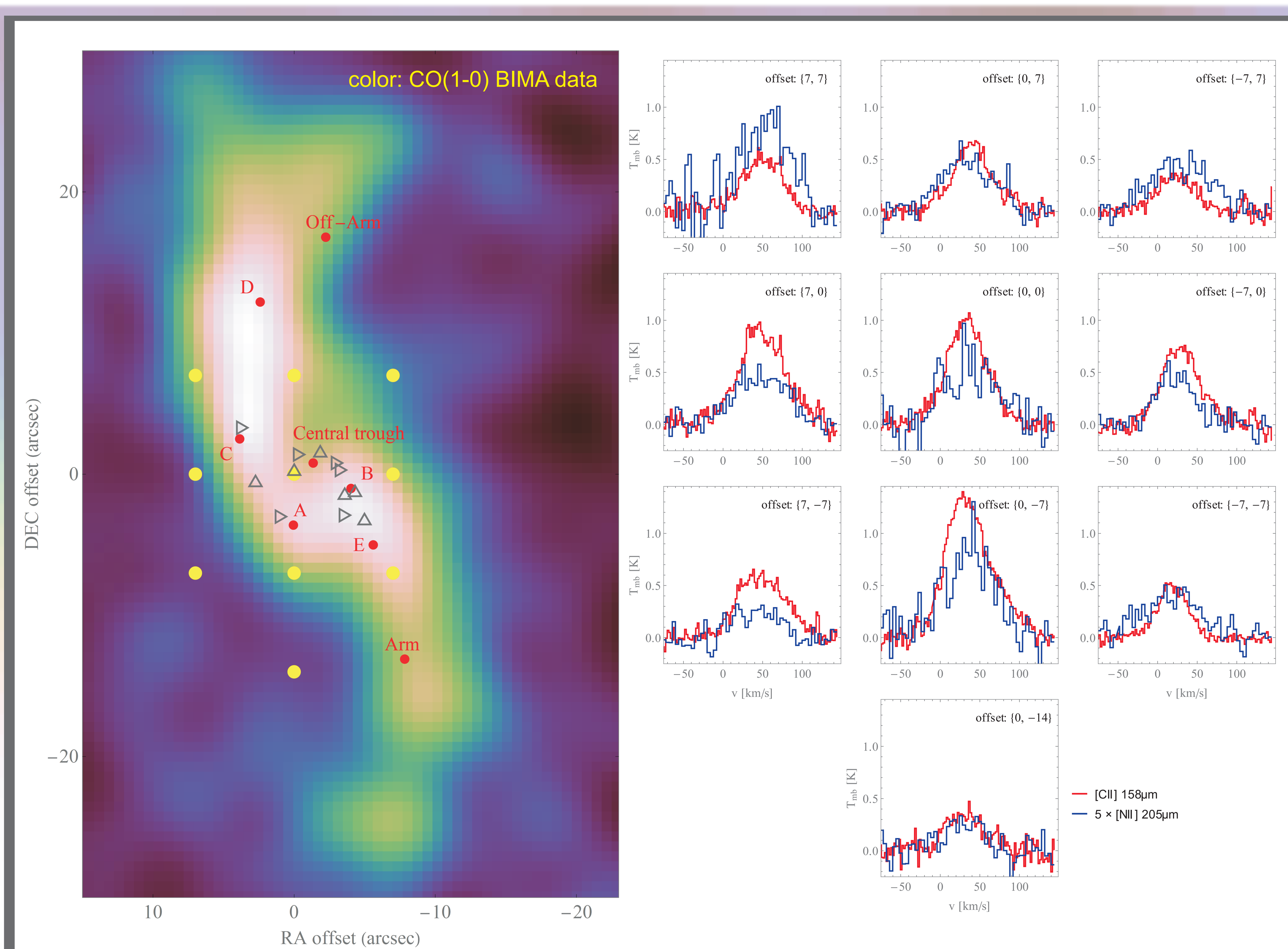
Overview and Motivation

IC 342 is the closest gas-rich spiral galaxy with starburst activity in its nucleus. At a distance of 3.3 Mpc and oriented face-on, it offers a unique opportunity to study the star formation in the center and its interaction with the local ISM.

The bar potential in IC 342 leads to the formation of a mini-spiral in the nucleus of the galaxy containing large amounts of gas and dust. It ends on a circum-nuclear molecular ring, with a massive star cluster in its center. The radiation from the cluster produces strong PDR emission along the inner rim of the ring. Along the arms and the ring we find a number of GMCs with various levels of star forming activity.

The nucleus of IC 342 also harbors at least six compact HII regions contributing significantly to the emission of ionized species such as [NII]. More interestingly, the observed [CII] emission will originate from both, the PDRs and the HII regions. Galactic studies showed that in general no more than ~25% of the observed [CII] is generated by HII regions and ~ 20% in the diffuse ionized gas. However, in the center of the Milky Way only a minor fraction of the [CII] emission comes from PDRs. IC 342 offers ideal conditions to estimate how its PDRs and HII regions and the diffuse components contribute to the overall [CII] emission.



Data Overview

We observed the [NII] 205µm and [CII] 158µm fine-structure lines at 10 positions around the nucleus of IC 342, with the GREAT receiver on SOFIA in the L1/L2 configuration (1496.9/1900.5 GHz) (Figure above). The observations were done in dual-beam switch mode, with system temperatures between 2000-5500 K and ON integration times between 2.5 and 7.5 minutes. The FFTS backend with 8192 channels gives 1.5 GHz bandwidth and 212 kHz spectral resolution.

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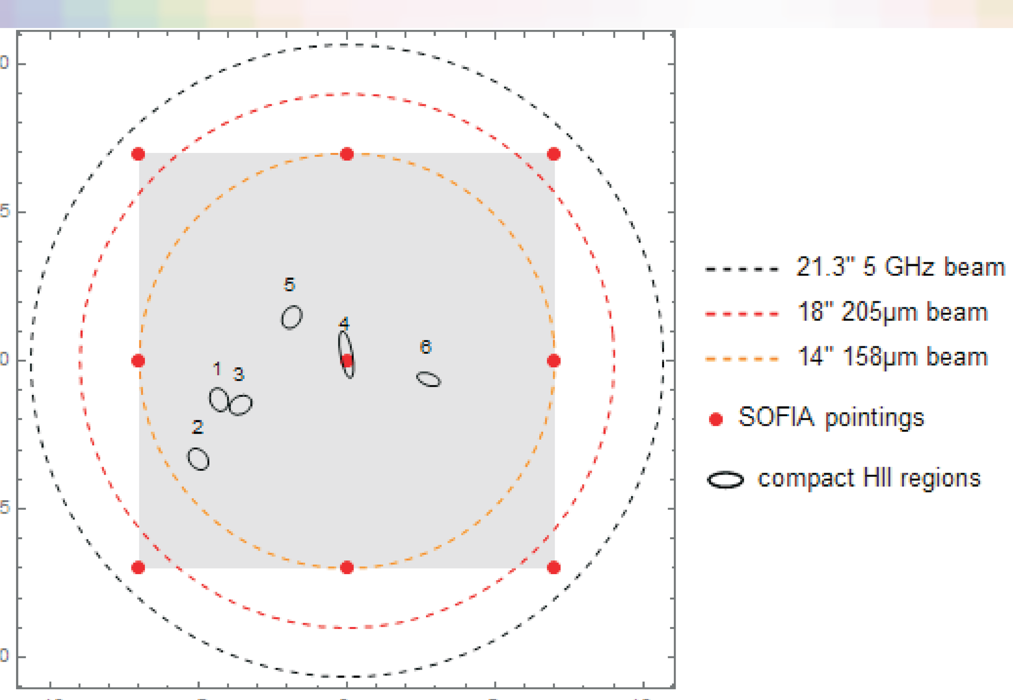
d	r_{RA}	r_{Dec}	rot. angle	A_{geo}	$A_{[CII]\ coupl}$	$A_{[NII]\ coupl}$
4.50383	0.4	0.3	20	0.376991	0.282953	0.316917
5.97836	0.4	0.3	40	0.376991	0.227383	0.277654
3.8863	0.4	0.3	120	0.376991	0.30447	0.331284
0.196013	0.8	0.2	10	0.502655	0.502382	0.50249
2.37826	0.4	0.3	150	0.376991	0.348003	0.359179
2.80544	0.4	0.2	70	0.251327	0.224847	0.234958
			Total	2.26195	1.89004	2.02248
			equiv. θ	1.69706	1.55128	1.60471
			$\int T_{mb}^{theo} dv$		39.2425	6.47627
			$\int T_{mb}^{obs} dv$		62.904	9.62188



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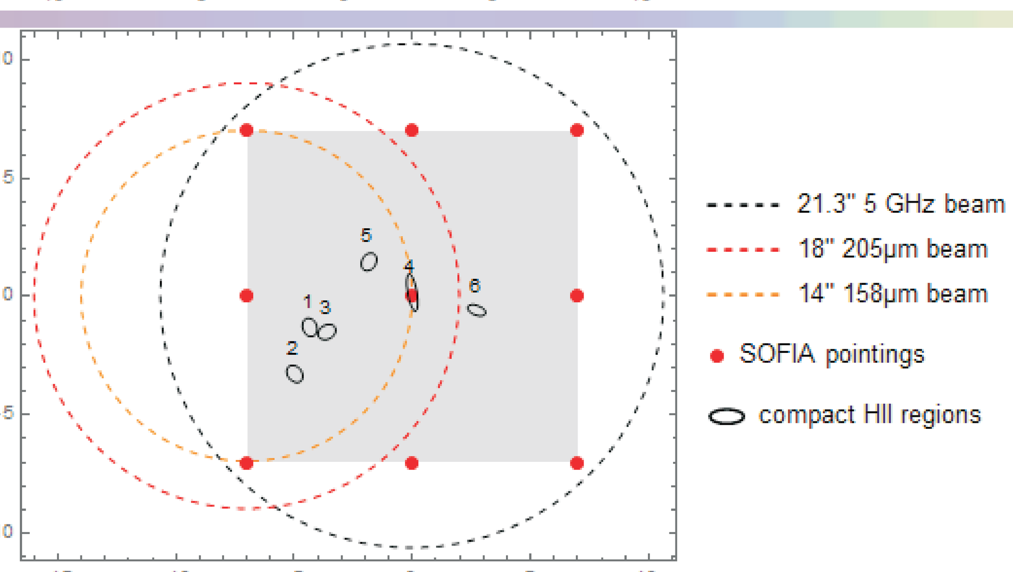
d	r_{RA}	r_{Dec}	rot. angle	A_{geo}	$A_{[CII]\ coupl}$	$A_{[NII]\ coupl}$
4.50383	0.4	0.3	20	0.376991	0.332246	0.349251
5.97836	0.4	0.3	40	0.376991	0.304971	0.331614
3.8863	0.4	0.3	120	0.376991	0.309545	0.334614
0.196013	0.8	0.2	10	0.502655	0.251302	0.330475
2.37826	0.4	0.3	150	0.376991	0.250938	0.294713
2.80544	0.4	0.2	70	0.251327	0.0653468	0.111261
			Total	2.26195	1.51435	1.75193
			equiv. θ	1.69706	1.38857	1.49353
			$\int T_{mb}^{theo} dv$		31.4422	5.60992
			$\int T_{mb}^{obs} dv$		44.0256	5.60387



[CII] and [NII] LTE emission from compact HII regions

The two panels above show how we modeled the compact HII emission at two of the observed 10 SOFIA pointings. Six compact HII regions are located in the center region. They are assumed to emit [CII] and [NII] under LTE conditions, derived from thermal radio data (T=8000K, n_e=350cm^{-3}). Their geometrical area A_{geo} couples differently with the SOFIA beams at 158µm ($A_{[CII]\ coupl}$) and 205µm ($A_{[NII]\ coupl}$) . The total model emission is then compared with the observed intensities.

Summary

Disentangling how different phases of the ISM contribute to its overall emission is particularly important for observations of unresolved targets. Galaxies such as IC 342 are ideal laboratories to study emission of individual ISM components.

Compared to the MW, we find that the nucleus of IC 342 shows a significantly larger fraction of [CII] emission contributed by the ionized gas (HII & diffuse). 35-90% of the observed [CII] intensities are produced in the ionized gas. Averaged over the central few hundred parsec we find for the [C II] emission an HII-to-PDR contribution ratio of 70:30. This is an important finding because attributing observed [CII] intensities entirely to PDRs leads to concluding significantly different local physical conditions, e.g. by comparing with PDR model resuls.

We also demonstrated how we can estimate the HII-to-PDR contribution ratio using the (kinematically resolved) [NII] 205 µm data observed in parallel with the GREAT receiver on SOFIA.

Details: **Data:**

References: Röllig et al. 2016, Pineda et al. 2014, Israel & Baas 2003, Downes et al. 1992, Meier & Turner 2001,2005, Tikhonov et al. 2010, Helfer et al. 2003

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